THE DEVELOPMENT OF HIGH-TECHNOLOGY CENTERS IN THE UNITED STATES, WITH A FOCUS ON ARIZONA

July 2024

Kent Hill, Ph.D.
Principal Research Economist, L. William Seidman Research Institute
Dennis Hoffman, Ph.D.
Director, Center for Competitiveness and Prosperity Research and the Office of the University Economist
Eva Madly, M.S.
Senior Research Economist, L. William Seidman Research Institute
Tom Rex, M.B.A.
Associate Director, Center for Competitiveness and Prosperity Research; and Manager of Research Initiatives, Office of the University Economist

P3 | PRODUCTIVITY AND PROSPERITY PROJECT

ASU W. P. CAREY SCHOOL of BUSINESS
ARIZONA STATE UNIVERSITY

THE DEVELOPMENT OF HIGH-TECHNOLOGY CENTERS IN THE UNITED STATES, WITH A FOCUS ON ARIZONA

A Report from the Productivity and Prosperity Project (P3), Supported by the Office of the University Economist

July 2024

Kent Hill, Ph.D.
Principal Research Economist, L. William Seidman Research Institute

Dennis Hoffman, Ph.D.
Director, Center for Competitiveness and Prosperity Research and
the Office of the University Economist

Eva Madly, M.S.
Senior Research Economist, L. William Seidman Research Institute

Tom Rex, M.B.A.
Associate Director, Center for Competitiveness and Prosperity Research;
and Manager of Research Initiatives, Office of the University Economist

With the assistance of Kaitlyn Ackron, Associate Research Economist, and Jazmin Castaneda, Administration Manager, L. William Seidman Research Institute

Center for Competitiveness and Prosperity Research
L. William Seidman Research Institute
W. P. Carey School of Business
Arizona State University
Box 874011
Tempe, Arizona 85287-4011

(480) 965-5362
EMAIL: Tom.Rex@asu.edu
ccpr.wpcarey.asu.edu
economist.asu.edu

TABLE OF CONTENTS

Executive Summary 1
Summary 3
High-Technology Literature Review 10
Relationship Between High Technology and Population Growth 10
Relationship Between High Technology and Productivity and Prosperity 13
Selected High-Technology Studies 20
The Spatial Concentration and Clustering of High Technology Activities 22
Determinants of the Locations of High-Tech Clusters 26
Selected Case Studies 29
Introduction to Empirical Analysis and Indicators 33
Occupational Versus Industrial Data 33
Identification of STEM Occupations and Industries 34
Industrial Clusters 35
Employment Versus Aggregate Earnings 36
States Versus Metropolitan Areas 36
Selection of States and Metropolitan Areas 37
Cost of Living 40
Evolution of High-Technology Activities in Selected States and Metropolitan Areas 42
Industrial Data Sources 42
Industrial Analysis, 1956 to 2022 45
Occupational Analysis, 2001 to 2022 88
Industrial and Occupational Summary, All States, 2022 113
A Broader Look at the Occupational and Industrial Mixes in Selected States and Metro Areas 117
Occupational Comparison 117
Industrial Comparison 145
High-Technology Indicators for Arizona 185
Milken Institute 185
Information Technology and Innovation Foundation 187
STEM Share of Employment and Aggregate Earnings 188
Human Capital Indicators 199
Financial Capital Indicators 208
References 215
Appendix A: STEM Occupations, Standard Occupational Classification, 2018 219
Appendix B: STEM Industries, North American Industry Classification System, 2022 221
Appendix C: Biotechnology 223
Appendix D: Research and Development 225
Appendix E: Tables Displaying All 53 Traded Clusters 227

LIST OF TABLES

1. Regression Analysis of Population Growth Between 2000 and 2018 in 83 Metropolitan Areas 12
2. Regression Analysis of Earnings Per Worker Adjusted for the Cost of Living in 2018 in 170 Metropolitan Areas 15
3. Regression Analysis of Output Per Worker Adjusted for the Cost of Living in 2018 in 170 Metropolitan Areas 19
4. Dispersion of Employment Shares in High Technology and Other Major Economic Sectors Across Metropolitan Areas, 2019 23
5. Top 15 Metropolitan Areas in Excess High-Technology Industrial Employment, 2019 24
6. Rank Among All States on the Share of Total Employment by High-Technology Industrial Category, 2022 68
7. Rank Among All States on the Share of Total Employment by High-Technology Occupational Category, 2022 98
8. Earnings Per Worker and Shares, Major Occupational Groups, United States, 2022 118
9. Earnings Per Worker and Shares, Major Occupational Groups, United States, 2012-to-2022 Change 119
10. Median Earnings Per Worker Adjusted for the Cost of Living, Major Occupational Groups, Arizona 120
11. Employment and Aggregate Earnings, Major Occupational Groups, Arizona, 2022 121
12. Employment Share of Total, Major Occupational Groups, Arizona and Selected States, 2022 122
13. Aggregate Earnings Share of Total, Major Occupational Groups, Arizona and Selected States, 2022 123
14. Employment and Aggregate Earnings, Major Occupational Groups, Arizona, 2012-to-2022 Change in Share Relative to the National Average 124
15. Change in Employment Share of Total, Major Occupational Groups, Arizona and Selected States, 2012 to 2022 125
16. Change in Aggregate Earnings Share of Total, Major Occupational Groups, Arizona and Selected States, 2012 to 2022 126
17. Employment and Aggregate Earnings, Major Occupational Groups, Metropolitan Phoenix, 2022 131
18. Employment Share of Total, Major Occupational Groups, Metropolitan Phoenix and Selected Large Metropolitan Areas, 2022 132
19. Aggregate Earnings Share of Total, Major Occupational Groups, Metropolitan Phoenix and Selected Large Metropolitan Areas, 2022 133
20. Employment and Aggregate Earnings, Major Occupational Groups, Metropolitan Phoenix, 2012-to-2022 Change in Share Relative to the National Average 134
21. Employment Share of Total, Major Occupational Groups, Metropolitan Phoenix and Selected Large Metropolitan Areas, 2012-to-2022 Change 136
22. Aggregate Earnings Share of Total, Major Occupational Groups, Metropolitan Phoenix and Selected Large Metropolitan Areas, 2012-to-2022 Change 137
23. Employment and Aggregate Earnings, Major Occupational Groups, Metropolitan Tucson, 2022 139
24. Employment Share of Total, Major Occupational Groups, Metropolitan Tucson and Selected Southwestern Metropolitan Areas, 2022 140
25. Aggregate Earnings Share of Total, Major Occupational Groups, Metropolitan Tucson and Selected Southwestern Metropolitan Areas, 2022 141
26. Employment and Aggregate Earnings, Major Occupational Groups, Metropolitan Tucson, 2012-to-2022 Change in Share Relative to the National Average 142

(continued)

LIST OF TABLES (continued)

27. Employment Share of Total, Major Occupational Groups, Metropolitan Tucson and Selected Southwestern Metropolitan Areas, 2012-to-2022 Change 143
28. Aggregate Earnings Share of Total, Major Occupational Groups, Metropolitan Tucson and Selected Southwestern Metropolitan Areas, 2012-to-2022 Change 144
29. Earnings Per Worker and Shares, Traded Clusters, United States, 2022 147
30. Earnings Per Worker and Shares, Traded Clusters, United States, 2012-to-2022 Change 149
31. Average Earnings Per Worker Adjusted for the Cost of Living, Selected Traded Clusters, Arizona 152
32. Employment and Aggregate Earnings, Selected Traded Clusters, Arizona, 2022 154
33. Employment Share of Total, Selected Traded Clusters, United States and Selected States, 2022 155
34. Aggregate Earnings Share of Total, Selected Traded Clusters, United States and Selected States, 2022 156
35. Employment and Aggregate Earnings, Selected Traded Clusters, Arizona, 2012-to-2022 Change in Share Relative to the National Average 157
36. Employment Share of Total, Selected Traded Clusters, United States and Selected States, 2012-to-2022 Change 158
37. Aggregate Earnings Share of Total, Selected Traded Clusters, United States and Selected States, 2012-to-2022 Change 159
38. Employment and Aggregate Earnings, Selected Traded Clusters, Metropolitan Phoenix, 2022 167
39. Employment Share of Total, Selected Traded Clusters, United States and Selected Large Metropolitan Areas, 2022 168
40. Aggregate Earnings Share of Total, Selected Traded Clusters, United States and Selected Large Metropolitan Areas, 2022 169
41. Employment and Aggregate Earnings, Selected Traded Clusters, Metropolitan Phoenix, 2012-to-2022 Change in Share Relative to the National Average 170
42. Employment Share of Total, Selected Traded Clusters, United States and Selected Large Metropolitan Areas, 2012-to-2022 Change 171
43. Aggregate Earnings Share of Total, Selected Traded Clusters, United States and Selected Large Metropolitan Areas, 2012-to-2022 Change 172
44. Employment and Aggregate Earnings, Selected Traded Clusters, Metropolitan Tucson, 2022 176
45. Employment Share of Total, Selected Traded Clusters, United States and Selected Southwestern Metropolitan Areas, 2022 177
46. Aggregate Earnings Share of Total, Selected Traded Clusters, United States and Selected Southwestern Metropolitan Areas, 2022 178
47. Employment and Aggregate Earnings, Selected Traded Clusters, Metropolitan Tucson, 2012-to-2022 Change in Share Relative to the National Average 179
48. Employment Share of Total, Selected Traded Clusters, United States and Selected Southwestern Metropolitan Areas, 2012-to-2022 Change 180
49. Aggregate Earnings Share of Total, Selected Traded Clusters, United States and Selected Southwestern Metropolitan Areas, 2012-to-2022 Change 181
50. Summary of Occupational High Technology in Arizona 191
51. Summary of Industrial High Technology in Arizona 194

LIST OF CHARTS

1. Earnings Per Worker Adjusted for the Cost of Living and the Occupational STEM Share of Employment, 2018 17
2. Industrial High-Technology Shares of Total Employment Nationally, 1956 to 2003 46
3. Industrial High-Technology Shares of Total Employment Nationally, 2001 to 2022 48
4. Industrial High-Technology Shares of Total Employment in Arizona as a Percentage of High-Technology Shares of Total Employment Nationally, 1956 to 2003 52
5. Industrial High-Technology Shares of Total Employment in Arizona as a Percentage of High-Technology Shares of Total Employment Nationally, 2001 to 2022 54
6. Industrial High-Technology Shares in Metropolitan Phoenix as a Percentage of High-Technology Shares Nationally, and Ranks Among 12 Large Metropolitan Areas, 2001 to 2022 68
7. Industrial High-Technology Shares in Metropolitan Tucson as a Percentage of High-Technology Shares Nationally, and Ranks Among Eight Southwestern Metropolitan Areas, 2001 to 2022 80
8. Occupational High-Technology Shares of Total Employment Nationally, 2001 to 2022 89
9. Occupational High-Technology Shares of Total Employment In Arizona as a Percentage of High-Technology Shares of Total Employment Nationally, 2001 to 2022 91
10. Occupational High-Technology Shares in Metropolitan Phoenix as a Percentage of High-Technology Shares Nationally, and Ranks Among 12 Large Metropolitan Areas, 2001 to 2022 100
11. Occupational High-Technology Shares in Metropolitan Tucson as a Percentage of High-Technology Shares Nationally, and Ranks Among Eight Southwestern Metropolitan Areas, 2001 to 2022 107
12. Earnings Per Worker, Arizona as a Percentage of the National Average, Selected Occupational Groups 127
13. Share of Total, Arizona as a Percentage of the National Average, Selected Occupational Groups 128
14. Average Earnings Per Worker Adjusted for the Cost of Living, Selected Traded Clusters, Arizona as a Percentage of the National Average, 2022 151
15. Total Traded Cluster Share, Arizona as a Percentage of the National Average 153
16. Traded Cluster Share Based on Aggregate Earnings, Arizona as a Percentage of the National Average 160
17. Arizona's Ranks in the Milken Institute's State Technology and Science Index 186
18. Arizona's Ranks in the ITIF's State New Economy Index 188
19. Total High-Technology Share in Arizona as a Percentage of the National Average 190
20. Aggregate Earnings Share in Arizona by Occupational High-Technology Category as a Percentage of the National Average 192
21. Aggregate Earnings Share in Arizona by High-Technology Industrial Category as a Percentage of the National Average 196
22. State and Local Government Educational Funding Per Student in Arizona as a Percentage of the National Average 200
23. Public Higher Education Revenue Per Full-Time-Equivalent Student as a Percentage of the National Average, Arizona 201
24. Educational Appropriations as a Share of Total Educational Revenue for Public Higher Education 201
25. Educational Attainment in Arizona as a Percentage of the National Average 202
26. Utility Patents in Arizona as a Percentage of the National Average 205
27. Human Capital Indicators in Arizona as a Percentage of the National Average 207
28. Research and Development Funding Relative to Gross Domestic Product in Arizona as a Percentage of the National Average 209
29. SBIR Grants in Arizona as a Percentage of the National Average 212
30. STTR Grants in Arizona as a Percentage of the National Average 212
31. Venture Capital in Arizona as a Percentage of the National Average 214

EXECUTIVE SUMMARY

The crucial location determinant for high-tech firms is access to a pool of highly skilled and knowledgeable workers. Since people are mobile, this makes the optimal location of high-tech industries indeterminate. The locations of many high-tech clusters can be traced to decisions that were made by key inventors or pioneering firms for reasons that are no longer important today.

While the initial location of a pioneering firm may be arbitrary, subsequent growth in the industry and a clustering of new firms around the pioneering firm creates efficiencies of agglomeration that serve to lock in the initial location. As the cluster grows, a spatial concentration of new firms helps to create thicker labor markets for specialized labor, attracts specialized suppliers and service providers, and promotes the spillover and informal exchange of industry knowledge that is critical for innovation. Because clusters are comprised of hundreds of independent firms and thousands of workers, their locations generally are resistant to change.

Most major high-tech clusters evolved through a special set of historical circumstances that would be difficult to replicate. In market economies, clusters are self-organizing and owe more to local entrepreneurial spirit and business culture than to an availability of venture capital, policies of local universities to commercialize their research, or to special relocation incentives provided by state and local governments. There is no standard rule or formula for cluster development. Nevertheless, there are some regularities and recurring themes:

- Many clusters have developed around the locations of pioneering inventors or "**star scientists**." In the early stages of innovation, new knowledge is tacit and difficult to codify. Transfer and application of that knowledge to industry requires face-to-face contact between industry scientists and pioneering scientists. As the cluster grows, agglomeration economies make the location appealing to new entrants long after the need to be close to the early star scientists.
- Observationally there is a strong correlation or coincidence between the locations of high-tech clusters and major research universities. However, absent star scientist effects, there is little evidence that the presence of universities "causes" the development of advanced industry clusters. Instead, "local universities are necessary but not sufficient for innovation."
- In the U.S. and other market economies, clusters are largely unplanned. They develop on their own in locations which are in large part determined by arbitrary and accidental paths of history. Governments play a relatively minor role in determining cluster location. There is little evidence that concerted cluster development policies of federal, state, or local governments have been effective in creating agglomerations.

In the late 1950s, California, Maryland, and Washington were the leading states for overall high-tech activity. During the 1960s, Arizona became one of the leaders while Maryland dropped back. Massachusetts gradually moved up, ranking second by 1988. In recent years, Washington and Massachusetts have led the states on the high-tech employment share of the total economy, followed by California and Colorado. The other first-tier high-tech states currently are Maryland, New Hampshire, Utah, and Virginia.

Arizona was in the top tier of states on high-technology activity from the 1960s into the 1980s. Its strength, however, was strictly in manufacturing, particularly in computing equipment,

electronics, and instruments. The concentration in computing equipment and instruments did not last, though gains in aerospace helped to cushion the losses in these sectors. As Arizona's overall high-technology activity declined relative to the nation, Arizona became classified as a second-tier high-tech state.

Currently, Arizona's overall high-tech share of the economy is only equal to the U.S. average. Arizona remains strong in semiconductors and aerospace, but has little high-tech activity in other sectors.

As discussed above, initial reasons for the development of most high-technology clusters were either arbitrary or no longer are of relevance. This certainly is true in Arizona. The development of the aerospace, electronics, and related high-tech clusters in Arizona in the 1950s and 1960s largely was the result of Arizona's climate and the affordability and availability of large parcels of private land. In addition, the federal government and a supportive congressional delegation channeled Department of Defense funding into the state, helping to attract Motorola's research division shortly after WWII to develop and manufacture transistors for the U.S. military.

Reasons for the subsequent decline in most high-tech activities are speculative, but Arizona has long compared unfavorably in various business location factors. Correcting these deficiencies was the focus of the early 1990s project "Creating a 21st Century Economy: Arizona's Strategic Plan for Economic Development" that ultimately was largely unsuccessful.

Based on a definition of an overall high-tech industrial employment share at least 50 percent higher than the national average, only four sizable high-tech metro areas were present in the United States in the late 1950s: Boston, Phoenix, San Diego, and Seattle. San Jose joined this exclusive group in the 1960s, followed in the late 1970s by Austin, Raleigh-Durham, and Washington, D.C. In the late 1990s, San Francisco attained a high-tech employment share at least 50 percent higher than the U.S. average, followed shortly after by Portland. Denver recently reached this threshold.

Once reaching a high-tech share at least 50 percent higher than the national average, only one large metro area — Phoenix — has dropped below this level. By the mid-1990s, Metro Phoenix was below this mark and its high-tech employment share has since dropped to only 9 percent above the national average. Based on aggregate earnings, its 2022 high-tech share was 3 percent *less* than the U.S. average. Metro Phoenix had ranked second or third among 12 selected large metro areas on the high-technology employment share from 1959 through 1973, but by 1998 its rank was down to tenth. It has ranked last on the high-tech employment share since 2005.

The high-tech share of the Metro Phoenix economy is negatively affected by the area's rapid growth in base industries other than high technology. However, this is not the major cause of the area's decline in high-tech share relative to the nation and to other large high-tech metro areas since the 1970s. The percent change in high-tech employment in Metro Phoenix between 1973 and 1998 was the least of the 12 large high-tech metro areas analyzed in this report. Since then, Metro Phoenix has ranked ninth on the percent change.

SUMMARY

High-Technology Literature Review

The presence of high tech in a metro area does not seem to make the area's population grow faster. But it is strongly associated with a higher quality of economic activity, as measured by average earnings per worker and GDP per worker, resulting in higher standards of living.

High-tech economic activity is highly concentrated spatially. STEM shares of employment not only vary (directly) with metro size but are highly variable even among large metro areas. Spatial concentration in high tech is thought to derive from the fact that innovation is integral to high-tech activity and clustering of innovative activity is important to take advantage of knowledge spillovers and other agglomeration economies.

The high degree of clustering and spatial concentration in STEM/high-tech activities is most often explained as a consequence of the fact that (1) innovation is an essential part of the operations of firms in advanced industries, and (2) success in innovation has always involved and continues to require the kind of social and face-to-face interaction that is only available when the various parties involved in the innovation process co-locate in the same space.

Integral to the geography of innovation is the idea that innovation involves the transfer of *tacit knowledge* which, by its nature, is difficult to exchange over long distances without face-to-face contact. Another important characteristic of modern innovative activity is that it involves interactions between many parties: inventors, firms, their customers and suppliers, research organizations, and public agencies. Geographic clustering serves to organize this activity by creating opportunities for chance encounters, observation, and social interaction.

The tendency for innovative activity to spatially concentrate has increased over time. The increase in clustering of innovative activity has been accompanied by a divergence in levels of education and prosperity across geographic areas. Increasingly, the most educated and prosperous U.S. metro areas are those that have developed innovation clusters.

The determinants of high-tech cluster locations differ from other economic activities. Since advanced industry products have high value in relation to weight and bulk, transportation costs are relatively unimportant. What is crucial for high-tech firms is having access to a pool of highly skilled and knowledgeable workers. Since people are mobile, this makes the optimal location of high-tech industries indeterminate. The locations of many high-tech clusters can be traced to decisions that were made by key inventors or pioneering firms for reasons that are no longer important today and that in hindsight seem to represent an arbitrary course of history. For example, most sources indicate that Microsoft moved from Albuquerque to the Seattle area because the company's two founders wished to return to their childhood home.

While the initial location of a pioneering firm may be arbitrary, subsequent growth in the industry and a clustering of new firms around the pioneering firm creates efficiencies of agglomeration that serve to lock in the initial location. As the cluster grows, a spatial concentration of new firms helps to create thicker labor markets for specialized labor, attracts specialized suppliers and service providers, and promotes the spillover and informal exchange of

industry knowledge that is critical for innovation. Clustering is an extremely efficient form of industry organization, as evidenced by the high land prices and cost of living that members are willing to pay to locate in the cluster. However, because clusters are comprised of hundreds of independent firms and thousands of workers, their locations are resistant to change. It is in no one's interest to be the first to move to a new location.

Most major high-tech clusters, including Silicon Valley, evolved through a special set of historical circumstances that would be difficult to replicate. In market economies, clusters are self-organizing and owe more to local entrepreneurial spirit and business culture than to an availability of venture capital, policies of local universities to commercialize their research, or to special relocation incentives provided by state and local governments. There is no standard rule or formula for cluster development. Nevertheless, there are some regularities and themes:

- Many clusters have developed around the locations of pioneering inventors or *star scientists*. In the early stages of innovation, new knowledge is tacit and difficult to codify. Transfer and application of that knowledge to industry requires face-to-face contact between industry scientists and pioneering scientists. Startup firms thus locate near the sources of intellectual human capital. As the cluster grows, agglomeration economies make the location appealing to new entrants long after the need to be close to the early star scientists.
- Observationally there is a strong correlation or coincidence between the locations of high-tech clusters and major research universities. However, there is little evidence that the presence of universities "causes" the development of advanced industry clusters and the presence of strong engineering schools may be as much the result of existing high-tech activity. Instead, "local universities are necessary but not sufficient for innovation." At the same time, universities can provide a catalyst if they attract star scientists and/or nurture the development of inventors.
- In the U.S. and other market economies, clusters are largely unplanned. They develop on their own in locations which are in large part determined by arbitrary and accidental paths of history. Governments play a relatively minor role in determining cluster location. There is little evidence to support the claim that the cluster development policies of federal, state, or local governments have been effective in creating agglomerations. However, local laws can influence development. California's ban on noncompete clauses in labor contracts may have hastened the development of Silicon Valley.

Evidence of successful planning initiatives are rare, with perhaps the Research Triangle Park in North Carolina the best example. The RTP concept grew from a late 1950s collaboration of civic leaders, local entrepreneurs, state officials, and university faculty and administrators. After more than six years of limited success, it became a reality only after a major investment by the federal government and a significant private-sector engagement by IBM that was predicated on infrastructure investments by state and local governments. Still, it was not until the late 1970s that Raleigh-Durham became a strong high-tech center. The economic benefits were ultimately transformational. Economic development in the RTP area has helped to transform the region from one of the poorest in the southeastern United States to among its wealthiest.

Evolution of High-Technology Activities in Selected States and Metropolitan Areas

Industrial Data, States

In the late 1950s, California, Maryland, and Washington were the leading states for overall high-tech activity. During the 1960s, Arizona became one of the leaders while Maryland dropped back. Massachusetts gradually moved up, ranking second by 1988. In recent years, Washington and Massachusetts have led the states on the high-tech employment share of the total economy, followed by California and Colorado. The other first-tier high-tech states currently are Maryland, New Hampshire, Utah, and Virginia.

Arizona ranked first or second among eight comparison states on the total high-tech share from 1968 through 1983 and third or higher from 1962 to 1988. Arizona's overall high-tech employment share relative to the national average peaked at twice the U.S. average in the late 1960s and early 1970s. Its strength, however, was strictly in manufacturing, particularly in computing equipment, electronics, and instruments. The concentration in computing equipment and instruments did not last, though gains in aerospace after 1973 helped to cushion the losses in these two categories. After 1988, Arizona's high-tech share of economic activity fell precipitously, dropping to a rank of seventh among the eight states by 1998. Arizona's high-tech employment share continued to fall to barely above the national average in recent years, last among the eight states. Based on aggregate earnings, Arizona's high-tech share in recent years has been *less* than the U.S. average.

While Arizona's aerospace and semiconductor manufacturing remain among the national leaders, Arizona's other early superlative high-tech activities — communications equipment, electronics other than semiconductors, computing equipment, and instruments — have declined sharply, with shares currently below the national average. Arizona also is below average, and last among the eight states, in the computing services and other professional services categories. These two growing high-tech categories accounted for just more than 70 percent of the total U.S. high-tech employment in 2022. They accounted for only 55 percent in Arizona. Arizona's share of these two services categories combined in 2022 was 18 percent below the national average based on employment and 28 percent below average based on aggregate earnings.

In 2022, California and Massachusetts had the most diverse high-tech industrial economies, ranking among the top 10 states nationally in seven of eight primary high-tech industrial categories. In contrast, Arizona was in the top 10 in only two categories.

In 2022, Arizona's overall high-tech industrial employment share ranked 14th among all states, despite being only 4 percent higher than the U.S. average. The overall high-tech industrial aggregate earnings share ranked 12th, despite being 4 percent *below* average. Arizona remained strong in electronics (ranked third nationally) and aerospace (ranked fourth), but its share was more than 10 percent below average in each of the other six primary industrial categories.

As discussed earlier, initial reasons for the development of most high-technology clusters were either arbitrary or no longer are of relevance. This certainly is true in Arizona. The development of the aerospace, electronics, and related high-tech clusters in Arizona in the 1950s and 1960s largely was the result of Arizona's climate and the affordability and availability of large parcels

of private land. In addition, the federal government and a supportive congressional delegation channeled Department of Defense funding into the state, helping to attract Motorola's research division shortly after WWII to develop and manufacture transistors for the U.S. military.

Reasons for the subsequent decline in most high-tech activities are speculative, but Arizona has long compared unfavorably in various business location factors. Correcting these deficiencies was the focus of the early 1990s project "Creating a 21st Century Economy: Arizona's Strategic Plan for Economic Development" that ultimately was largely unsuccessful.

Recent announcements regarding semiconductor manufacturing in Metro Phoenix should result in a rebound in that activity relative to the nation. However, this will only increase the state's dependence on just two high-tech activities. Moreover, many of the new manufacturing jobs will be in production occupations that do not require substantial educational attainment and will not be high-paying jobs. The state needs to diversify its high-tech base, particularly in the growing services categories, with a focus on high-tech jobs that pay well and utilize substantial educational attainment.

Industrial Data, Metropolitan Areas

Based on a definition of an overall high-tech industrial employment share at least 50 percent higher than the national average, only four sizable high-tech metro areas were present in the United States in the late 1950s: Boston, Phoenix, San Diego, and Seattle. San Jose joined this exclusive group in the 1960s, followed in the late 1970s by Austin, Raleigh-Durham, and Washington, D.C. In the late 1990s, San Francisco attained a high-tech employment share at least 50 percent higher than the U.S. average, followed shortly after by Portland. Denver recently reached this threshold.

Once reaching a high-tech share at least 50 percent higher than the national average, only one large metro area — Phoenix — has dropped below this level. By the mid-1990s, Metro Phoenix was below this mark and its high-tech employment share has since dropped to only 9 percent above the national average. Based on aggregate earnings, its 2022 high-tech share was 3 percent *less* than the U.S. average. Metro Phoenix had ranked second or third among 12 selected large metro areas from 1959 through 1973, but by 1998 its rank was down to tenth. It has ranked last on the high-tech employment share since 2005.

The high-tech share of the Metro Phoenix economy is negatively affected by the area's rapid growth in base industries other than high technology. However, this is not the major cause of the area's decline in high-tech share relative to the nation and to other large high-tech metro areas since the 1970s. The percent change in high-tech employment in Metro Phoenix between 1973 and 1998 was the least of the 12 large high-tech metro areas analyzed in this report. Since then, Metro Phoenix has ranked ninth on the percent change.

Metro Tucson is compared to seven similarly sized southwestern metro areas. Most have reached a high-tech employment share at least 50 percent higher than the U.S. average. Albuquerque reached this level by 1959, followed by Boulder in 1965. Colorado Springs, Fort Collins, Provo, and Tucson reached the mark between the late 1970s and late 1980s. Since then, Colorado Springs, Fort Collins, and Tucson have dropped below the threshold, but in 2022 the high-tech

employment share in each remained at least 30 percent above average. Metro Tucson ranked seventh among the eight metro areas on the high-tech employment share in 2022.

Overall high-tech industrial shares in 2022 were higher in Metro Tucson — 30 percent above the U.S. average on employment and 33 percent above average on aggregate earnings — than in Metro Phoenix (9 percent above average on employment and 3 percent *below* average on aggregate earnings). The high-tech base was narrow in each area. In Metro Phoenix, the electronics share was more than 4 times higher than the national average and the aerospace share was more than twice the average. In Metro Tucson, the aerospace share was more than 10 times the U.S. average and the instruments share was about double the average.

Occupational Data

Conceptually, occupational data are preferable to industrial data in defining high technology. However, since the earliest occupational data are for 2001, it is not possible to determine the early evolution of high tech using occupational data.

In 2022, Washington, Maryland, Massachusetts, Colorado, California, and Utah ranked near the top of all states on the overall high-tech occupational share and ranked in the top 10 states in between three and five of six occupational categories. In contrast, Arizona ranked 17th on employment share and 18th on aggregate earnings share, not ranking in the top 10 in any of the categories. Arizona ranked last in the science category with a share just half of the national average. Arizona's overall high-tech occupational share was 3 percent above the national average based on employment and 4 percent *below* average based on aggregate earnings.

Overall high-tech occupational shares in 2022 were higher in Metro Tucson — 11 percent above the U.S. average on employment and 3 percent above average on aggregate earnings — than in Metro Phoenix (6 percent above average on employment and 2 percent *below* average on aggregate earnings). Metro Phoenix did not have particular strength in any occupational category and was far below the national average in the science category. Metro Tucson's share was at least 20 percent above average in the engineering, engineering technician, and science technician categories. Based on both the high-tech employment share and the high-tech aggregate earnings share in 2022, Metro Phoenix ranked last among its group of 12 large metro areas and Metro Tucson ranked seventh among its group of eight southwestern metro areas.

A Broader Look at the Occupational and Industrial Mixes in Selected States and Metropolitan Areas

Occupational Data

Arizona, Metro Phoenix, and Metro Tucson were among the weakest of the comparison areas in 2022 on occupational mix. Each ranked at or near the top on their 2022 share in the low-paying category and at or near the bottom in the high-paying category. Arizona and Metro Phoenix ranked near the bottom on each of the high-paying occupational groups except for healthcare practitioners and technical. They were near the bottom in each of three STEM occupational groups. Metro Tucson ranked in the middle of its eight metro areas in some of the high-paying groups, but ranked next to last on the sum of three STEM groups.

Arizona, Metro Phoenix, and Metro Tucson all compared poorly on the change in share between 2012 and 2022, ranking at or near the top in the low-paying category and below the middle of the comparison areas in the high-paying category. Arizona and Metro Phoenix had strong gains in the healthcare practitioners and technical group, but ranked near the bottom in the sum of three STEM groups. Metro Tucson compared a little better in the STEM groups.

Industrial Data

The traded cluster share of total aggregate earnings in 2022 was 11-to-12 percent below the national average in Arizona, Metro Phoenix, and Metro Tucson. Relative to their respective comparison areas, Arizona and Metro Phoenix ranked last, and Metro Tucson was second to last. Among all states, Arizona ranked 41st.

On the 2012-to-2022 change in the traded cluster share based on aggregate earnings, Arizona ranked second to last among its eight states with a decline relative to the national average; it ranked 26th nationally. Metro Phoenix also experienced a decrease versus the U.S. average, ranking ninth of 12 areas. In contrast, Metro Tucson was in the middle of its comparison group with a gain relative to the nation.

High-Technology Indicators for Arizona

Based on reports from the Milken Institute and the Information Technology and Innovation Foundation, Arizona is a second-tier high-tech state, with overall national ranks between 2010 and 2022 generally between 15th and 21st. Each report is based on a mix of input and output variables. These rankings are consistent with the output measures of high-tech aggregate earnings shares that place Arizona in the second tier of states based on both occupational and industrial data. The following summarizes selected input indicators.

Human Capital

Arizona's education funding per student has fallen significantly versus the national average. Per student K-12 state and local government funding had been near average in the late 1980s but was fourth lowest in the nation in FY 2022 at 33 percent below the U.S. average. State and local government support for higher education per FTE student had been only a little below average from the 1980s through the 2000s, but was 37 per cent below average in FY 2023, ranking 45th.

In the middle of the 20th century, educational attainment in Arizona exceeded the national average. Attainment in Arizona declined relative to the nation through 2010 and has been flat since then at below the national average. In 2022, Arizona ranked 37th nationally and last among the comparison states on the percentage of those 25-to-64 years old with at least a bachelor's degree, at 11 percent less than the U.S. average.

The number of patents granted to Arizonans, per capita and relative to GDP, rose from considerably below average in the 1960s to average on a per capita basis and above average relative to GDP in the 1980s, remaining at that level until recently. The latest (2020) figures for the state were the lowest since the 1970s at 18 percent below average on a per capita basis and 4 percent below average relative to GDP. Arizona still ranked relatively high at 19th on a per capita basis and 13th relative to GDP, but was sixth on each measure among the eight comparison states.

Arizona's performance among six indicators produced by the NSF that are related to higher education in science and engineering fields was mixed. Based on the latest data for each indicator, Arizona was above the national average on three. Arizona ranked among the leaders on advanced science and engineering degrees as a percentage of all science and engineering degrees conferred but was at the bottom on science and engineering degrees as a percentage of all higher education degrees conferred.

Financial Capital

Research and development funding in Arizona is erratic from year to year, but the total relative to GDP generally has been below the national average. In 2021, the total was 22 percent below average, ranking 17th nationally and fifth in the comparison group. Funding from business and industry, the largest source, was 15 percent below average relative to GDP in Arizona in 2021, but ranked 13th nationally and fourth in the comparison group. Federal government funding was 32 percent below average in 2022, seventh among the comparison states but ranking 18th nationally. Academic funding was only 6 percent below average in 2022, ranking 28th nationally and fifth in the comparison group.

In the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, Arizona's grant value relative to the nation is erratic from year to year, with no trend apparent. Arizona's SBIR value generally is below the national average while its STTR value is usually above average. In 2023, Arizona's SBIR value relative to GDP was 8 percent below average, ranking 20th nationally but seventh in the comparison group. In 2023, Arizona's STTR value relative to GDP was 5 percent below average, ranking 22nd nationally and seventh in the comparison group.

Arizona companies receive considerably less venture capital funding than the national average, regardless of the measure. No trend exists in any of the measures, but they are erratic from year to year. In 2023, the per capita number of deals in Arizona was slightly less than half of the national average, ranking 26th nationally and last in the comparison group. The per capita value in Arizona was 40 percent less than the national average, ranking 10th nationally and sixth in the comparison group. The value relative to GDP in Arizona was 29 percent less than the national average, ranking 10th nationally and sixth in the comparison group.

HIGH-TECHNOLOGY LITERATURE REVIEW

The terms "high technology" (high tech) and "STEM" (science, technology, engineering, and mathematics) are used interchangeably in this paper.

Relationship Between High Technology and Population Growth

The literature on determinants of U.S. urban population growth since the middle of the 20th century has identified three principal factors that are positively related to metropolitan population growth: the warmth of winters, the elasticity of housing supply,[1] and human capital as measured by educational attainment.

Based on his extensive research, Ed Glaeser has concluded that no single variable can better predict population growth in U.S. metro areas from 1950 to 2000 than climate, particularly the *warmth of winters* as measured by mean January temperature.[2] The analysis presented in Hill (2021) confirms Glaeser's conclusion for the period from 2000 to 2018. Mean January temperature is still the single-most significant variable in explaining recent patterns of U.S. urban population growth. It is unclear whether the continued pull of the Sunbelt is driven by household preferences for living in warm climates or by a lower relative cost of production in this region of the country.

Ed Glaeser, Enrico Moretti, and others have argued that metropolitan area differences in *the degree to which housing supply responds to demand*, whether due to geography or housing policy, have had a profound effect on the pattern of U.S. urban growth.[3] Responsiveness of new home construction to increases in housing demand determines whether urban success reveals itself in the form of a larger population or higher housing prices. Using estimates from Saiz (2010) of elasticities of housing supply for individual metro areas, Hill (2021) finds local conditions of housing supply to be an important determinant of urban population growth over the 2000-to-2018 period. Explicit consideration of housing supply helps to explain the underperformance (in terms of population growth) of coastal metro areas such as San Francisco, Boston, and Miami and the overperformance of inland areas such as Atlanta, Dallas, and Houston.

Initial levels of human capital in an urban area, as typically measured by the *share of the population with at least a bachelor's degree*, have been shown in numerous studies to be a significant predictor of subsequent population growth.[4] A positive association between initial years of schooling and subsequent metro area growth appears to have existed in every decade since 1900 (Simon and Nardinelli 2002). A common explanation for the importance of local human capital as a determinant of urban growth centers on the concept of knowledge spillovers, articulated originally by Alfred Marshall in his theory of industrial clusters and more recently in writings on the economics of cities by Jane Jacobs (1969) and Ed Glaeser (2008). Through the sharing and rapid transmission of ideas, a concentration of educated workers in an urban area

[1] The elasticity of housing supply measures the percentage change in the quantity of new housing that is produced in response to a one-percent increase in the price of housing. The larger is the elasticity, the larger is the effect of an increase in housing demand on new home construction and the smaller the effect on housing prices.

[2] See Glaeser and Shapiro (2003), Glaeser and Tobio (2008), and Glaeser and Gottlieb (2009).

[3] See Glaeser and Gottlieb (2009), Glaeser and Gyourko (2018), and Hsieh and Moretti (2019).

[4] See, for example, Glaeser and Shapiro (2003), Glaeser and Saiz (2003), and Hill (2021).

sets off a process of self-reinforcing growth and creates increasing returns. The interaction between education and technology affects the speed of technological creation and adoption that is reinforced by flows of private investment and educated workers.

Glaeser and Saiz (2003) tested for the relative validity of three alternative theories of why education would affect urban growth: the "information city" view, where urban areas help to facilitate the flow of ideas and living around other educated people increases individual productivity; the "consumer city" view where educated people support and help to develop urban amenities[5] that then attract more people; and the "reinvention city" view where education enables people to better adapt to economic change. When looking across metro areas, Glaeser and Saiz found that initial education levels are positively associated not only with population growth, but also with nominal wage growth, housing price growth, and real wage growth. The coincidence of these observations is more consistent with theories of productivity-led growth, such as the information city view and the reinvention city view, than the consumer city theory of consumption-led growth. Additional support for the reinvention city view comes from the finding that the relationship between education and population growth is strongest in areas that have experienced a negative economic shock and that areas with high manufacturing intensity in 1940 switched out of manufacturing more rapidly if they had high education levels in 1940.

Initial high-tech presence does not help to explain subsequent urban population growth over and above the explanations provided by the three above-mentioned factors. Table 1 presents a regression analysis of the determinants of metro area population growth in which measures of high-tech presence are added to the three established variables.[6] The analysis is similar to that in Hill (2021). The sample consists of 83 U.S. metropolitan areas that had a population of at least 250,000 in 2000 and had price elasticities of housing supply available from Saiz (2010).[7] The dependent variable is population growth over the period from 2000 to 2018, as measured by the change in natural logarithms.[8] The explanatory variables include mean January temperature, the elasticity of housing supply, and educational attainment in the population measured as the percentage of the metro population aged 25 years and older that had a bachelor's degree or higher, with the data coming from the three-year American Community Survey from 2005 through 2007. As found in Hill (2021), the most successful regressions are those in which the independent variables are interacted with (multiplied by) elasticity of housing supply. A highly elastic supply of housing serves to increase the marginal effect on population growth of any given increase in January temperature, educational attainment, etc.

---

[5] Amenities are nonmonetary features of an area that make it more attractive to residents, such as natural beauty, climate, and culture.

[6] Regression analysis is a statistical method used to estimate or predict the unknown values of one variable from the known values of other variables. The variable being predicted is known as the dependent variable. The variables that are used to predict the dependent variable are called the independent or explanatory variables. A least-squares regression method is a form of regression analysis which establishes the relationship between the dependent and independent variables along with a linear line referred to as the "line of best fit."

[7] The specific metro areas used are listed in Hill (2021) Table 2, pp. 11-13.

[8] When a variable changes by a large amount, as is the case with population growth over a decade or more, percentage changes are often calculated as the change in the natural logarithm of the variable. The result is similar to one obtained by taking the absolute change and dividing it by the average value of the variable rather than by its initial value.

TABLE 1
REGRESSION ANALYSIS OF POPULATION GROWTH BETWEEN 2000 AND 2018 IN 83 METROPOLITAN AREAS

Dependent Variable: Log Change in Population

	Regression 1	Regression 2
Independent Variable		
Elasticity of Housing Supply	-0.261***	-0.245***
	(0.033)	(0.035)
Mean January Temperature Times the Elasticity of Housing Supply	0.00524***	0.00509***
	(0.00057)	(0.00057)
Educational Attainment Times the Elasticity of Housing Supply	0.00438***	0.00327***
	(0.00126)	(0.00114)
Occupational STEM Share of Employment in 2001 Times the Elasticity of Housing Supply	-0.00076	
	(0.0044)	
Industrial STEM Share of Employment in 2001 Times the Elasticity of Housing Supply		0.00395
		(0.00295)
Constant	0.0719***	0.0712***
	(0.0251)	(0.0245)
Adjusted R-Squared	0.530	0.541

Notes:
The sample consists of 83 Metropolitan Statistical Areas with a population in 2000 of at least 250,000 people and for which an estimate of the price elasticity of housing supply is available from Saiz (2010).

The value on the first line of each independent variable is the coefficient. The value in the second line in parentheses is the standard error. The statistical significance of an independent variable is indicated as follows: *** p < .01, ** p < .05, * p < .1. For example, a “p” (probability) of less than 0.05 indicates that the variable is significant at the 95 percent level of confidence.

Educational attainment is defined as the percentage of the population 25 years and older with a bachelor’s degree or higher in 2005-07.

R-squared is a statistical measure that ranges from zero to one. It represents the proportion of the variance in a dependent variable that is explained by an independent variable or variables in a regression model.

When evaluated at sample means, the estimated combined coefficient relating elasticity of housing supply to population growth is 0.34 in each of the two regressions.

Sources: U.S. Department of Commerce, Census Bureau (population and educational attainment); U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Centers for Environmental Information (temperature); Saiz (2010) (housing supply elasticity); and Lightcast, www.economicmodeling.com (employment).

The two alternative measures of high-tech presence considered are those presented in Hill, Hoffman, Madly, and Rex (2021), pp. 46-47 and Appendices A and B. What is referred to as the "occupational STEM share of employment" is based on estimates by metro area of the share of employment in 2001 comprised of workers in 81 STEM occupations. The sample mean for this measure was 5.1 percent. What is referred to as the "industrial STEM share of employment" is the share of total metro employment in 2001 accounted for by 57 industries designated as STEM intensive.[9] The sample mean for this variable was 4.5 percent.

Setting aside a discussion of the high-tech variables for the moment, each of the other explanatory variables is of high statistical significance with a coefficient that is large and has the expected sign. The sample mean rate of population growth over the entire period was 16.9 percent. Warmth of winters is the most important determinant of metro population growth. Using the estimated coefficient for mean January temperature and the mean value for the elasticity of housing supply, a one standard deviation increase in mean January temperature is found to increase the rate of metro population growth by 11.5 percentage points based on the results of regression 1 and by 11.2 percentage points according to regression 2. Accounting for its presence throughout the regression as an interactive variable, a one standard deviation increase in the elasticity of housing supply is found to increase the rate of metro population growth by 5.9 percentage points in both regressions. An increase of one standard deviation in the share of the adult population with at least a bachelor's degree is found to increase population growth by 5.4 percentage points according to regression 1 and by 4.0 percentage points according to regression 2.

The question of particular interest in the regression analysis is whether the addition of a variable measuring initial presence of high-tech activity helps to explain differences in urban population growth. If high-tech presence is measured by the share of workers in STEM occupations, the answer is decidedly "no". The occupational STEM variable in regression 1 has an estimated coefficient and a t-statistic that are essentially zero.[10] High-tech presence comes closer to being useful as a predictor of future population growth when measured using the industrial STEM share of employment. Even in this case, however, the t-statistic on the estimated coefficient is only 1.34.[11] An increase of one standard deviation in the industrial STEM share is estimated to raise the population growth rate by only 1.8 percentage points. Altogether, an analysis of patterns of U.S. metropolitan population growth since 2000 suggests that if high-tech activity enhances metro area economic performance, it is not by delivering a larger population.

Relationship Between High Technology and Productivity and Prosperity

Analysis of recent data indicates that the share of employment in STEM occupations is highly significant in explaining variations across metro areas in real (cost-of-living-adjusted) earnings per worker. The strength of the association found in the data far exceeds the arithmetic result guaranteed by the fact that STEM occupations pay above-average earnings, supporting the idea

[9] Occupations are defined in the Standard Occupational Classification and industries are defined in the North American Industry Classification System. Occupations and industries each are the most-detailed (six-digit) categories.

[10] The t-statistic is a measure of the significance of an independent variable in explaining variations in the dependent variable. It is the ratio of the departure of the estimated value of a parameter from its hypothesized value to its standard error.

[11] To be significant at 95 percent confidence, the t-statistic would need to be at least 1.66.

that a concentration of STEM workers in an urban area generates positive productivity spillovers. Once occupational STEM employment is accounted for, no additional explanatory power is provided by other human capital variables such as college educational attainment.

The share of employment in STEM-intensive industries is also a significant predictor of average real earnings per worker. The industrial STEM share of employment is somewhat less important a determinant of earnings per worker than is metro area size and is about on par in its significance with warm winter weather. When STEM presence is measured using industrial rather than occupational employment share, college educational attainment becomes statistically significant as an additional predictor of real earnings per worker.[12]

Both measures of STEM presence are also useful predictors of urban labor productivity, as measured by real metro area gross domestic product (GDP) per worker. Their significance in explaining variations in output per worker is somewhat smaller than their importance as a determinant of average earnings. This is to be expected since high GDP per worker can be the result of factors other than the skill intensity of the workforce.

STEM Intensity and Earnings Per Worker

Table 2 presents a regression analysis of determinants of real earnings per worker in 2018 using a sample of 170 U.S. metropolitan areas that had a population of at least 250,000 in 2000. The determinants include contemporaneous college educational attainment in the workforce as a measure of human capital intensity, a population dummy variable intended to capture any economic efficiencies associated with metro area size,[13] and mean January temperature as an amenity variable. Two STEM variables are also considered: contemporaneous values for occupational STEM share of employment in regression 1 and industrial STEM share of employment in regression 2.

Focusing first on regression 1, coefficients measuring the importance of STEM skills in the workforce, metro area size, and weather are all large and highly significant. Among these the STEM variable is most significant as a determinant of average real earnings. Mean earnings per worker in the sample is $67,220. According to the estimates, a one standard deviation increase in occupational STEM share of employment increases real earnings per worker by $3,859. A one standard deviation in the metro area size variable increases average earnings by $2,151. A one standard deviation increase in mean January temperature is associated with a decrease in average earnings of $1,562. The lower earnings in this case presumably represent a wage differential that offsets or compensates for the benefits of living in a warmer climate.

The size of the estimated coefficient for the occupational STEM variable is much larger than would be expected from a process that simply averages relatively high-paying STEM jobs across metro areas with varying STEM shares of employment. Across all U.S. metro areas in 2019, the

[12] Educational attainment requirements are used to help define occupations. In contrast, industries are defined without reference to educational attainment. As a result, average earnings by industry is less highly correlated to educational attainment than average earnings by occupation.

[13] The repeated finding in urban studies of agglomeration economies in large urban areas is thought to reflect efficiencies associated with thicker labor markets, a greater availability of specialized suppliers, and knowledge spillovers.

TABLE 2
REGRESSION ANALYSIS OF EARNINGS PER WORKER ADJUSTED FOR THE COST OF LIVING IN 2018 IN 170 METROPOLITAN AREAS

Dependent Variable: Adjusted Earnings Per Worker

	Regression 1	Regression 2
Independent Variable		
Population Dummy Variable (=1 if population > 1 million, 0 otherwise)	4,654.6*** (843.0)	5,051.9*** (916.6)
Percentage of Workforce With a Bachelor's Degree or Higher in 2014-18	-43.9 (75.4)	152.8** (75.3)
Occupational STEM Share of Employment in 2019	1,761.5*** (269.2)	
Industrial STEM Share of Employment in 2019		618.0*** (187.0)
Mean January Temperature	-123.1*** (30.3)	-141.8*** (33.4)
Constant	63,371*** (2,490.9)	63,322*** (2,902.3)
Adjusted R-Squared	0.554	0.473

Notes:
The sample consists of 170 Metropolitan Statistical Areas with a population in 2000 of at least 250,000 people. Because it was an extreme outlier, the San Jose metro area was dropped.

The value on the first line of each independent variable is the coefficient. The value in the second line in parentheses is the standard error. The statistical significance of an independent variable is indicated as follows: *** p < .01, ** p < .05, * p < .1. For example, a “p” (probability) of less than 0.05 indicates that the variable is significant at the 95 percent level of confidence.

R-squared is a statistical measure that ranges from zero to one. It represents the proportion of the variance in a dependent variable that is explained by an independent variable or variables in a regression model.

The dependent variable is employee compensation (wages and salaries plus benefits) divided by the number of wage and salary workers, adjusted for regional differences in the cost of living.

Sources: U.S. Department of Commerce, Census Bureau (population and educational attainment); U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Centers for Environmental Information (temperature); Lightcast, www.economicmodeling.com (employment); and U.S. Department of Commerce, Bureau of Economic Analysis (regional price parities).

average earnings of workers in STEM occupations was 1.92 times as much as average earnings in non-STEM occupations. In a hypothetical world in which each metro area has the same STEM and non-STEM earnings per worker but different STEM shares of total employment, the percentage increase in average metro area earnings associated with a marginal increase in the STEM share of total employment would be 0.874.[14] Using the mean average earnings figure from the regression sample, this would suggest a regression coefficient of approximately $600. The estimated coefficient in regression 1 is $1,761. The large size of the estimated STEM variable coefficient is consistent with the notion that a concentration of STEM workers generates positive productivity spillovers.[15]

In regression 1, college attainment in the workforce adds nothing to an explanation of earnings per worker that is not already provided by the occupational STEM variable. With STEM skills controlled for, the coefficient on college education effectively captures the effect on average earnings of an increase in workers with non-STEM degrees. These would include workers with business degrees who commonly receive high wages but also workers with degrees in education, psychology, and other social sciences who receive below-average pay.

Chart 1 shows a scatterplot and line of best fit for the relationship between the occupational STEM share of employment and real earnings per worker across the 170 metro areas. Real earnings per worker are adjusted for the estimated effect that deviations from the sample mean in the other independent variables have on earnings per worker. The STEM share of employment is seen to be significant in explaining variations in earnings per worker. Observations with large

---

[14] To formalize these claims and calculations, let θ_N represent the share of STEM workers in aggregate employment and θ_w the share of STEM earnings in aggregate earnings. Then the ratio of average STEM earnings per worker (w_S) to average non-STEM earnings per worker (w_{NS}) will be $[\theta_w /(1- \theta_w)]/[(1- \theta_N)/ \theta_N]$. Using the STEM occupations identified in Hill, et al. (2021), $\theta_w = .104$ and $\theta_N = .057$ when aggregating across all metro areas in 2019. Substituting in these values, the average relative earnings of STEM workers to non-STEM workers is 1.92.

Consider an economy comprised of metro areas with the same STEM earnings per worker and non-STEM earnings per worker, but different STEM shares of total employment (θ_N). The overall average earnings per worker in any given metro area will be $w = w_{NS}[1+\theta_N(w_S/w_{NS}-1)]$. The impact on average earnings of moving to a metro area with a marginally higher STEM share of employment would be $dw/d\theta_N = w_{NS}(w_S/w_{NS}-1) = w[(1- \theta_w)/ (1- \theta_N)](w_S/w_{NS}-1)$. Using 2019 values from Hill, et al. for θ_w, θ_N, and the STEM/non-STEM wage differential, and a value of $67,220 for w as in the regression sample, $dw/d\theta_N$ = $67,220 (.874) = $58,750. The equivalent value for a derivation in which STEM earnings and employment shares are measured in percent (as in regression 1) would be $587.5 which is only one-third the size of the estimated coefficient.

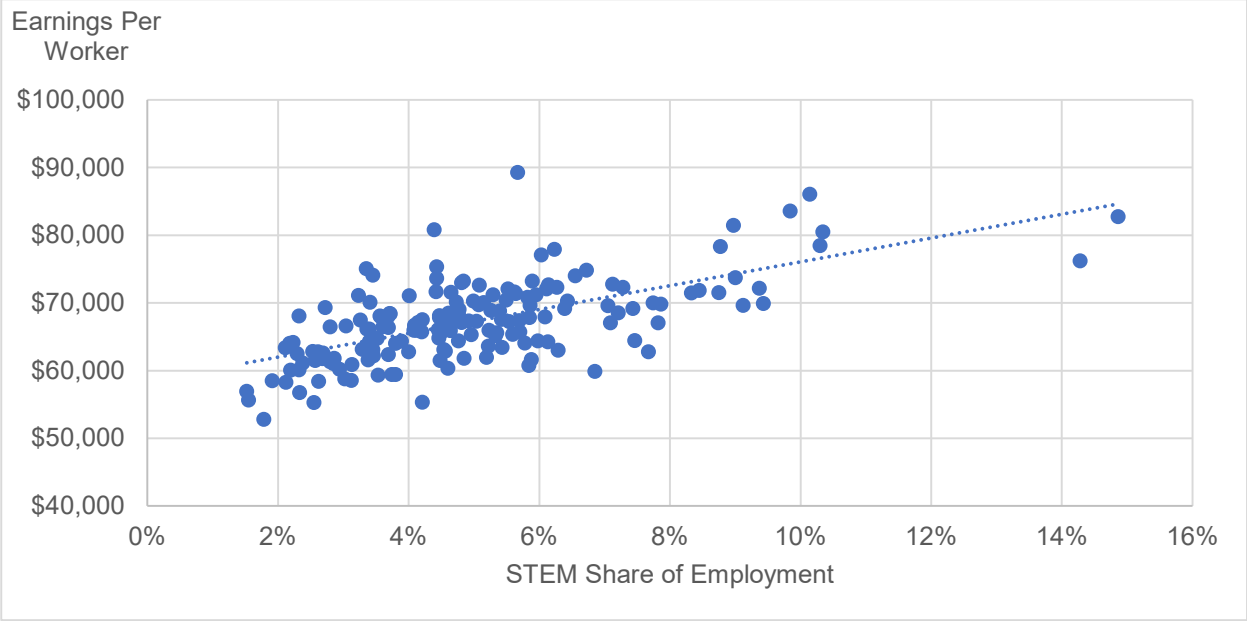
A complication in the above demonstration is that the occupational STEM share of aggregate earnings taken from Hill, et al. is based on nominal earnings while the dependent variable in the regression analysis of Table 2 is cost-of-living adjusted. If metro cost of living is positively correlated with STEM share of employment, then the economywide ratio of average real STEM earnings per worker to average real non-STEM earnings per worker will be less than the value of 1.92 calculated from the data in Hill, et al. This would make the arithmetically constructed coefficient for the STEM share smaller than $587.5 and would strengthen the finding of productivity spillovers from STEM employment.

[15] The term “productivity spillovers” in this context refers to the idea that the employment of a person with STEM skills in a metro area would directly increase the productivity of other workers in the area through an informal sharing of skills and knowledge. Evidence of knowledge spillovers associated with general educational attainment was first provided by Rauch (1993) who found that workers in a metro area with above-average educational attainment earned higher wages even after controlling for the productivity-enhancing attributes of the individual.

positive error terms (where earnings per worker are larger than predicted) include Stamford, Connecticut (home to a large number of corporate headquarters and many highly compensated corporate executives); Beaumont, Texas and Baton Rouge, Louisiana (with large petrochemical manufacturing facilities); and Fayetteville, North Carolina and Killeen, Texas (home to important military bases). Observations with large negative error terms (where earnings per worker are lower than predicted) include Santa Cruz, California and Myrtle Beach, South Carolina (with economies that are heavily tourist oriented); Boulder, Colorado and Fort Collins, Colorado (where low earnings may be the result of desirable amenities associated with skiing and living near the Rocky Mountains); and Provo, Utah.

Regression 2 in Table 2 shows what happens if the industrial STEM share of employment is used instead of the occupational STEM share of employment to help explain metro area variations in real earnings per worker. There are two notable differences between the two regressions. First, the industrial STEM share is not as significant in explaining variations in earnings per worker. Given the size of its estimated coefficient, a one standard deviation in the industrial STEM share would be expected to increase real earnings per worker by $1,835. This is much smaller than the standardized impact of the occupational STEM share. Metro size is a more important determinant of earnings per worker than the industrial STEM share of employment. A one

CHART 1
EARNINGS PER WORKER ADJUSTED FOR THE COST OF LIVING AND THE OCCUPATIONAL STEM SHARE OF EMPLOYMENT, 2018



Note: In addition to the cost of living, earnings per worker are adjusted for the estimated effect of metro deviations from mean population size, workforce educational attainment, and January temperature.

Sources: U.S. Department of Commerce, Census Bureau (population and educational attainment); U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Centers for Environmental Information (temperature); Lightcast, www.economicmodeling.com (employment and earnings); and U.S. Department of Commerce, Bureau of Economic Analysis (regional price parities).

standard deviation increase in metro size would be expected to increase earnings per worker by $2,334. A second noteworthy result in regression 2 is that college educational attainment becomes statistically significant and provides additional explanatory power when STEM presence is measured using share of employment accounted for by STEM-intensive industries.

STEM Intensity and Output Per Worker

Another metric used to measure the economic performance of a geographic area is real GDP (output), commonly standardized by dividing by area employment. Output per worker will vary not only with the human capital intensity of production in the area but also with the importance of physical capital (including plant and equipment and the housing stock), arable land, and intangible assets such as intellectual property. Table 3 provides the results of a regression analysis of the contribution of STEM presence and other factors to metro area real GDP per worker. The sample consists of the same 170 metro areas used in the analysis of real earnings per worker. Real GDP per worker is for the year 2018 and is expressed by dividing real GDP by total metro area employment (wage and salary workers plus proprietors). In regression 1, STEM presence is measured using the occupational STEM share of employment, while regression 2 uses the share of total employment accounted for by STEM-intensive industries.

Looking first at the results of regression 1, the adjusted R-squared is lower in the analysis of real GDP per worker than it was for earnings per worker. This is not surprising since more factors influence the size of output per worker than the human capital intensity of the workforce. Of the independent variables used, the occupational STEM share is found to be the most important determinant of metro area output per worker. Based on the estimated regression coefficient, a one standard deviation increase in the occupational STEM share of employment would be expected to increase output per worker by $5,369. While also statistically significant, metro area size is a somewhat less important determinant of output per worker. A one standard deviation increase in the metro size variable is found to increase metro output per worker by $3,422. Similar to the result found in Table 2, when STEM presence is measured using the occupational STEM share of employment, college educational attainment in the workforce is not statistically significant as a separate factor helping to explain variations in real GDP per worker across metro areas.

Metro areas with large positive error terms (with much higher output per worker than predicted by the regression) include areas with highly capital-intensive production such as Beaumont, Texas (petrochemical manufacturing) and Bakersfield, California (petroleum refining); areas receiving substantial income from intellectual property such as San Francisco, California, Stamford, Connecticut, and Seattle, Washington; areas with high-value agricultural land such as Salinas, California; and Vallejo, California with its highly valued housing stock and entertainment capital.

In regression 2 of Table 3, STEM presence is measured by the share of total metro area employment accounted for by STEM-intensive industries. STEM presence is the most important determinant of variations in output per worker. A one standard deviation increase in the industrial STEM share is found to increase real GDP per worker by $4,011. Metro area size is also important in determining output per worker. A one standard deviation increase in metro size increases real GDP per worker by $3,645. When STEM presence is measured by industrial share

TABLE 3
REGRESSION ANALYSIS OF OUTPUT PER WORKER ADJUSTED FOR THE COST OF LIVING IN 2018 IN 170 METROPOLITAN AREAS

Dependent Variable: Adjusted Gross Domestic Product Per Worker

	Regression 1	Regression 2
Independent Variable		
Population Dummy Variable (=1 if population > 1 million, 0 otherwise)	7,408.0*** (2,121.2)	7,889.5*** (2,138.8)
Percentage of Workforce With a Bachelor's Degree or Higher in 2014-18	110.1 (186.8)	272.9* (165.3)
Occupational STEM Share of Employment in 2019	2,451.6*** (688.1)	
Industrial STEM Share of Employment in 2019		1,350.4*** (437.6)
Constant	65,298*** (4,418.3)	66,137*** (4,674.8)
Adjusted R-Squared	0.302	0.289

Notes:
The sample consists of 170 Metropolitan Statistical Areas with a population in 2000 of at least 250,000 people. Because it was an extreme outlier, the San Jose metro area was dropped.

The value on the first line of each independent variable is the coefficient. The value in the second line in parentheses is the standard error. The statistical significance of an independent variable is indicated as follows: *** p < .01, ** p < .05, * p < .1. For example, a “p” (probability) of less than 0.05 indicates that the variable is significant at the 95 percent level of confidence.

R-squared is a statistical measure that ranges from zero to one. It represents the proportion of the variance in a dependent variable that is explained by an independent variable or variables in a regression model.

The dependent variable is gross domestic product divided by total employment (the number of wage and salary workers plus the number of proprietors), adjusted for regional differences in the cost of living.

Sources: U.S. Department of Commerce, Census Bureau (population and educational attainment); U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Centers for Environmental Information (temperature); Lightcast, www.economicmodeling.com (employment); and U.S. Department of Commerce, Bureau of Economic Analysis (regional price parities).

rather than occupational share, college educational attainment becomes marginally significant as a separate determinant of output per worker. A one standard deviation increase in college educational attainment increases output per worker by $2,241.

Selected High-Technology Studies

The Hidden STEM Economy

Jonathan Rothwell (2013) of the Brookings Institution used the O*NET database[16] from the U.S. Department of Labor to score occupations based on their STEM knowledge requirements. His approach defines STEM occupations based on what workers need to know to perform their jobs rather than on what workers do (laboratory research, computer programming, etc.). His definition of STEM occupations is relatively broad and includes not only professional workers with at least a bachelor's degree but also workers with STEM knowledge obtained from high schools, vocational training programs, and community colleges. In a narrow definition of STEM, where a STEM job requires that a worker have a high degree of knowledge across several STEM fields, 9 percent of U.S. workers in 2011 were in STEM occupations. Under a broader definition, where a job is STEM if it requires a high level of knowledge in any one STEM field, 20 percent of workers were in STEM jobs. By way of comparison, in the STEM definition of Hill, et al. (2021), only 6 percent of U.S. workers were in STEM occupations in 2019.

Using micro data for 2011, Rothwell confirms the well-known result that individual earnings are higher in STEM occupations, after controlling for educational attainment and other individual productivity characteristics. Less obvious, but similar to results from earlier studies of knowledge and productivity spillovers from higher education, Rothwell finds that the earnings of individuals in STEM occupations that require at least a four-year college degree are positively related to the overall STEM score of the resident metro area. Rothwell also shows that STEM-oriented metro areas are more innovative in that they have more patents per capita. The presence of STEM workers with less than a bachelor's degree increases innovation in a metro area by one-fourth to one-half as much as STEM workers with a bachelor's degree.

America's Advanced Industries: What They Are, Where They Are, and Why They Matter

Mark Muro, et al. (2015) of the Brookings Institution define an "advanced industry" as one where the share of workers in STEM jobs is above the national average and in which research and development (R&D) spending per worker is in the top 20 percent of all industries. Based on this definition, there are 50 advanced industries in the United States, employing 9 percent of all U.S. workers in 2013. This definition of an advanced industry is broader than the definition of a STEM-intensive industry used by Hill, et al. (2021), in which only 5 percent of U.S. workers were employed in STEM-intensive industries in 2019.

The U.S. cities and regions in which advanced industries are most heavily concentrated are identified by Muro, et al., who present a variety of descriptive statistics on the comparative economic performance of advanced industries. The following summarizes some of their findings:

[16] The O*NET program is the nation's primary source of occupational information. Central to the project is the O*NET database, containing information on hundreds of standardized and occupation-specific descriptors.

- Output per worker in advanced industries averaged $210,000 in 2013, more than twice the average output per worker in the rest of the economy.
- High value-added per worker in advanced industries is in large part a reflection of the high compensation paid to their workers. The average worker in advanced industries was paid $90,000 in total compensation in 2013. This was almost twice as much as the $46,000 in average compensation paid to workers outside of this sector.
- Advanced industries employ a disproportionate number of workers with STEM knowledge and advanced degrees, both of which involve scarce abilities and substantial human capital investment. So, it is not surprising that average compensation in this sector would be high. Even so, workers in advanced industries with less than a bachelor's degree earn considerably more than their counterparts in the rest of the economy. For example, workers in advanced industries with some college but no degree earned on average $53,000 a year in 2013. This compares with average compensation of $31,000 received by workers with similar educational attainment who are employed elsewhere in the economy.
- Advanced industries play a major role in the U.S. national innovation system. They account for 90 percent of all private-sector R&D spending. They also dominate U.S. patenting. From 2007 to 2012, developers in advanced industries were awarded 82 percent of all U.S. patents.

An underlying factor that links both STEM employment and advanced industry presence to metro area economic performance is innovation. In the 21st-century economy, product innovation has become crucial for commercial success in many industries. Innovation creates value that is realized by both shareholders and workers. High GDP per worker in advanced industries is partly attributable to high income from intellectual property that is created through innovation. High GDP per worker is also a reflection of the high compensation paid to advanced industry workers, many of whom perform STEM jobs. Innovation is itself a STEM-intensive activity.

Patenting Prosperity: Invention and Economic Performance in the United States and its Metropolitan Areas

In another Brookings study, Jonathan Rothwell, et al. (2013) attempted to identify the contributions made by local innovation to metro area economic performance. Innovation is measured using patent data. Deborah Strumsky has used information on the names and addresses of patent inventors and assignees to link patents to the metropolitan area of residence of the inventor. Her data covers all patents going back to 1975. The analysis of Rothwell, et al. uses these data in a pooled cross-section time series covering 358 metropolitan areas over the 1980-to-2010 period. The dependent variable in their analysis is the natural logarithm of metro area GDP per worker. Independent variables include number of patents, the quality of patents (as measured by claims and citations), and control variables such as population, the percentage of the adult population with at least a bachelor's degree, and the level of output per worker predicted by the metro area's industrial mix. To be more confident that the results represent causal relationships between the independent variables and the dependent variable, the independent variables are lagged 10 years. The 10-year lag of productivity is also included as an independent variable. This means that an estimated coefficient represents the marginal effect of an independent variable on the growth rate of metro area output per worker.

Rothwell, et al. find that local patenting activity, especially the number of high-quality patents, has a significant positive effect on metro area productivity growth. If metro areas in the bottom quartile of patenting activity could patent as much as metros in the top quartile, their rate of productivity growth over a 10-year period would rise by 6.5 percentage points. As a reference, the average metro area in the bottom patenting quartile experienced a rate of productivity growth equal to 13 percent. An increase in patenting activity of this magnitude would require an extra 960 patents per year, or what could be generated by a few large corporate R&D headquarters or research universities.

The effect of patenting on metro area productivity growth is less important than the effect of population size or industry mix, but it is somewhat larger than the effect of having a college-educated population. A one standard deviation increase in the log of the number of patents is estimated to increase the rate of productivity growth by 2.7 percent. This compares with an impact of 2.5 percent associated with a one standard deviation increase in the share of the population with a bachelor's degree or higher.

The Spatial Concentration and Clustering of High Technology Activities[17]

High-tech economic activity is highly concentrated spatially. STEM industry shares of employment not only vary (directly) with metro size but are highly variable even among large metro areas. The transportation costs of delivering STEM products to customers are low, so geographic concentration that provides economic efficiencies in production becomes a dominant form of spatial organization. STEM industries are even more geographically concentrated than general manufacturing, a sector with highly tradable output. As argued by Ellison and Glaser (1997), patterns of geographic concentration in the manufacturing sector are based in large part on *natural advantage* — locational cost advantages associated with being close to natural resources or avenues for cheap water transportation. Spatial concentration in high tech, on the other hand, is thought to derive from the fact that innovation is integral to high-tech activity and clustering of innovative activity is important to take advantage of knowledge spillovers and other agglomeration economies.

Measuring the Dispersion of High-Tech Activity

The comparatively high degree of spatial concentration in high tech is evident in standard measures of statistical dispersion. Table 4 shows coefficients of variation (CV) calculated for STEM industries and six other major economic sectors using data on metro area shares of employment. The data are for 2019 and cover all metropolitan areas for which data are available (e.g., not subject to disclosure restrictions). The lowest CV found is in the retail trade sector, where the standard deviation of shares of total employment is only 15 percent of the mean employment share. Retail trade services are often used as a classic example of a nontradable economic good. Notwithstanding the important trend of online purchases of goods from Internet retailers, retail transactions frequently require in-person interaction between the service provider

[17] In the words of Michael Porter, who made profound contributions to management strategy by bringing cluster analysis to the discipline, "clusters are geographic concentrations of interconnected companies, specialized suppliers and service providers, firms in related industries, and associated institutions (e.g., universities, standards agencies, and trade associations) in particular fields that compete but also cooperate" (Porter 2000, p. 253).

TABLE 4
DISPERSION OF EMPLOYMENT SHARES IN HIGH TECHNOLOGY AND OTHER MAJOR ECONOMIC SECTORS ACROSS METROPOLITAN AREAS, 2019

Economic Sector	Coefficient of Variation*
High Technology	0.91
Manufacturing	0.60
Information	0.56
Professional, Scientific, and Technical Services	0.43
Accommodation and Food Services	0.28
Health Care and Social Assistance	0.25
Retail Trade	0.15

*The coefficient of variation (CV) is the standard deviation divided by the mean. Underlying data used to calculate CVs are sectoral shares of total employment by metro area.

Note: Data on high-technology industry employment are based on the definition of STEM industries in Hill, Hoffman, Madly, and Rex (2021).

Sources: Calculated from data from Lightcast, www.economicmodeling.com (high-technology employment) and U.S. Department of Commerce, Bureau of Economic Analysis (employment in other sectors).

and the customer. This is especially true when the transaction involves a personal service. Thus, with largely uniform demand, it is not surprising that there is a high degree of uniformity (low dispersion) in the importance of retail trade employment across metro areas.

Industries that provide health care services, accommodations, and food services also have relatively low coefficients of variation, meaning that their relative importance in total employment is fairly uniform across metro areas. These, too, are industries with a large nontradable component. People living in medium-to-large urban areas generally feel comfortable with, and prefer to receive, health care services from local providers. Of course, routine prepared meals are purchased from local restaurants.

Somewhat higher CVs are found for the information sector and for industries that provide professional, scientific, and technical services. This suggests that the products in these industries are more tradable and that there are production efficiencies that can be realized through the larger scale afforded by spatial concentration. Many of the products provided by firms in these sectors can be communicated or electronically transmitted at near zero cost to customers over long distances. However, long-distance exchange may not be desirable in cases where trust is important or where there is a need for face-to-face contact to communicate nuanced customer needs.

Among the six non-STEM sectors in the table, manufacturing has the highest coefficient of variation. This aligns with the conclusions of Ellison and Glaeser (1997) who find a high degree of geographic concentration in manufacturing. The products in this sector are, as a rule, highly tradable, and there are substantial economies associated with spatial concentration of production (economies that, according to Ellison and Glaser, can often be linked to the natural advantages of an area).

According to the calculated CVs, geographic concentration or clustering in STEM industries is another magnitude higher than it is in manufacturing. This may not be due as much to greater tradability of STEM industry products than to more significant agglomeration economies in that sector.

Metro Areas With Large High-Tech Industry Clusters

The extent of clustering in industrial STEM activities and the metro locations of large clusters are shown in Table 5. The metro areas listed in the table have both a large absolute level of STEM employment and an above-average STEM share of total employment. What is referred to as "excess STEM employment" is the difference between actual STEM employment and what would be expected given a metro area's total employment if the metro had a STEM share of employment equal to 5.8 percent, the average across the 100 metropolitan areas with the highest STEM employment. The table shows the 15 metro areas with the highest excess STEM employment based on industrial data. Not making the table are New York, Los Angeles, Chicago, and Houston, which have high levels of STEM employment but below-average STEM shares of employment. The data indicate that there are five metro areas with very large excess STEM employment: San Jose, San Francisco, Seattle, Boston, and Washington, D.C. There is

TABLE 5
TOP 15 METROPOLITAN AREAS IN EXCESS HIGH-TECHNOLOGY INDUSTRIAL EMPLOYMENT, 2019

	STEM Employment	Excess STEM Employment*	STEM Share of Total Employment
San Jose-Sunnyvale-Santa Clara, CA	362,279	289,891	29.1%
San Francisco-Oakland-Berkeley, CA	360,645	199,927	13.1
Seattle-Tacoma-Bellevue, WA	306,708	172,569	13.3
Boston-Cambridge-Newton, MA-NH	317,091	141,734	10.5
Washington-Arlington-Alexandria, DC-VA-MD-WV	326,908	120,692	9.2
San Diego-Chula Vista-Carlsbad, CA	160,341	57,267	9.0
Austin-Round Rock-Georgetown, TX	116,925	48,571	9.9
Huntsville, AL	44,329	29,659	17.6
Raleigh-Cary, NC	70,121	29,187	10.0
Boulder, CO	38,646	26,231	18.1
Denver-Aurora-Lakewood, CO	121,802	23,952	7.2
Portland-Vancouver-Hillsboro, OR-WA	101,302	22,078	7.4
Durham-Chapel Hill, NC	41,029	19,934	11.3
Wichita, KS	37,659	18,521	11.4
Palm Bay-Melbourne-Titusville, FL	30,203	15,858	12.2

*Excess STEM employment is the difference between actual STEM employment and what would be expected given a metro area's total employment if the metro had a STEM share of employment equal to 5.8 percent, the average across the 100 metropolitan areas with the highest STEM employment.

Note: Data on high-technology industry employment are based on the definition of STEM industries in Hill, Hoffman, Madly, and Rex (2021).

Source: Calculated from data from Lightcast, www.economicmodeling.com.

then a big drop-off, with significantly lesser excess STEM employment in each of the other 10 metro areas.

Industries classified here as STEM include both manufacturing industries and service industries (Hill, et al. 2021, Appendices A and B). Employment in STEM manufacturing industries accounts for roughly one-quarter of total STEM employment, with employment in STEM service industries making up the difference. Some of the metro areas listed in the table are heavily oriented toward manufacturing: Wichita (aerospace), Palm Bay (semiconductors), and Portland (semiconductors). Some of the metro areas are highly specialized in STEM service industries: San Francisco, Boston, and Washington, D.C. (computer systems design, software, and research development services). And some of the clusters are diversified with important manufacturing and service STEM industries: San Jose (which is in a size class by itself), Seattle, San Diego, and Austin.

The list of metro areas with the most excess STEM employment based on occupational data is somewhat different from the list based on industrial data. The same five metro areas top the list, though Washington, D.C. ranks second based on occupational data. Metro Denver also moves up the list, while the San Diego, Huntsville, Boulder, and Portland metro areas drop a few places. The Durham, Wichita, and Palm Bay metro areas drop out of the top 15, replaced by the Detroit, Baltimore, and Minneapolis metro areas.

Clustering for Innovation[18]

The high degree of clustering and spatial concentration in STEM/high-tech industries is most often explained as a consequence of the fact that (1) innovation is an essential part of the operations of firms in advanced industries, and (2) success in innovation has always involved and continues to require the kind of social and face-to-face interaction that is only available when the various parties involved in the innovation process co-locate in the same space.

History is full of examples of bursts of creativity and new ideas that occurred in a particular place at a particular moment in time: advances in art in Florence during the Renaissance, in literature in Paris during the 1920s, in early industrial science in England during the late 18th and early 19th centuries, and in information technology in Silicon Valley beginning in the late 1950s. Despite the low cost of modern communication and the "flatness" of the world, economic geographers continue to regard spatial concentration as fundamental to the process of innovation (Asheim and Gertler 2005).

Integral to the geography of innovation is the idea that innovation involves the transfer of *tacit knowledge* which, by its nature, is difficult to exchange over long distances without face-to-face contact. Darby and Zucker (2003) explain how modern "metamorphic" innovations — those associated with the creation of new industries or radical technological transformation in an existing industry — typically are driven by breakthrough discoveries in science and engineering. Examples include integrated circuits, recombinant DNA, and nanotechnology. These kinds of discoveries are not well understood initially and cannot be codified. In the beginning, the new

[18] For further development of the ideas in this section, see Asheim and Gertler (2005) and Feldman and Kogler (2010).

knowledge is largely tacit, so transfer and application to industry requires bench-level (e.g., work conducted in a laboratory) relationships between industry scientists and the pioneering scientists.

Another important characteristic of modern innovative activity is that it involves interactions between many parties: inventors, firms, their customers and suppliers, research organizations, and public agencies. Geographic clustering serves to organize this activity by creating opportunities for chance encounters, observation, and social interaction between the parties.

The tendency for innovative activity to spatially concentrate has increased over time (Asheim and Gertler 2005). As innovation has come to involve more parties, efficiencies from agglomeration have increased. Forces of globalization and international competition have encouraged U.S. export industries, which are highly knowledge intensive and innovation intensive, to seek and realize greater efficiencies from clustering. The increase in clustering of innovative activity has been accompanied by a divergence in levels of education and prosperity across geographic areas. Increasingly, the most educated and prosperous U.S. metro areas are those that have developed innovation clusters (Moretti 2012).

Determinants of the Locations of High-Tech Clusters

Historically, manufacturing industries tended to locate near natural resources, waterways, or railroad networks. But natural resources generally are not important to high-tech production. And because advanced industry products have high value in relation to weight and bulk, transportation costs are also relatively unimportant. What is crucial for high-tech firms is having access to a pool of highly skilled and knowledgeable workers. Since people are mobile, this makes the optimal location of high-tech industries indeterminate. The locations of many high-tech clusters can be traced to decisions that were made by key inventors or pioneering firms for reasons that are no longer important today and that in hindsight seem to represent an arbitrary course of history. The process by which high-tech industries have been located is said to be *path dependent*.[19]

While the initial location of a pioneering firm may be arbitrary, subsequent growth in the industry and a clustering of new firms around the pioneering firm creates efficiencies of agglomeration that serve to lock in the initial location. As the cluster grows, a spatial concentration of new firms helps to create thicker labor markets for specialized labor, attracts specialized suppliers and service providers, and promotes the spillover and informal exchange of industry knowledge that is critical for innovation. Clustering is an extremely efficient form of industry organization, as evidenced by the high land prices and cost of living that members are willing to pay to locate in the cluster. However, because clusters are comprised of hundreds of independent firms and thousands of workers, their locations are resistant to change. It is in no one's interest to be the first to move to a new location.

Most major industrial high-tech clusters, including Silicon Valley, evolved through a special set of historical circumstances that would be difficult to replicate. In market economies, industrial clusters are self-organizing and owe more to local entrepreneurial spirit and business culture than to an availability of venture capital, policies of local universities to commercialize their research, or to special relocation incentives provided by state and local governments. There is no standard

[19] Processes where past events or decisions constrain later events or decisions; "history matters."

rule or formula for cluster development. Nevertheless, there are some regularities and recurring themes.

Star Scientists

Many clusters have developed around the locations of pioneering inventors or *star scientists*. In the early stages of innovation, new knowledge is tacit and difficult to codify. Transfer and application of that knowledge to industry requires face-to-face contact between industry scientists and pioneering scientists. Startup firms thus locate near the sources of intellectual human capital (Zucker and Darby 1996, Feldman 2000). As the cluster grows, agglomeration economies make the location appealing to new entrants long after the need to be close to the early star scientists.

As demonstrated in the empirical work of Zucker, Darby, and their colleagues, U.S. biotech clusters can be linked to the locations of a few star scientists who, following the discovery of recombinant DNA, had tacit knowledge of gene transfer and ways of identifying promising gene sequences. The heavy concentration of the software industry in Seattle can be traced to a decision by Bill Gates and Paul Allen to move their promising and rapidly growing software company from Albuquerque to the Seattle area. At the time (1979), Metro Seattle had a struggling economy dependent on old-style manufacturing and lumber. The decision to move to the Seattle area was not based on business principles but was purely sentimental — the two founders simply wanted to return to the place they had grown up (Moretti 2012). Another illustrative if less glamorous example of cluster development involves the center for U.S. carpet manufacturing in Dalton, Georgia. Why Dalton? The tufting method which has come to dominate carpet manufacturing technology was learned by manufacturers in the late 19th century from Catherine Evans, who lived near Dalton and who had invented the tufting method for use in making bedspreads (Krugman 1991). This is another case of the role of historical accident in determining the location of industry clusters.

The Role of Research Universities in High-Tech Cluster Development

Observationally there is a strong correlation or coincidence between the locations of high-tech clusters and major research universities. Famous examples include Silicon Valley and its proximity to Stanford University and the Universities of California at San Francisco and Berkeley, and the Route 128 tech corridor in Boston and nearby MIT and Harvard University (and numerous other universities). In their study of the U.S. biotech industry, Cortright and Mayer (2002) find that innovation in the industry is dominated by clusters located in a few metropolitan areas, each of which includes a first-class medical research center located either in a university or government lab.

There are several ways universities can assist in the development of high-tech clusters:

- As in the case of biotechnology and other biomedical industries, the original knowledge base may come from the basic research findings of university faculty. If the knowledge is not yet codifiable, commercial firms may need to locate near the university so that industrial scientists can work in face-to-face contact with star scientists.
- The research of university faculty may be shaped by the short-term practical needs of local businesses. Faculty assist in industrial problem solving, including the development of instrumentation and measuring devices.

- Historically, the most important contribution universities have made to technical advance in industry is to train industrial scientists and engineers (Nelson 1986).
- There is much anecdotal evidence from MIT and other universities, and systematic empirical evidence from Tartari and Stern (2021), of university graduates contributing to local entrepreneurship and the generation of high-tech startups.

While there is a strong spatial coincidence between high-technology agglomerations and research universities, there is little evidence that the presence of universities "causes" the development of advanced industry clusters (Mowery and Sampat 2005). Studies show that the flow of knowledge between universities and industry is bidirectional. The expertise and needs of existing firms in an area often influence the direction of local academic research. Many of the case studies in Kenney and Mowery (2014) of the University of California system contain examples of how university faculty that made important technological advances first came from industry. Making a similar point, Lecuyer (2005) in his book on the development of the Silicon Valley from 1930 to 1970 documents how Stanford University built a major research program in solid-state electronics on the basis of the needs and knowledge of local electronics firms.

There are, of course, many examples of universities with high-quality faculty and research output that have not spawned local high-tech clusters. In assembling a list of stylized facts in the geography of innovation, Feldman and Kogler (2010) conclude that "local universities are necessary but not sufficient for innovation."

U.S. High-Tech Clusters Are Not Planned

The U.S. model of industrial clusters relies on individual initiative and self-organization. Entrepreneurs start businesses and finance them with funds from private banks and the private capital market, including venture capitalists. Governments play a relatively minor role in determining cluster location. National and local governments in the U.S. and other advanced countries have tried to stimulate the development of high-tech clusters by using public funds to set up science parks or induce foundational firms to locate in their local economy. Notwithstanding the success the state of North Carolina eventually had in developing Research Triangle Park and other occasional success stories such as the emergence of an automotive manufacturing cluster in South Carolina following the attraction of BMW to the state, there is little evidence to support the claim that the cluster development policies of federal, state, or local governments have been effective in creating agglomerations (Mowery and Sampat 2005). In the U.S. and other market economies, clusters are largely unplanned. They develop on their own in locations which are in large part determined by arbitrary and accidental paths of history.

There are other countries, such as China, Singapore, and Taiwan, in which governments plan and in some cases finance the development of industrial clusters. Specific locations are chosen in which to concentrate R&D activity and the production of advanced industry products. Compared to the self-organized, market-driven style of cluster development, the planned model generally yields larger firms, a slower pace of new firm entry, less worker mobility, and less spillover and sharing of new ideas.

One virtue of the centrally planned approach is that high-tech industries can be quickly assembled. As of yet, it is unclear whether planned clusters can achieve a rapid pace of

innovation and sustain a long-run competitive advantage in advanced industries. The analysis of Saxenian (1994) of competition between Silicon Valley and Route 128 during the 1980s and early 1990s suggests that they will not. In her analysis, Silicon Valley responded better to foreign competition and technological change because of the structure and culture of its industries. Silicon Valley had an open, adaptive, and highly mobile system compared to Route 128's more closed, rigid, and loyalty-based system. Eventually, Route 128 not only diversified into new industries such as biotechnology and medical devices but moved toward an open business architecture that more closely resembles the system in Silicon Valley (Asheim and Gertler 2005).

Selected Case Studies

Silicon Valley

Among high-tech clusters, Silicon Valley in Metro San Jose, California is truly in a class by itself. Its size and breadth of innovative activity are unparalleled. Metro area employment in San Jose is 1.25 million, and 29 percent of its workers are in STEM industries. Among other U.S. metro areas with over 1 million workers, the next highest STEM shares of employment are in Seattle, Washington and San Francisco, California (adjacent to San Jose), each with a 13 percent STEM share of employment. Metro San Jose specializes in 17 different advanced industries including semiconductor and computer equipment manufacturing, computer systems design, R&D services, and data processing and hosting (Muro, et al. 2015). Silicon Valley provides a textbook illustration of an industrial cluster. It offers a deep market for both employers and employees in electrical and computer software engineering. There is a well-developed "ecosystem" of specialized suppliers including engineering service firms, manufacturers of chemicals and equipment for testing newly designed semiconductors, intellectual property attorneys, and venture capitalists. And, of course, Silicon Valley is renowned as a place in which innovation is moved forward by the sharing of knowledge that occurs through observation, chance encounters, and social interaction between inventors, firms, their customers and suppliers, and research organizations.

The evolution of Silicon Valley is complex and illustrates how high-tech clusters generally are unplanned and difficult to predict. In a simplified but common account of the region's history, the seeds of Silicon Valley can be traced to the arrival of William Shockley, the inventor of the transistor, who in 1955 founded Shockley Transistor Corporation. In 1956, eight of the employees at Shockley Transistor established Fairchild Semiconductor Corporation, which created the first integrated circuit. Over the next decade Fairchild grew into one of the most innovative companies in the industry, spinning off several high-tech startups including Advanced Micro Devices and Intel.

Fairchild chose to locate in Palo Alto (near Stanford University and within metro San Jose) because of the culture of entrepreneurship and innovation in the region. Sturgeon (2000) documents that Silicon Valley's reputation as a center for startups and innovation dates to the early decades of the 20th century. There had been a dynamic electronics industry in the San Francisco Bay Area since the earliest days of experimentation in radio and television. Leslie (2000) and others also have noted how a massive increase in federal government defense spending following the end of World War II was important in supporting the formation of new high-technology firms in the area.

Stanford University played an important part in the early development of the semiconductor industry, but its role is frequently overstated. Scientists at Fairchild Semiconductor consulted with Stanford faculty. However, the electrical engineering department at Stanford did not achieve world-class status until after the formative years of Fairchild and, of course, well after the early pioneering electronics firms in the Bay Area. Frederick Terman, the dean of Stanford's School of Engineering from 1944 to 1958 and provost of the university from 1955 to 1965, was an early and enthusiastic advocate of partnerships between commercial technology firms and research universities. He can be credited with helping to secure some of the federal military contracts for electronics firms in the Valley. However, as noted by Sturgeon (2000, p. 2), Terman was "as much a product of local ferment in electronics as he was its catalyst."

In his classic historical analysis of the origins of Silicon Valley, Sturgeon (2000) finds that the evolution of the Valley and the formation of its special innovation culture considerably predates the formation of Fairchild Semiconductor and the efforts of Fredrick Terman. Instead of a story of "instant industrialization," he describes a process "much more typical of studies in economic and historical geography: industrial development takes a long time to build up momentum, is profoundly structured by place and historical context, and acquires path-dependent characteristics that continue to influence outcomes far into the future" (Sturgeon 2000, p. 2).

Biotechnology

Biotechnology offers the most recent example of an important new industry built directly on basic scientific research in which commercial firms are known to have close ties to university-based scientists. A single scientific moment defines the beginning of the industry — the 1973 discovery by Stanford professor Stanley Cohen and University of California-San Francisco professor Herbert Boyer of the basic technique for recombinant DNA. Techniques for genetic engineering would eventually become standardized, mechanized, and widely known. But for 15 years following the discovery, knowledge of how to identify promising gene sequences and even the skills of gene transfer were held by a small group of discovering scientists and their co-workers. Knowledge of the techniques was difficult to transfer because of its complexity and tacitness. Commercial development required frequent face-to-face contact with discovering scientists. Since many of these scientists were academics who were unwilling to leave university appointments, their location often served to determine the location of commercial firms. The most successful biotech firms were those in which discovering scientists had a financial interest and were actively involved in bench-level scientific collaboration with industry scientists.

Zucker, Darby, and Brewer (1998) were among the first to systematically test for a geographic coincidence between new biotechnology firms and university scientists who made early contributions to gene sequencing. The authors first identify a set of star scientists who were highly productive in discovering gene sequences. These scientists represented only 0.75 percent of the authors in *GenBank* but accounted for 17 percent of the published articles — 22 times the number of the average author. The authors then find the location of star scientists who were active in gene sequencing research between 1976 and 1980 to be a powerful predictor of the geographic distribution of biotech firms in 1990. Zucker, Darby, and Armstrong (2002) also found that firms that established working relationships with star scientists outperformed other

firms in terms of employment growth and the number of products in development or on the market.

Innovation in the biotechnology industry continues to be dominated by firms in Boston, San Francisco, and San Diego, three of the oldest and most-established centers. Metro areas with more recently formed concentrations of biotech activity include Raleigh-Durham, Seattle, New York, Washington, D.C., and Los Angeles. Cortright and Mayer (2002) found that the two most important factors associated with an emerging biotech cluster are the presence of a first-class local medical research facility and local policies and institutions that help to translate research into commercially viable products.

Research Triangle Park (RTP)[20]

North Carolina's Research Triangle in the Raleigh-Durham area is an important hub for medical research and life science innovation. Established firms and startups have been successful in using the results of academic life science research at Duke University in Durham, North Carolina State University in Raleigh, and the University of North Carolina at Chapel Hill, to develop commercially viable products.[21] Excess industrial STEM employment in the combined Raleigh-Durham metro areas in 2019 was a little more than 49,000, which ranks sixth highest among the top high-tech metro areas identified in Table 5.

The Research Triangle Park is located on the border of the Durham-Chapel Hill and the Raleigh-Cary metro areas. The RTP is notable in the economic geography of U.S. innovation hubs for having been centrally planned and built primarily through the recruitment of out-of-state established firms rather than developing spontaneously from the independent decisions of startups and pioneering technology firms.

The initial concept of the RTP dates to the 1950s and is attributed to Romeo Guest, a civic booster and local entrepreneur who was trained as an architectural engineer at MIT. Brandon Hodges, a former state treasurer of North Carolina, also played an important early role in moving the concept forward. The vision was to jumpstart economic development in the state by recruiting out-of-state technology firms and establishing industrial research laboratories that would partner with local universities. Selected faculty in the departments of engineering and chemistry at UNC-Chapel Hill were used in early recruiting efforts. But the local universities were initially reluctant to change their research priorities and culture. The role of universities was not to engage directly in industrial research but to provide knowledge and guidance for the research efforts of industrial firms. It was not until the 1980s that the RTP began to generate technology-based startups that were traceable to local university research.

The Research Triangle Park officially opened for business in 1959. But despite extensive recruiting efforts in both the U.S. and Europe, it remained largely empty until 1965. Two important developments occurred in that year. First, through the advocacy efforts of North Carolina governor Terry Sanford, President John F. Kennedy committed to building in the RTP, but it was not until 1965 that the federal government announced its decision to locate in the Park

[20] This section relies heavily on National Research Council (2013) which provides a detailed history of the RTP.

[21] North Carolina's Research Triangle was initially defined by the location of these three universities.

what would become the National Institute of Environmental Health Sciences. At the time, this was the only branch of the National Institutes of Health that was located outside of Bethesda, Maryland. Also in 1965, representatives of the RTP concluded a seven-year-long negotiation with IBM to locate a new facility in the Park. Reportedly, IBM agreed to the deal when the state promised to build a four-lane highway linking the RTP to Raleigh and Cary. The highway would eventually become Interstate 40. IBM now has roughly 40 departments and organizations operating in the Park and is its largest employer.

Another important development occurred in 1984 when the North Carolina General Assembly established the North Carolina Biotechnology Center (NCBC). This was the world's first government-sponsored economic development organization in the field of biotechnology. Dr. Charles Hammer, who is referred to as the "biofather" of North Carolina's biotech industry, ran the NCBC from 1987 to 2001. During his tenure, the NCBC set up its headquarters in the Park where it became a networking and meeting place for biotech executives. Hammer also succeeded in recruiting 10 biotech companies to the state, directed $50 million to the state's universities, and created a $26 million venture capital fund that invested in local biotech startups. North Carolina now ranks third in the life sciences, behind only Massachusetts and California.

North Carolina's Research Triangle is the best example of a U.S. innovation cluster developed through a state-led effort to recruit established high-tech companies from other states and countries. The RTP is a model and best-case scenario for economic development strategies that focus on building partnerships between local research universities and innovation-based industrial firms. Economic development in the RTP area has helped to transform the region from one of the poorest in the southeastern United States to among its wealthiest. When the RTP was formed in the 1950s, per capita income in the Raleigh-Durham area was well below the national average. Today the metro area's per capital income is significantly above the U.S. average.

INTRODUCTION TO EMPIRICAL ANALYSIS AND INDICATORS

Two data sources are primarily used in the empirical analysis of the development of high-tech centers in selected states and metropolitan areas. Much of the data come from Lightcast (www.economicmodeling.com), a private-sector company providing selected economic and related data for the nation, states, metropolitan areas, and counties. Access to the data is available only to subscribers. The advantage of using Lightcast's data is that Lightcast imputes values for the large volume of data that are withheld by the federal government. Federal laws intended to prevent the disclosure of information of a specific business or a specific individual result in a substantial amount of data being withheld.

Among the data available from Lightcast is employment and earnings by industry and employment and earnings by occupation. The industry data are based on the latest revision (2022) to the North American Industry Classification System (NAICS); the occupational data are based on the latest revision (2018) to the Standard Occupational Classification (SOC). The industrial data and the occupational employment estimates are available annually for 2001 through 2022, but the earliest occupational earnings estimates are for 2005. By industry, Lightcast measures earnings as average earnings per job. Occupational earnings from Lightcast are expressed as median earnings per job.

Data by occupation are not available prior to 2001. Industrial data exist back to the late 1940s from "County Business Patterns," a product of the U.S. Census Bureau. However, these earlier data were organized by the Standard Industrial Classification (SIC), which was not fully consistent with the NAICS, and not as detailed.

Occupational Versus Industrial Data

Conceptually, it is far superior to define STEM by occupation than by industry. Every worker classified into a STEM occupation, such as electronics engineers, is involved in STEM activities. In contrast, though a particular industry, such as semiconductor manufacturing, may be STEM intensive, a sizable proportion of its workforce do not work in STEM occupations, such as business support functions and production activities that may not require a substantive STEM education or knowledge base. On the other hand, industries that have little relationship to STEM, such as retail trade, have some employees working in STEM occupations, particularly those related to computers.

While occupational data are preferred, industrial data also are analyzed for a variety of reasons. The quality of the industrial data is superior to that of the occupational data. A large portion of the industrial data reported by Lightcast comes from the Quarterly Census of Employment and Wages (QCEW), produced by the U.S. Department of Labor's Bureau of Labor Statistics (BLS). The QCEW counts wage and salary employees who are covered by the unemployment insurance program. Each quarter, all employers in the program report actual wages paid and the number of employees. Lightcast must estimate the figures when the BLS withholds QCEW data from publication due to federal disclosure laws and must estimate employment and earnings for those workers not covered by the unemployment insurance program.

The primary source for the occupational data reported by Lightcast is the Occupational Employment Statistics (OES) program of the BLS, which releases estimates annually. The OES

data are subject to serious limitations. Since the data are derived from a survey of employers, sampling error is a concern. Further, the survey instructs employers to report the number of employees in each occupation by wage range rather than report actual wages. In addition, the survey is conducted over a three-year cycle — it takes three years of semiannual surveying for the full panel of respondents to be surveyed. Thus, most of the responses used to produce the latest May 2023 estimates were collected before 2023, though the wage data from the earlier periods were adjusted for inflation. Lightcast must estimate employment and earnings for workers not covered by the OES survey and for the substantial number of OES occupations for which employment and/or earnings data are withheld from publication.

Identification of STEM Occupations and Industries

Numerous efforts to identify STEM occupations and industries have been made (see the references for some of these sources). While the efforts have produced slightly different lists of occupations, the correspondence is strong across the sources. Based on the consensus of these efforts, the STEM occupational definition used in this report includes the following occupations:

- Three occupations in the "management" major group.
- All occupations in the "computer and mathematical" major group.
- The engineering portion of the "architecture and engineering" major group.
- The life and physical sciences portion of the "life, physical, and social science" major group.

Based on the 2018 SOC, a total of 88 STEM occupations have been selected; the definitions of these occupations are consistent over the entire 2001-to-2022 period in the Lightcast data. The high-tech occupations have been grouped into six categories: computer, mathematical science (math), engineering, engineering technician, life and physical science (science), and science technician. See Appendix A for a list of the STEM occupations by category.

Not all occupations that require high educational attainment in technical fields are identified as high tech. For example, the list does not include healthcare practitioners and technicians since these occupations primarily serve local residents. A core concept of a high-tech economy is that most customers are spread across the nation or the world, referred to as "tradability."

A significant difference in size, as measured by employment or aggregate earnings, existed across the six occupational categories in 2022, with the computer category the largest by far, with nearly 5.6 million workers nationally. Employment in the engineering category was a little less than 2 million. The other four categories were considerably smaller, with employment ranging from approximately 352,000 to 733,000.

Much lesser consensus exists across the efforts to identify STEM-intensive industrial activities (see the references for these sources). In addition, most definitions of STEM-intensive industrial activities have been made at the industry group level (four-digit NAICS) rather than at the six-digit industry level. Thus, the authors of this report had to decide both which industry groups to classify as STEM intensive and which of the six-digit industries within the selected industry groups to include. STEM industries are limited to those that are primarily tradable and thus do not include such industries as health care or higher education in which workers on average have high educational attainment in technical fields.

Based on the 2022 NAICS, a total of 55 STEM-intensive industries have been selected; the definitions of these industries are consistent over the 2001-to-2022 period in the Lightcast data. Of these 55 industries, 35 are manufacturing industries, which have been subdivided into seven categories, listed in order of U.S. employment in 2022: aerospace products and parts; navigational, measuring, electromedical, and control instruments; electronic components; biopharmaceuticals; computing equipment; communications equipment; and miscellaneous high-tech manufacturing. Employment across these seven categories accounted for just 1.23 percent of the U.S. total.

The other 20 STEM-intensive industries provide services. They have been subdivided into three categories, listed in order of U.S. employment in 2022: computer systems design and other computer-related services; other professional services; and miscellaneous high-tech services. Employment across these three categories accounted for 3.96 percent of the U.S. total.

The STEM share of total U.S. employment in 2022 based on industries (5.19 percent) is somewhat less than the STEM share based on occupations (5.74 percent). The STEM-intensive industries based on the NAICS are listed in Appendix B.

For the period prior to 2001, data on high-tech activities was derived from "County Business Patterns." Prior to 1998, these data were organized by the SIC. The SIC was revised several times from the 1940s through 1987, the last revision. The differences in the high-tech industries between the 1987 SIC and the NAICS is not substantial. In contrast, high-tech industry definitions in the earlier versions of the SIC are substantially different from the 1987 industries, with the earlier industries less detailed. In 1957, only one industry was related to computers, high-tech electronics was limited to one industry, and guided missiles and space vehicles were not yet identified in the SIC.

As noted earlier, the antecedents of high technology date back to before World War II, with the development of radios and television. The war effort provided a boost to the development of technology, but it was not until the 1950s that high-technology centers began to form. The term "high technology" was first used in 1958. An earlier version of "STEM" — "SMET" — was first used by the National Science Foundation during the 1950s. Data collection from "County Business Patterns" for this paper goes back to 1956.

Industrial Clusters

A key concept in regional economics is the distinction between "traded" economic activities and other economic activities. Goods and services sold to customers (individuals or businesses) who are not residents of a region are referred to as "traded" — money is imported into the regional economy that would otherwise not be present.

In contrast to traded activities, nontraded (or "local") economic activities are location specific since they sell their goods and services primarily to regional customers. Their presence largely is proportional to a region's size, as defined by purchasing power. While an integral part of a regional economy, nontraded activities do not import money into the regional economy. Their presence in the region is due to traded activities — the expenditures made locally by companies selling traded goods and services and by the employees of these businesses. In this way, traded

activities "drive" the regional economy while nontraded activities respond to the growth occurring in traded activities.

Historically, industrial activity was analyzed using the SIC/NAICS. An alternative way is to group industries into economic clusters. The Institute for Strategy and Competitiveness (ISC) at the Harvard Business School, directed by Professor Michael Porter, is a leading research unit on economic clusters. According to the ISC, "A cluster is a geographic concentration of related companies, organizations, and institutions in a particular field that can be present in a region, state, or nation. Clusters arise because they raise a company's productivity, which is influenced by local assets and the presence of like firms, institutions, and infrastructure that surround it."[22] The ISC states that clusters increase productivity and operational efficiency, stimulate and enable innovation, and facilitate commercialization and new business formation.

The ISC categorizes industries into one of 51 traded clusters or 16 local clusters.[23] No industry is included in more than one cluster, though an industry may have connections to more than one cluster. The dataset used by the ISC does not include the public sector or most of the agriculture sector. Two traded sectors — for farming and ranching and for the federal government — were added to those defined by the ISC, resulting in 53 traded clusters. One additional nontraded cluster — for state and local governments — was created, resulting in 17 nontraded clusters.

Employment Versus Aggregate Earnings

Commonly, economic analyses focus on employment due to its simple concept and more ready data availability. However, employment as reported in the United States has a serious shortcoming in that no measure of full-time equivalency is available: a part-time worker is counted the same as a full-time worker. In addition, since earnings per job vary widely by occupation and industry, an indicator measured in dollars is more indicative of the impact of particular economic activities.

Aggregate earnings are calculated by multiplying employment by average/median earnings per job for each industry/occupation. STEM totals are obtained by summing employment/aggregate earnings across the relevant industries/occupations. While conceptually preferable to employment, the occupational aggregate earnings data are disadvantaged by the necessity of using median rather than average earnings per worker. Arithmetic operations using median values are limited. Aggregate earnings data also are limited by not being available prior to 2001 by industry and prior to 2005 by occupation. In this paper, both employment and aggregate earnings are used to measure STEM activities during the 21st century; 20th century data are limited to employment. Throughout this paper, industrial and occupational data are expressed as a share of total employment or total aggregate earnings, generally in relation to the national average.

States Versus Metropolitan Areas

A metropolitan area is defined by the federal government as one or more adjacent counties or county equivalents that have at least one urban core area of at least 50,000 population plus

[22] From http://www.isc.hbs.edu/competitiveness-economic-development/frameworks-and-keyconcepts/Pages/clusters.aspx.
[23] https://www.clustermapping.us/content/cluster-mapping-methodology

adjacent territory that has a high degree of social and economic integration with the core as measured by commuting ties. Economic activity is closely tied to individual labor market areas, which correspond to official definitions of metropolitan and micropolitan areas.

Assuming that adequate data are available, metropolitan areas are the preferred level of geography for most economic analyses. However, most economic analyses are conducted at the state level, due to some combination of superior data, acknowledgement of state-level economic programs and organizations, or ease of analysis. Much of the data used to investigate high-tech activity geographically are only available by state. Thus, the analyses in this paper use states and, when possible, metro areas, with comparisons to the national average.

Prior research revealed that even after adjusting for the cost of living, various economic measures — including high-technology intensity — are positively correlated with metro size, as measured by population or employment.[24] Thus, the metro areas examined in this paper are split into two groups based on economic size.

Selection of States and Metropolitan Areas

The selection of states and metro areas to examine in detail is based primarily on existing high-tech strength, as measured by the high-tech share of the total economy, using occupational and industrial data and the employment and aggregate earnings indicators. The change between 2005 and 2022 also is considered. The size of the economy, as measured by total employment in 2022, and proximity to Arizona are other selection factors.

Relatively few states had high-tech shares above the U.S. average in 2022:

- 18 based on occupational employment.
- 14 based on occupational aggregate earnings.
- 16 based on industrial employment.
- 11 based on industrial aggregate earnings.

Similarly, less than half of the states had a 2005-to-2022 change in the high-tech share that exceeded the national average:

- 19 based on occupational employment.
- 15 based on occupational aggregate earnings.
- 14 based on industrial employment.
- 6 based on industrial aggregate earnings.

An even lesser share of metropolitan areas have a high-tech share greater than the national average. For example, an earlier analysis using 2019 industrial employment data indicated that only 57 of 384 metro areas (15 percent) had an above-average high-tech share. This list included a number of the largest metro areas, some of which had a high-tech share much higher than the national average.

[24] For example, see "STEM Economic Activity by Metropolitan Area," February 2021, https://ccpr.wpcarey.asu.edu/sites/default/files/2022-09/stemmetros02-21.pdf.

Six populous states stand out as leaders on the high-tech share of the economy, regardless of how high-tech is measured. These states and their leading high-tech metropolitan areas that are included in this paper follow:

- California and the San Diego, San Francisco, and San Jose metro areas.
- Colorado and the Boulder, Colorado Springs, Denver, and Fort Collins metro areas.
- Maryland and the Baltimore metro area. The Washington, D.C. metro area includes the District of Columbia as well as adjacent areas of Maryland and Virginia.
- Massachusetts and the Boston metro area.
- Virginia, as well as the Washington, D.C. metro area.
- Washington and the Seattle metro area.

Utah is not quite as strong of a high-tech center as the preceding six states and is not as populous, but does belong in the first tier of high-tech states and thus was selected as another comparison state. Its high-tech growth rate, proximity to Arizona, and other similarities to Arizona were other factors behind its selection. The Salt Lake City and Provo metro areas are included in the analysis. Arizona, and the Phoenix and Tucson metro areas, do not have high-tech intensities matching these other states and metro areas.

Several other states with high-tech intensity similar to (or greater than) Arizona were considered, but were not selected for the following reasons and in order to keep the number of comparison areas manageable:

- Connecticut. The state's high-tech employment shares in 2022 generally were a little above the U.S. average, but the change in shares between 2005 and 2022 were less than the national average.
- Delaware. Based on occupational data, Delaware is a strong high-tech state. However, based on industrial data, it is weak. In addition, regardless of the means of measurement, Delaware's high-tech shares declined substantially relative to the nation between 2005 and 2022, and the size of the state's economy is small.
- District of Columbia. The District is a very strong high-tech center based on occupation but not on industry, since so many of the high-tech workers are employed by the federal government. The broader Washington, D.C. metro area is analyzed.
- Michigan. The state's high-tech shares in 2022 based on occupational data were a little above the U.S. average, but the industrial shares were a little below average and the change in shares between 2005 and 2022 were less than the national average.
- New Hampshire. New Hampshire is a strong high-tech state, particularly based on industrial data. It was not included in the analysis due to its small size.
- New Jersey. The state's high-tech shares in 2022 were a little above the U.S. average, but the change in shares between 2005 and 2022 were less than the national average.
- New Mexico. The state's high-tech shares in 2022 were a little above the U.S. average, but the change in shares between 2005 and 2022 were less than the national average. However, the Albuquerque metro area is examined as a comparison to Metro Tucson.
- North Carolina. Despite the publicity received by the state's Research Triangle, the state's high-tech shares until recently were well below the national average, and the

shares based on industrial data still were below average in 2022. However, the combination of the Raleigh and Durham metro areas is examined.[25]
- Oregon. The state's high-tech shares in 2022 were slightly above the U.S. average. The Portland metro area is examined.

In addition, two metro areas in Texas are analyzed: Austin and El Paso. The latter is not a high-tech center but was included due to its proximity and size similarity to the Tucson metro area.

A total of 20 metro areas are examined in this report, split into two groups. Prior to 1998, data were available only by county; data were collected only for counties with at least a moderate level of employment. Subsequent data are for the entire metro area.

The first group consists of 12 strong high-tech centers with employment in 2022 of more than 1 million; each of the 10 populous metro areas listed in Table 5 are included:

- Austin. Data were collected for Travis and Wiliamson counties. Currently, the metro area consists of five counties.
- Baltimore. Data were collected for Anne Arundel and Baltimore counties and Baltimore city. Currently, the metro area consists of six counties and the city.
- Boston. Data were collected for Essex, Middlesex, Norfolk, Plymouth, and Suffolk counties. Currently, the metro area consists of these five counties in Massachusetts and two counties in New Hampshire.
- Denver. Data were collected for Adams, Arapahoe, Denver, Douglas, and Jefferson counties. Currently, the metro area consists of 10 counties.
- Phoenix. Data were collected for Maricopa County. Currently, the metro area also includes Pinal County. With employment of nearly 2.5 million, Phoenix ranks fourth among these 12 metro areas.
- Portland. Data were collected for Clackamas, Multnomah, and Washington counties. Currently, the metro area consists of five counties in Oregon and two counties in Washington.
- Raleigh-Durham. Data were collected for Durham and Wake counties. Currently, the Raleigh metro area consists of three counties and the Durham metro area includes four counties.
- San Diego. Data were collected for San Diego County, the only county in this metro area.
- San Francisco. Data were collected for Alameda, Conta Costa, San Francisco, and San Mateo counties. Currently, the metro area consists of five counties.
- San Jose. Data were collected for Santa Clara County. Currently, the metro area consists of two counties.
- Seattle. Data were collected for King, Pierce, and Snohomish counties. Currently, the metro area consists of these three counties.
- Washington, D.C. Data were collected for King, Pierce, and Snohomish counties. Currently, the metro area consists of the District of Columbia and 22 cities and counties in Maryland, West Virginia, and Virginia.

The second group consists of eight smaller metro areas in the Southwest:

[25] These two metro areas were combined not only because they are adjacent, but because Research Triangle Park is located in part in each of the two metro areas.

- Albuquerque. Data were collected for Bernalillo County. Currently, the metro area consists of four counties.
- Boulder. Data were collected for Boulder County, the only county in this metro area.
- Colorado Springs. Data were collected for El Paso County. Currently, the metro area consists of two counties.
- El Paso. Data were collected for El Paso County. Currently, the metro area consists of two counties.
- Fort Collins. Data were collected for Larimer County, the only county in this metro area.
- Provo. Data were collected for Utah County. Currently, the metro area consists of two counties.
- Salt Lake City. Data were collected for Salt Lake County. Currently, the metro area consists of two counties.
- Tucson. Data were collected for Pima County, the only county in this metro area. With employment of nearly 450,000, Tucson ranks second among these eight metro areas.

Based on high-tech shares in 2022, considering occupational and industrial data and the employment and aggregate earnings measures, eight states have high-tech shares well above the national average and are included in the first tier of high-tech states: California, Colorado, Maryland, Massachusetts, New Hampshire, Utah, Virginia, and Washington. Eight other states have high-tech shares ranging from about the national average to somewhat above average and are included in the second tier: Arizona, Connecticut, Michigan, New Jersey, New Mexico, North Carolina, Oregon, and Texas.

While Arizona currently is a second-tier high-tech state, its high-tech shares are only similar to the national average. The state's 2005-to-2022 change in high-tech share exceeded the U.S. average based on occupational employment, but Arizona fell behind the nation on the other measures. While recent announcements in the semiconductor industry should bolster Arizona's high-tech status, the announced activity will not be enough to move the state into the first tier.

High-tech employment shares in Metro Phoenix in 2022 were a little higher than the national average, but lower than in each of the 11 comparison metro areas. High-tech aggregate earnings shares in Metro Phoenix were slightly below the U.S. average, also last among the comparison areas. High-tech shares were higher in Metro Tucson in 2022 than in Metro Phoenix, but Metro Tucson ranked near the bottom of its comparison group, generally higher than only Metro El Paso.

Cost of Living

Most of the measures/indicators examined in this paper are not measured in dollars. For those measured in dollars, the figures ideally would be adjusted for regional differences in the cost of living. However, the time series of the cost-of-living estimates — regional price parity figures from the U.S. Bureau of Economic Analysis — only extends from 2008 to 2022. Moreover, Arizona's cost of living is not substantially different from the national average, ranging from 3 percent above average in 2008 and 2009 to 3 percent below average in 2018 and 2021.

The cost-of-living adjustment is more important when comparing states and metro areas. The 2022 regional price parity figures, and the change between 2012 and 2022, for the eight comparison states follow (the national average is 100 in each year):

- Arizona: 99.9, 1.9
- California: 112.5, 2.8
- Colorado: 102.3, -0.9
- Maryland: 105.0, -2.5
- Massachusetts: 109.4, 4.9
- Utah: 94.5, -5.0
- Virginia: 102.1, -0.3
- Washington: 109.8, 7.3

EVOLUTION OF HIGH-TECHNOLOGY ACTIVITIES IN SELECTED STATES AND METROPOLITAN AREAS

Industrial Data Sources

Two sources of data are used for the industrial analysis. First, County Business Patterns (CBP), produced by the U.S. Department of Commerce, Census Bureau, is used for the 20th century data.[26] Lightcast is used for the 2001-to-2022 period.

County Business Patterns

CBP was first produced in 1946. It was updated every few years through 1962 and has been produced annually since 1964. In addition to county-level data, CBP has reported data for states and the nation. Detailed data for metropolitan areas were first available in the 1990s.

CBP provides three types of data by industry:

- The total number of business establishments[27] and a frequency distribution of the number of establishments by employee size as of mid-March.[28] Only private-sector nonfarm establishments are included.
- Employment as of mid-March. Some workers are not included: self-employed, employees of private households, railroad employees, agricultural production workers, and most government employees. Importantly, employment is not disclosed in industries in which the disclosure would violate federal law that ensures the confidentiality of a company's data. When the employment data was withheld, the authors of this report imputed an employment estimate largely based on the frequency distribution of the number of establishments and the average number of employees per employment size class.[29] No information (including establishment data) was provided for any industry with fewer than 100 employees until the late 1970s.
- Payroll in the first quarter. In later years, annual payroll is reported as well. Like the employment data, the payroll data are subject to the federal disclosure laws. Payroll data are not used in this analysis since there is no way to impute missing figures.

A serious challenge to any analysis of industrial data over a long time period is the changes in industry definitions that have occurred over the years. The Standard Industrial Classification was used prior to 1998 in CBP, but over the years, changes were made to the SIC, in part to identify new industries and to subdivide other industries. The SIC was designed hierarchically, with two-digit code numbers used for major groups, three-digit for industry groups, and four-digit for industries.

---

[26] CBP data also were collected for 2003 and are displayed in the state analysis. However, substantial changes in the NAICS between 2003 and the current time have limited the comparability of the 2003 CBP data and the 2003 Lightcast data. CBP data for 2003 were not examined in the metro area analysis.
[27] An establishment is a physical place of work. A business may consist of multiple establishments. Prior to 1974, nonmanufacturing industries were not reported by establishment — all establishments of a particular company within a county were combined.
[28] One industry is assigned to each establishment. If more than one type of economic activity is performed at a single establishment, the industry assigned is that of the major activity.
[29] With the highest employment category open-ended (500 or more in early years; 1,000 or more in later years), it was necessary to employ additional imputation techniques for industries with establishments in the open-end size class.

A significant change in the industry classification occurred with the 1998 CBP, which used the new North American Industry Classification System. The NAICS also was designed hierarchically, with two-digit code numbers used for sectors, three-digit for subsectors, four-digit for industry groups, and five-digit and six-digit for industries. Since it is not possible to consistently measure some of the high-tech activities over time due to these definitional changes, the main focus of this analysis is to compare high-tech industry shares of total employment by state and metro area to the national average by year.

Since the prevalence of withheld data is greater for industries than for industry groups, and since definitional changes are of greater magnitude for industries than broader categories, industry groups rather than industries were of necessity used in much of this analysis. Using the SIC, most high-tech activities were defined at the three-digit industry group level; a few four-digit industries also were used. Using the NAICS, most high-tech activities were defined at the four-digit industry group level; a few six-digit industries also were used. The high-tech activities were grouped into eight categories:

- Biopharmaceutical Manufacturing. SIC industry group 283: Drugs. NAICS industry group 3254: Pharmaceuticals and Medicine.[30]
- Computing Equipment Manufacturing. SIC industry group 357: Computer and Office Equipment. NAICS industry group 3341: Computer and Peripheral Equipment.
- Communications Equipment Manufacturing. SIC industry groups 365: Household Audio and Video Equipment (began 1959); and 366: Communications Equipment. NAICS industry groups 3342: Communications Equipment; and 3343: Audio and Video Equipment.
- Electronics Manufacturing. SIC industry group 367: Electronic Components and Accessories (began 1959). NAICS industry group 3344: Semiconductor and Other Electronic Component Manufacturing.
- Instruments Manufacturing. SIC industry groups 381: Search, Detection, Navigation, Guidance, Aeronautical, and Nautical Systems, Instruments, and Equipment; and 382: Laboratory Apparatus and Analytical, Optical, Measuring, and Controlling Instruments; and 383: Optical Instruments and Lenses (all three began 1959; 383 not used after 1983). NAICS industry group 3345: Navigational, Measuring, Electromedical, and Control Instruments.
- Aerospace Manufacturing. SIC industry groups 372: Aircraft and Parts; and 376: Guided Missiles and Space Vehicles and Parts (began 1978). NAICS industry group 3364: Aerospace Product and Parts.
- Computer Services. SIC industry group 737: Computer Programming, Data Processing, and Other Computer Related Services (began 1978). NAICS industry groups 5112: Software Publishers; and 5415: Computer Systems Design and Related Services. Other NAICS definitions changed over time. In 1998: 514191: On-Line Information Services; and 5142: Data Processing Services. In 2003: 516: Internet Publishing and Broadcasting; and 518: Internet Service Providers, Web Search Portals, and Data Processing Services.

[30] Biopharmaceutical manufacturing is not the same as “biotechnology.” The latter includes research and development in biotechnology industry, data for which are not available prior to 2001. For more on biotechnology, and research and development in general, see Appendices C and D.

- Other Professional Services. SIC industry groups 7391: Research and Testing Laboratories (began 1959), and 7397: Commercial Testing Laboratories (began 1968); and 891: Engineering and Technical Services; and 892: Noncommercial Research Organizations (began 1959). NAICS industries 541330: Engineering Services; and 541340: Drafting Services; and 541360: Geophysical Surveying and Mapping Services; and 541370: Surveying and Mapping Services; and 541380: Testing Laboratories and Services; and 541710: Scientific Research and Development Services.

Since the focus of this analysis is metro areas, not counties, and because metro area data are not available for most of the 20th century, an approximation of metro area totals was created by summing CBP data for the major counties in each metro area. Metro counties with limited employment were not included since most of the data are withheld and because of the heavy time requirements to make imputations.

The earliest CBP data had to be transcribed from the original printed reports. Most of these early CBP reports are available online from the HathiTrust digital library (https://www.hathitrust.org/). Due to the time required to transcribe the early data and to make the extensive data imputations, only selected years of CBP data have been included in this analysis. Prior to the late 1950s, few high-tech activities were identified in the SIC, so a start year of 1956 was adopted. The available CBP reports for 1959 and 1962 were included. With the advent of annual data, the key consideration in the selection of years to include in the analysis is to avoid recessionary periods. The years 1965, 1968, 1973, 1978, 1983, 1988, 1993, 1998, and 2003 were included.

Lightcast

The employment and average earnings data used for this paper were obtained from Lightcast (formerly Emsi, www.economicmodeling.com), a private-sector labor market data company providing selected economic and related data for the nation, states, counties, and metropolitan areas by industry and occupation. Lightcast updates the data quarterly; the data used in this report come from the third quarter 2023 data release. Lightcast provides annual employment and average earnings data by industry since 2001. Aggregate earnings are calculated from the employment and average earnings figures.

Lightcast uses a variety of sources, predominantly federal government agencies, to develop its data, which are available only to subscribers. A major advantage of using the Lightcast data is that Lightcast imputes values for the large volume of data that are withheld by the federal government due to the federal disclosure restrictions. In addition, all of the data have been adjusted by Lightcast to reflect changes in the NAICS definitions such that the entire time series is consistently defined.

Employment and earnings are reported by Lightcast for each of four categories; totals are available for any combination of two or more categories. The first category corresponds to the Quarterly Census of Employment and Wages (QCEW) produced by the U.S. Department of Labor's Bureau of Labor Statistics (BLS). The QCEW is limited to wage and salary employees who are covered by the unemployment insurance program.

The second category of data from Lightcast is wage and salary workers who are not covered by unemployment insurance. Those in the military and those working for railroads are in this category, as are some employees of the federal government, religious organizations, etc. The third category of self-employed includes those individuals whose self-employment constitutes a high proportion of their earnings and working hours. The fourth category includes individuals with earnings from self-employment, but who are either primarily retired or primarily work at a wage and salary job and are counted in one of the first two categories. In this analysis, the sum of the first three categories is used.

Lightcast six-digit NAICS industry data are used in this analysis. The full list of industries defined as STEM are shown in Appendix B. Most are a part of one of the eight high-tech categories defined using CBP data. The others have been aggregated into two additional categories: miscellaneous high-tech manufacturing and miscellaneous high-tech services.

Industrial Analysis, 1956 to 2022

Industrial High-Tech Activities in the Nation

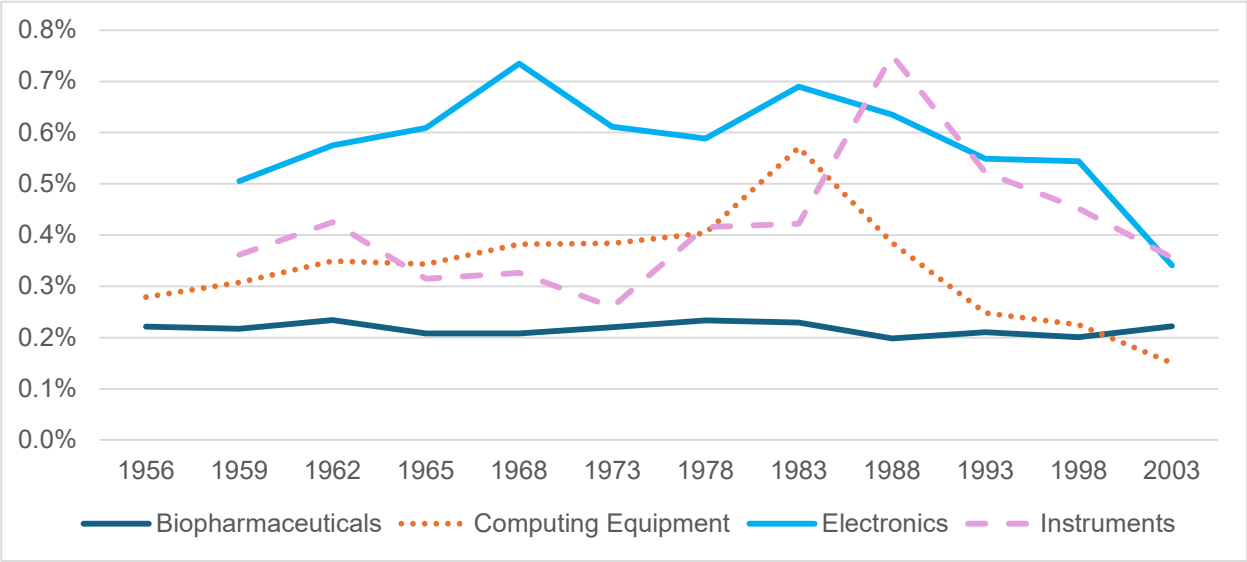
The high-tech share of total employment nationally is presented in Chart 2 for each of eight high-tech categories for the period from 1956 to 2003; these data come from County Business Patterns. Some of the fluctuations in shares may result from changes in industrial definitions within the SIC from 1956 through 1993; the data for 1998 and 2003 use the NAICS definitions.

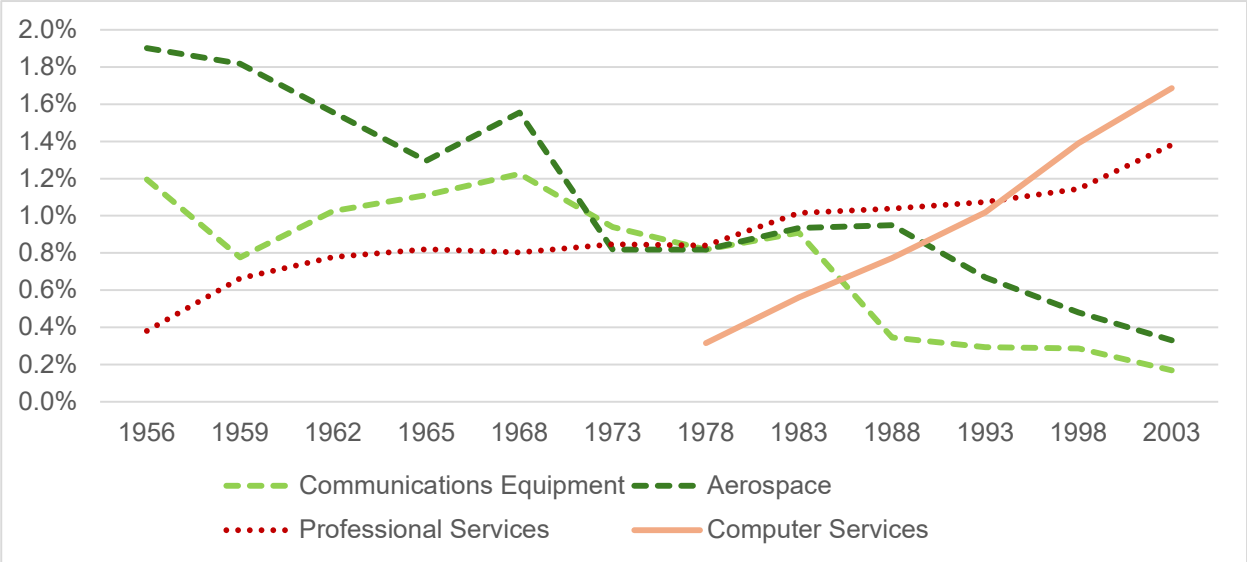
Looking at the high-tech total reveals fluctuations in the high-tech share of total employment nationally over time, but no trend from 1956 to 2003. This may seem surprising in a world in which high technology was seemingly of increasing importance, but examination of each of the eight categories provides an explanation. In short, much of the nation's high-tech manufacturing was moved overseas beginning around 1970. Gains in productivity also contributed to the decrease in manufacturing employment share. This decline in high-tech manufacturing caused a drop in the overall high-tech share between 1968 and 1973, but after that, increasing shares of high-tech services more or less offset the manufacturing declines. The decline in the high-technology manufacturing shares occurred particularly in aerospace and communications equipment. These were the dominant high-tech activities in the 1950s and 1960s. The two high-tech services categories became dominant by the 1990s.

Annual data for 2001 through 2022 from Lightcast are displayed in Chart 3 for the nation for each of 10 high-tech categories. Since high tech from the Lightcast data is defined strictly by industry, the employment figures for 2003 do not match those from the CBP, which is defined largely by industry group. The high-tech shares are smaller using the Lightcast data in each category, but the differences are modest except in the two services categories.

The following summary of the high-tech share of total employment nationally combines data from CBP and Lightcast. Aggregate earnings information for 2001 to 2022 supplements the employment summary:

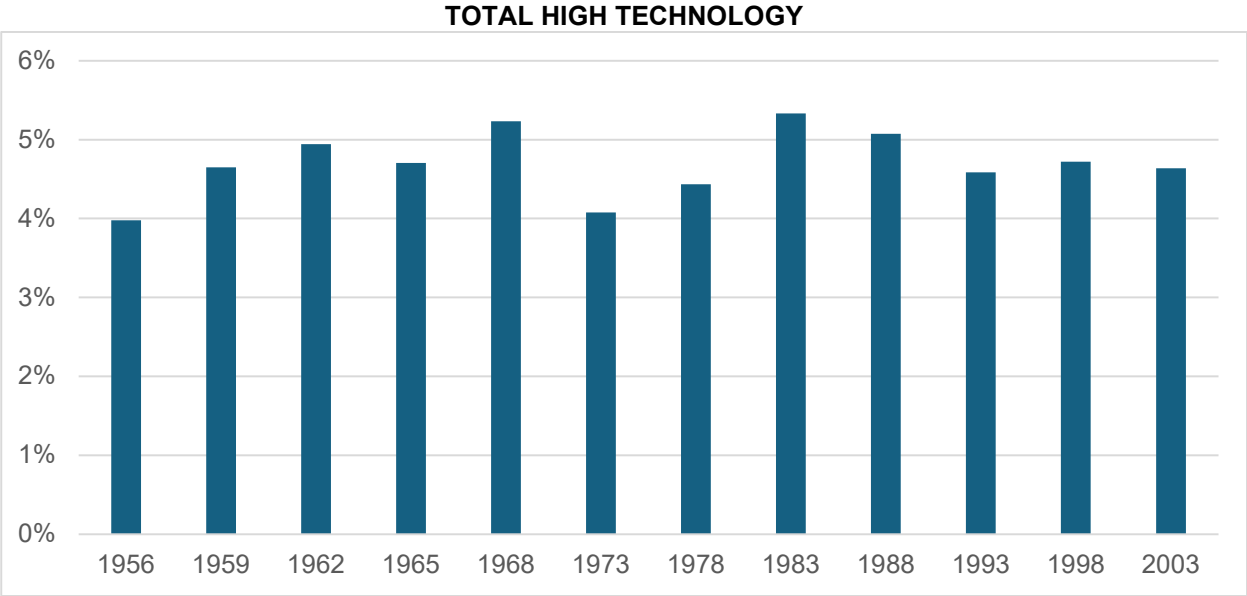
CHART 2
INDUSTRIAL HIGH-TECHNOLOGY SHARES OF TOTAL EMPLOYMENT NATIONALLY, 1956 TO 2003





(continued)

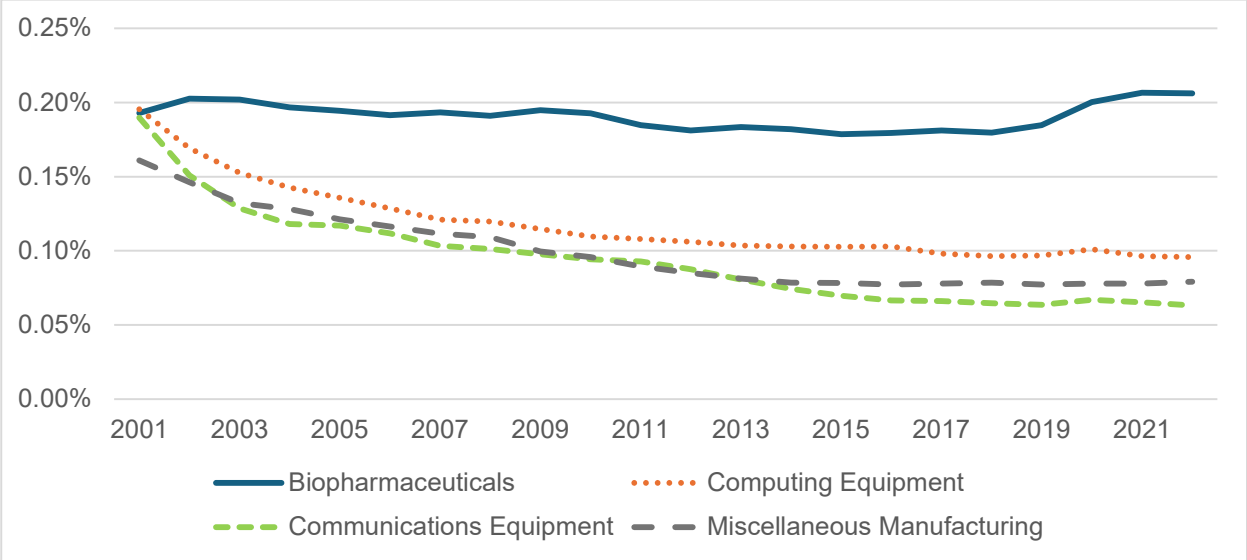
CHART 2 (continued)
INDUSTRIAL HIGH-TECHNOLOGY SHARES OF TOTAL EMPLOYMENT NATIONALLY, 1956 TO 2003

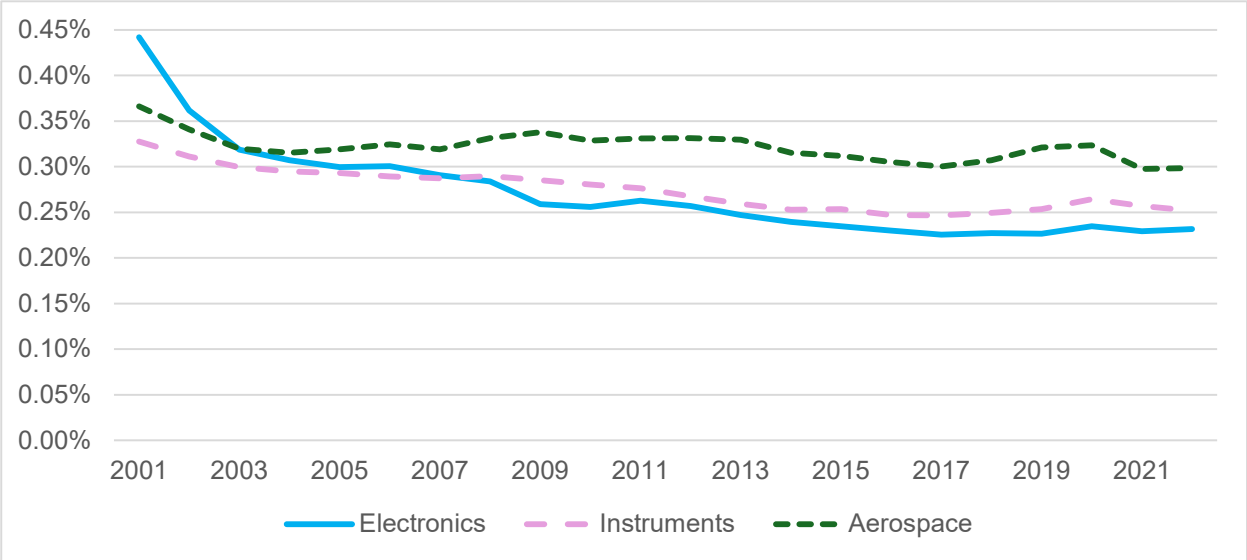


Source: Calculated from data from U.S. Department of Commerce, Census Bureau, County Business Patterns. High-technology categories defined by authors.

- Total High Tech. Based on employment, the overall high-tech share was erratic through the early 2000s. It has increased since then, from 4.1 percent in 2004 to 5.2 percent in 2022. Due to high earnings per worker in high-tech activities, the share based on aggregate earnings is much higher; it increased from 7.5 percent in 2004 to 10.4 percent in 2022.
- Biopharmaceuticals. There has been little change in the employment share throughout the 1956-to-2022 period. In 2022, the employment share was 0.21 percent; the aggregate earnings share was 0.42 percent.
- Computing Equipment. The employment share rose through 1983 but has fallen since. In 2022, the employment share was only 0.10 percent; the aggregate earnings share was 0.35 percent.
- Communications Equipment. The employment share was erratic but on net went down through 1983, and has fallen since. In 2022, the employment share was only 0.06 percent; the aggregate earnings share was 0.11 percent.
- Electronics. The employment share rose through 1968, was erratic from 1968 to 1983, and has dropped since. In 2022, the employment share was 0.23 percent; the aggregate earnings share was 0.46 percent.
- Instruments. The employment share was erratic but on net increased through 1988, but has fallen since. In 2022, the employment share was 0.25 percent; the aggregate earnings share was 0.44 percent.

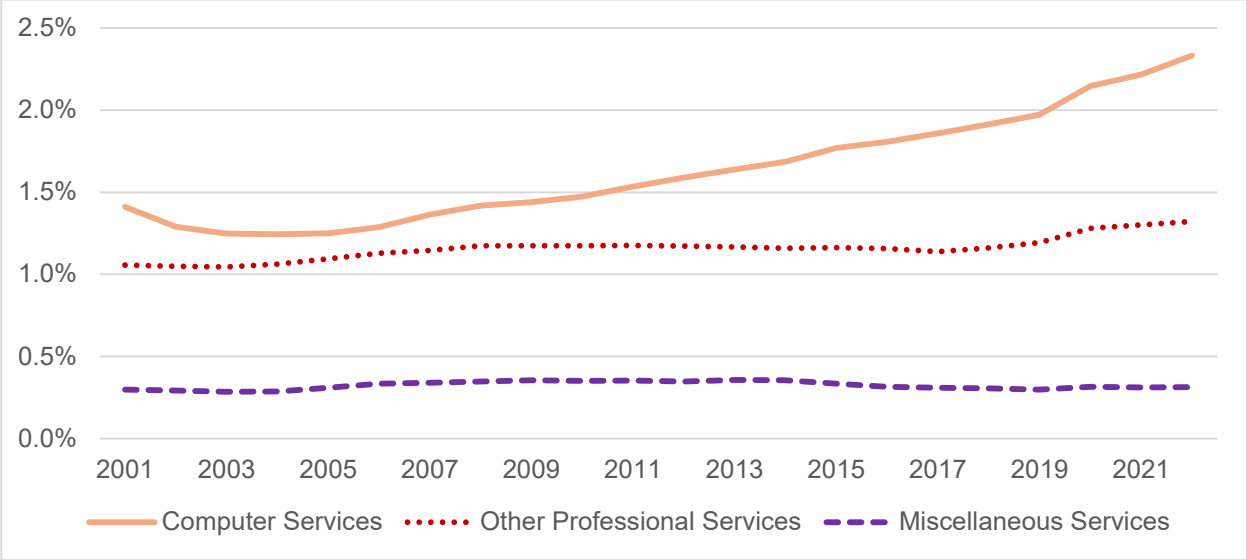
CHART 3
INDUSTRIAL HIGH-TECHNOLOGY SHARES OF TOTAL EMPLOYMENT NATIONALLY, 2001 TO 2022



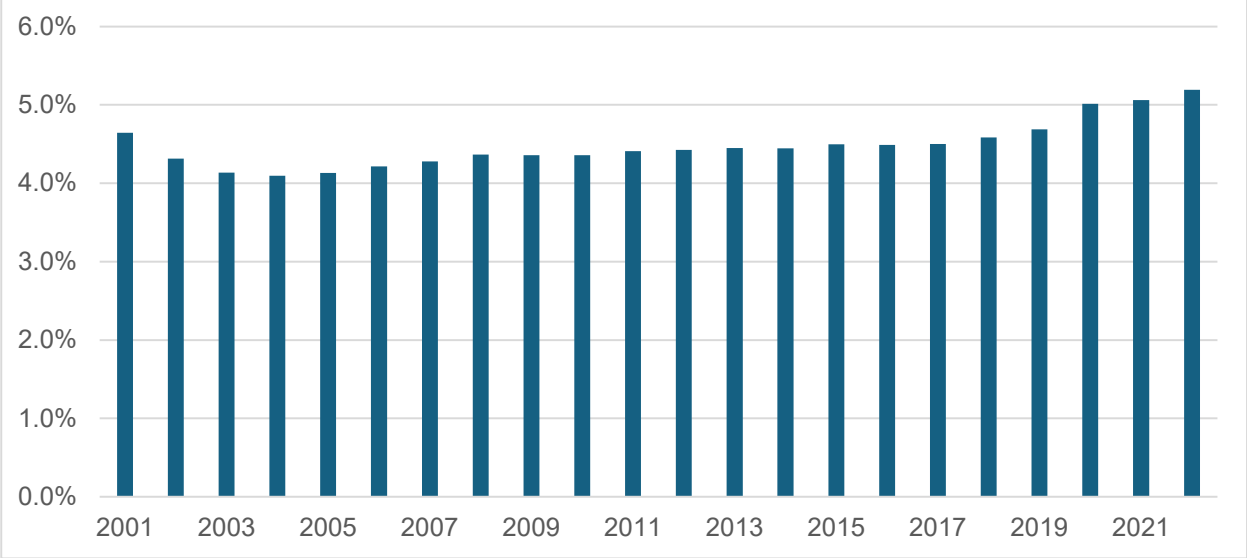


(continued)

CHART 3 (continued)
INDUSTRIAL HIGH-TECHNOLOGY SHARES OF TOTAL EMPLOYMENT NATIONALLY, 2001 TO 2022



TOTAL HIGH TECHNOLOGY



Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. High-technology categories defined by authors.

- Aerospace. The employment share was erratic but on net went down through 1988, dropped considerably from 1988 to 2003, and has continued to fall. In 2022, the employment share was 0.30 percent; the aggregate earnings share was 0.52 percent.
- Computer Services. The employment share has increased sharply since the earliest data in 1978. In 2022, the employment share was 2.33 percent; the aggregate earnings share was 5.10 percent.
- Other Professional Services. The employment share was erratic but on net advanced through 1978, and has increased since. In 2022, the employment share was 1.32 percent; the aggregate earnings share was 2.38 percent.

In 2022, including the miscellaneous services category, high-tech services accounted for 4.0 percent of total employment and represented 76 percent of the high-tech total. High-tech services accounted for 7.9 percent of total aggregate earnings and represented 76 percent of the high-tech total.

States

As explained in the introduction, this section focuses on the STEM industry shares of total employment in Arizona and in the seven other selected states relative to the national average.

Development of High-Technology Activities by Industrial Category. This subsection examines CBP data from 1956 to 1998, focused on the high-tech share of total employment relative to the national average. The analysis is limited to the eight selected states.

- Total High Tech. In the late 1950s, California, Maryland, and Washington were the leading states for overall high-tech activity. During the 1960s, Arizona became one of the leaders while Maryland dropped back. Massachusetts gradually moved up, ranking second by 1988. After 1988, Arizona fell precipitously, going from a rank of first in 1973 to a rank of seventh in 1998.
- Biopharmaceuticals. None of the eight states were an early leader in this category. It was not until the 1990s that shares regularly exceeded the national average in any of the eight states. Utah and Massachusetts were the leaders in 1998.
- Computing Equipment. By 1959, Arizona was the clear leader among the eight states; it continued to rank first through 1983. Massachusetts and California were the next to develop in this category, followed by Colorado in the late 1960s and Utah in the late 1970s. Arizona's activity in this category plummeted after 1983, ranking seventh by 1993 with a share well below the national average.
- Communications Equipment. Massachusetts and Maryland were the early leaders in this category, followed by California in the 1960s. Arizona's rank was erratic, sometimes among the leaders.
- Electronics. In 1959, Massachusetts was the leader, followed by Arizona and California. Arizona ranked first beginning in 1962, with California and Massachusetts alternating between second and third.
- Instruments. As with electronics, Massachusetts was the leader in 1959 but was surpassed by Arizona by 1962. Arizona ceased being a leader after 1973, with its rank falling to seventh by 1998. California was the other early leader, joined by Colorado during the 1970s.

- Aerospace. Beginning in 1956, Washington was dominant in this category. California also was strong starting in 1956. Utah was the next state to develop substantial activity, followed by Arizona after 1973. By the 1990s, Arizona ranked second to Washington.
- Professional Services Other Than Computer Services. California, Maryland, and Massachusetts were the early leaders. Virginia joined the leaders in the 1970s as California dropped back.
- Computer Services. Data for this category begins in 1978. Maryland and Virginia were the early leaders, later joined by Massachusetts.

Arizona. The high-tech share of total employment in Arizona as a percentage of the national high-tech share of total employment for 1956 through 2003 is displayed in Chart 4. The sum of the eight categories shows strong high-tech growth in Arizona relative to the nation between 1959 and 1968. However, after 1973, Arizona's high-tech share fell relative to the nation. Four of the eight categories — all manufacturing — followed this up-and-down pattern: computing equipment, electronics, instruments, and communications equipment.

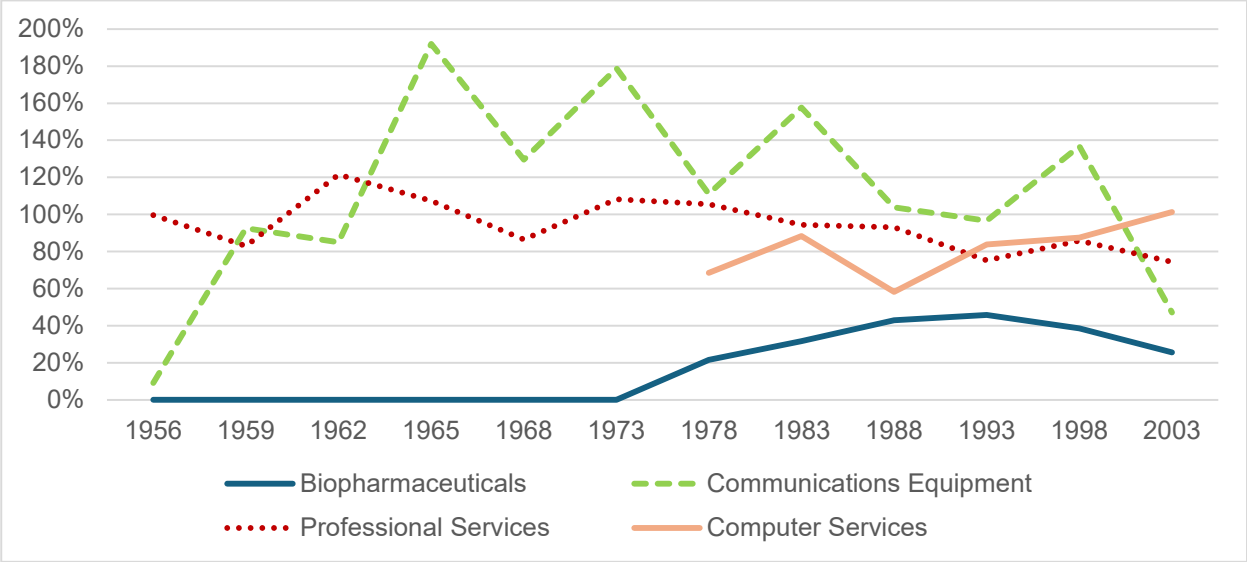
Arizona ranked first or second among the eight comparison states on the total high-tech share from 1968 through 1983, and third or higher from 1962 through 1988. Its strength, however, was strictly in manufacturing, particularly in computing equipment, electronics, and instruments. The concentration in computing equipment and instruments did not last, though gains in aerospace after 1973 helped to cushion the losses in these two categories. As Arizona's overall high-technology activity declined relative to both the nation and the comparison states, Arizona became identified as a second-tier high-tech state. By 1998, it ranked seventh among the eight states, ahead of only Utah.

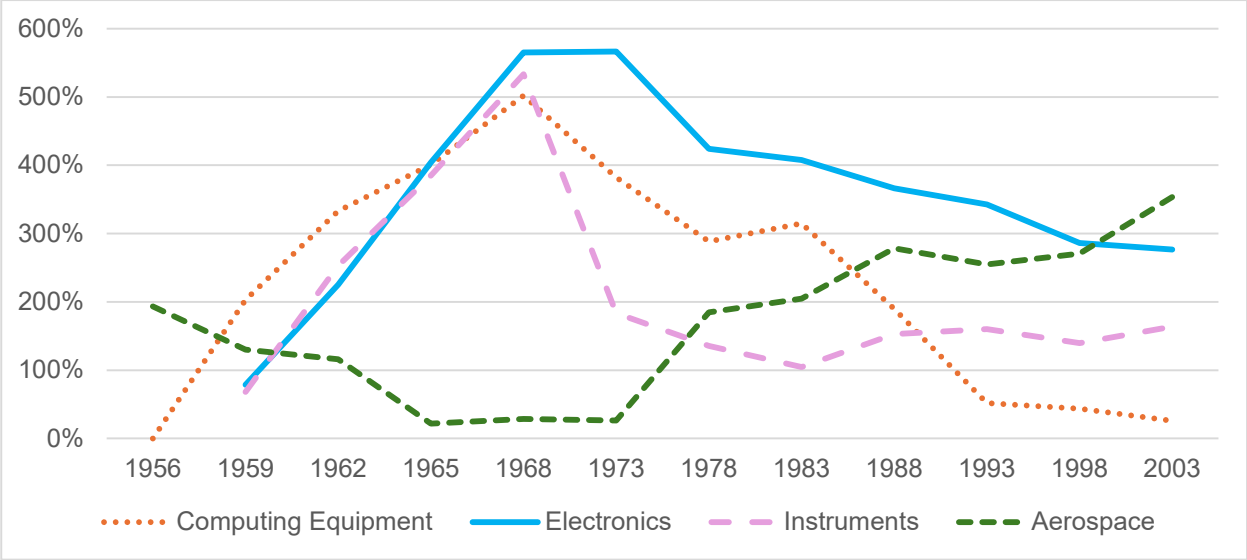
Annual data for 2001 through 2022 from Lightcast are displayed in Chart 5 for Arizona relative to the nation for each of 10 high-tech categories. Since high tech from the Lightcast data is defined strictly by industry, the Arizona figures as a percentage of the national average for 2003 do not match those from the CBP, which is defined largely by industry group. Using the Lightcast data, the percentages of the United States are higher in some categories, particularly computing equipment and electronics, and lower in other categories, especially computer services.

In 2022, Arizona's overall high-tech employment share was the lowest of the eight states, barely higher than the national average. The overall high-tech aggregate earnings share also was the lowest, a little below the U.S. average. Arizona remained strong in electronics (ranked first) and aerospace (ranked second), but its share was below average in each of the other eight primary categories, ranking between sixth and eighth in each.

The following summary of the high-tech share of total employment in Arizona relative to the national average combines data from CBP and Lightcast. Aggregate earnings information for 2001 to 2022 supplements the employment summary. Ranks and leading states are expressed as among the eight comparison states:

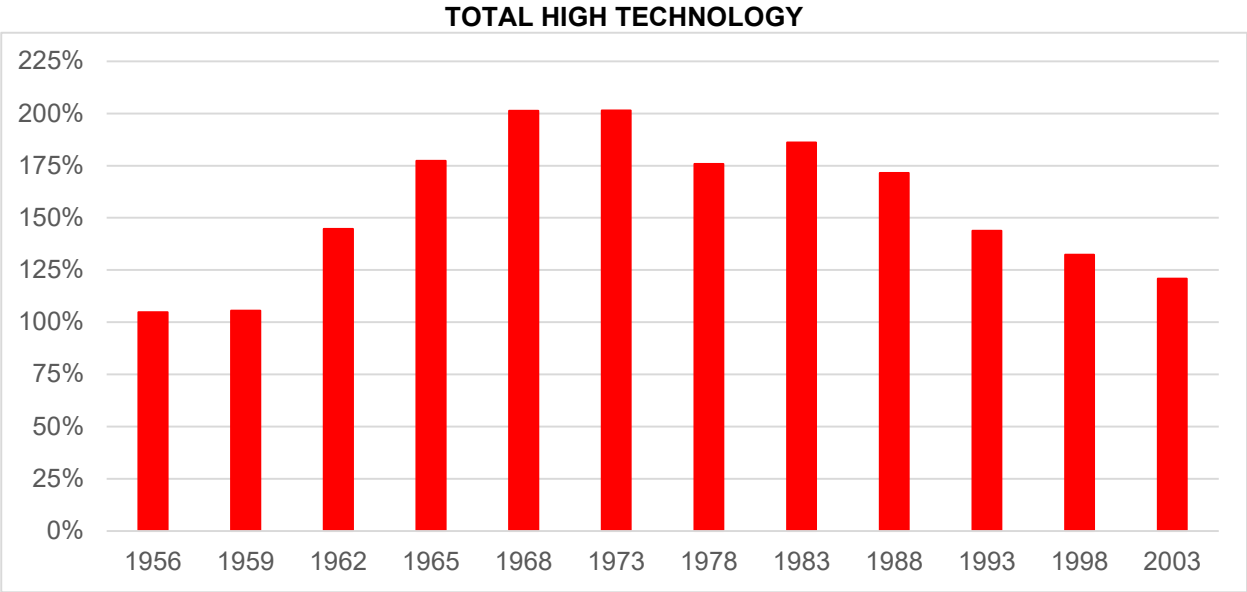
CHART 4
INDUSTRIAL HIGH-TECHNOLOGY SHARES OF TOTAL EMPLOYMENT IN ARIZONA AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES OF TOTAL EMPLOYMENT NATIONALLY, 1956 TO 2003





(continued)

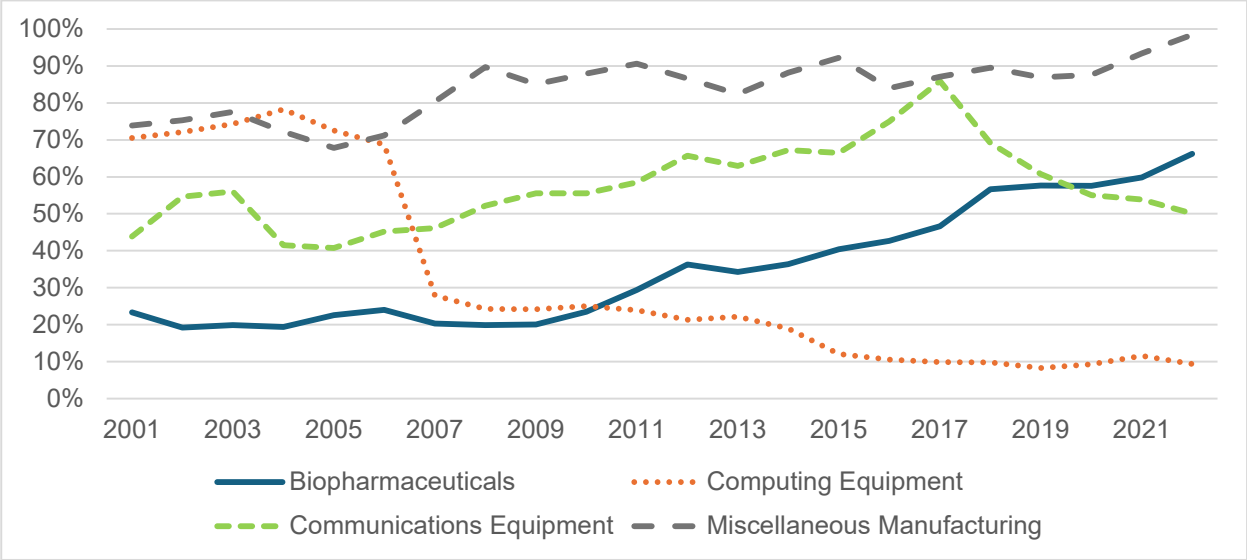
CHART 4 (continued)
INDUSTRIAL HIGH-TECHNOLOGY SHARES OF TOTAL EMPLOYMENT IN ARIZONA AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES OF TOTAL EMPLOYMENT NATIONALLY, 1956 TO 2003

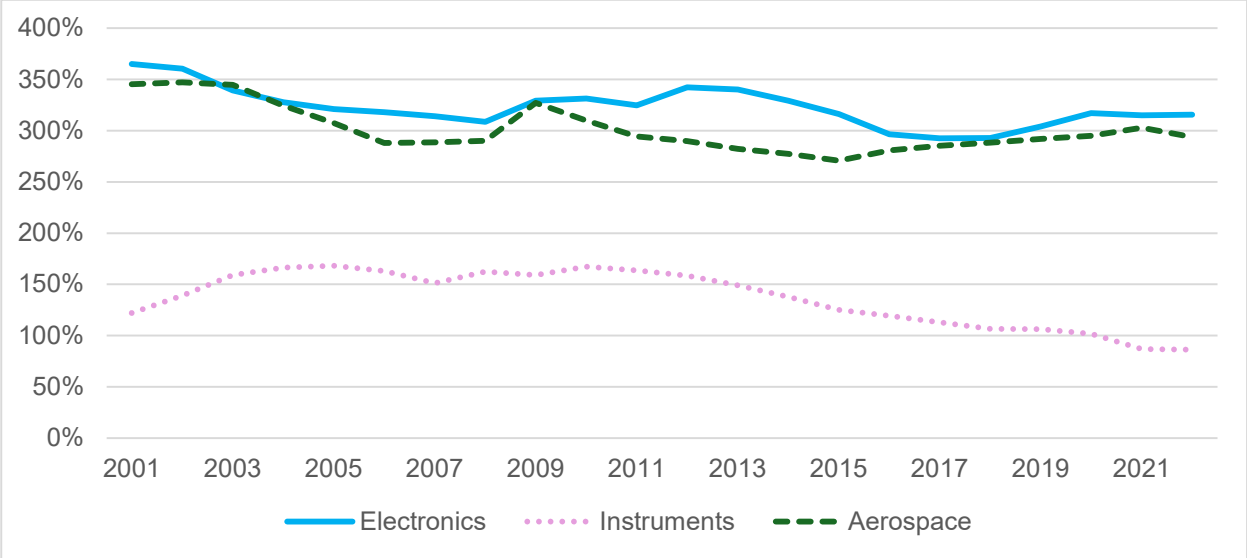


Source: Calculated from data from U.S. Department of Commerce, Census Bureau, County Business Patterns. High-technology categories defined by authors.

- Total High Tech (including the miscellaneous categories since 2001). Arizona's overall high-tech employment share relative to the national average rose from 1959 to 1968, reaching to twice the U.S. average. It has declined since 1973, dropping by 2022 to barely above the national average. In 2022, it was a little below the U.S. average based on aggregate earnings. In the late 1950s, California and Washington led the high-tech evolution, though in Washington only the aerospace category was among the leaders. By the 1990s, Massachusetts had surpassed California. In recent years, Washington and Massachusetts have led the eight states, followed by California and Colorado.
- Biopharmaceuticals. While Arizona's employment share relative to the nation increased somewhat in the 1970s and 1980s, the percentage of the national average remained quite low. Activity began to increase more vigorously in 2010, with the percentage of the national average rising from 20 percent in 2009 to 66 percent in 2022. The aggregate earnings share also increased relative to the nation, but only from 11 percent in 2009 to 38 percent in 2022. Based on employment, Arizona generally ranked seventh or eighth from 1978 through 2016; since then, it has ranked sixth, ahead of Virginia and Washington. Based on aggregate earnings, the rank also improved from eighth to sixth. The leaders among the eight states varied from 1956 through 2003, but California and Maryland consistently ranked above the middle. More recently, Utah has led the eight states based on employment, followed by California, Maryland, and Massachusetts. In recent years, Maryland has been the leader on aggregate earnings.

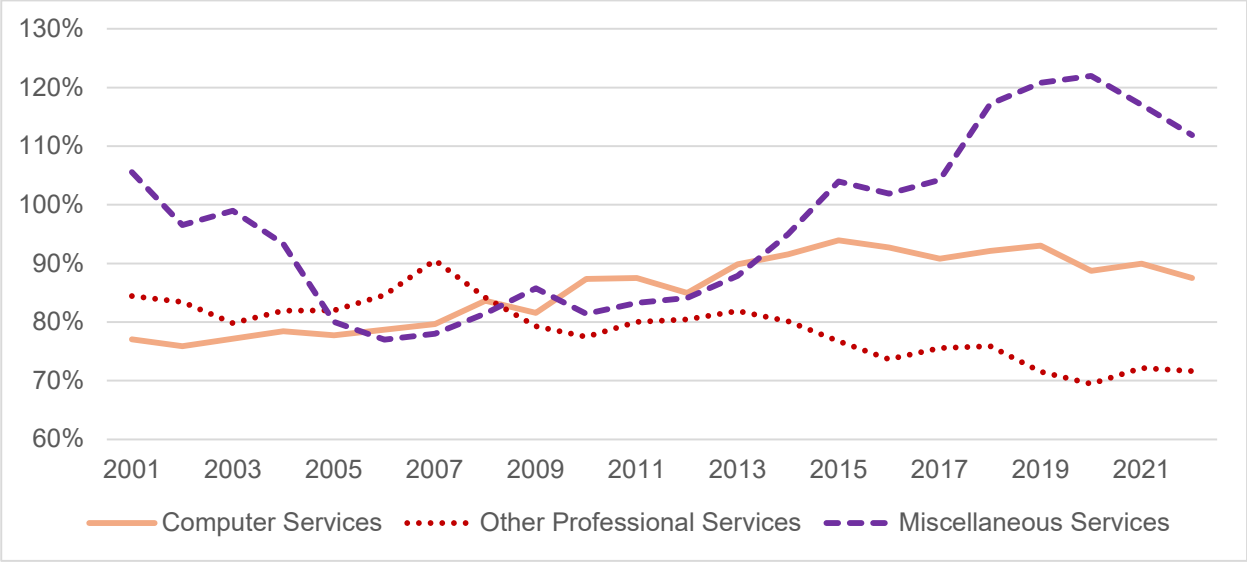
CHART 5
INDUSTRIAL HIGH-TECHNOLOGY SHARES OF TOTAL EMPLOYMENT IN ARIZONA AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES OF TOTAL EMPLOYMENT NATIONALLY, 2001 TO 2022

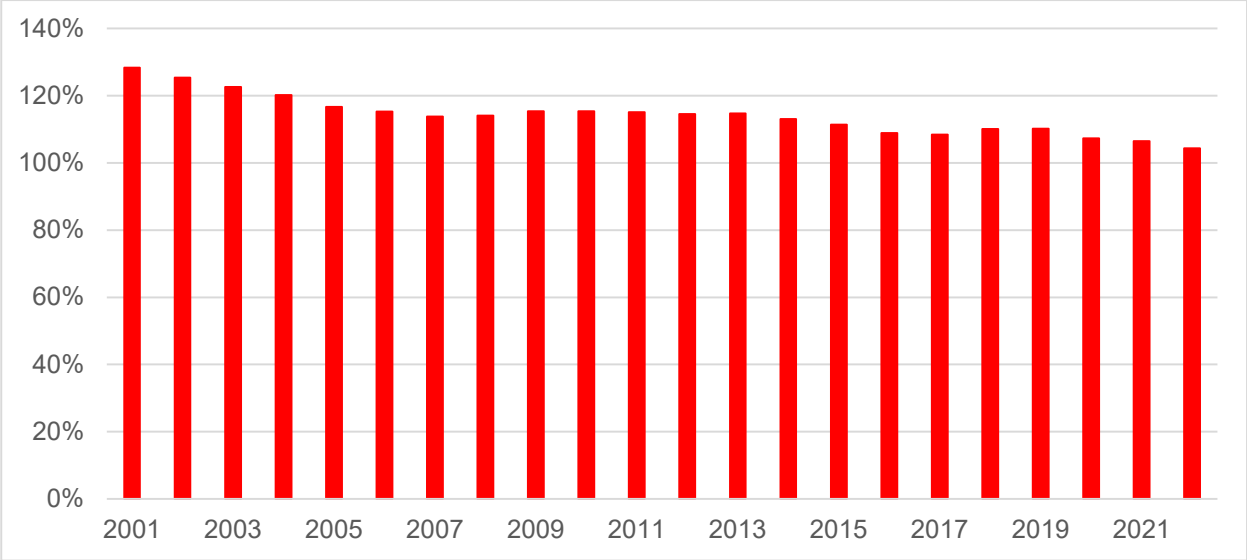




(continued)

CHART 5 (continued)
INDUSTRIAL HIGH-TECHNOLOGY SHARES OF TOTAL EMPLOYMENT IN ARIZONA AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES OF TOTAL EMPLOYMENT NATIONALLY, 2001 TO 2022





Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. High-technology categories defined by authors.

- Computing Equipment. Arizona's employment share climbed substantially relative to the nation between 1956 and 1968, reaching a level five times the national average. However, Arizona's share subsequently fell sharply, dropping below the U.S. average by 1993. It has continued to decline, to only 9 percent of the U.S. average in 2022. The aggregate earnings share in 2022 was even lower at 4 percent of the U.S. average. Arizona ranked first or second among the eight states from 1959 through 1983, but generally has ranked seventh in recent years on both measures, ahead of Maryland. California and Massachusetts have been consistently among the leaders; Colorado joined the leaders beginning in 1983.
- Communications Equipment. Arizona's employment share rose considerably relative to the nation between 1956 and 1965, reaching a level nearly twice the U.S. average. Arizona's relative share subsequently declined, falling well below the national average by 2001. Since then, it has fluctuated without trend. Based on employment, it was 50 percent of the U.S. average in 2022; the aggregate earnings figure was 37 percent of average. Arizona ranked as high as second in 1965 and 1973, but its rank since 2001 has been seventh or eighth based on both measures. California and Massachusetts have been consistently among the leaders; Maryland joined the leaders after 2001.
- Electronics. Arizona's employment share advanced substantially relative to the nation between 1959 and 1968, reaching a level more than five times the national average. Arizona's share declined after 1973, though it has remained at least three times the U.S. average; the employment share was 3.16 times the national average in 2022 and the aggregate earnings share was higher at 3.83 times the average. Arizona has ranked among the leaders since 1956, including first among the eight states since 1965. California and Massachusetts also have been consistently among the leaders.
- Instruments. Arizona's employment share climbed substantially relative to the nation between 1959 and 1968, reaching a level more than five times the national average. However, Arizona's relative share declined considerably from 1968 through 1983. The share has dropped further in the last decade, to below the national average (86 percent of average based on employment, and 83 percent of average based on aggregate earnings, in 2022). Arizona ranked among the leaders from 1959 through 1973, but the rank has dropped in recent years to sixth based on aggregate earnings and seventh based on employment. Massachusetts ranked first or second throughout the 1956-to-1998 period and has been first since then.
- Aerospace. Arizona's share has been well above the national average since 1978, reaching a level more than triple the U.S. average. In 2022, Arizona's share was 2.94 times the national average based on employment and 3.23 times higher based on aggregate earnings. Arizona generally has ranked second among the eight states since 1978. Washington led the eight states by a wide margin throughout the 1956-to-2022 period.
- Computer Services. The earliest data are for 1978. Arizona's employment share has been below the national average throughout the period, by 12 percent in 2022; the aggregate earnings shortfall in 2022 was 25 percent. Arizona has ranked last among the eight states since 1988. In recent years, Virginia and Washington have led the eight states.
- Other Professional Services. Arizona's employment share ranged from somewhat higher to somewhat lower than the national average from 1956 through 1998. It has been lower since then, by 28 percent in 2022; it was 36 percent below average based on aggregate

earnings. In most years through 1998, Arizona ranked seventh or eighth among the eight states; it generally has been last since 2001 on both measures. In recent years, Maryland and Massachusetts have been the leaders among the eight states.

As discussed in the Literature Review section, initial reasons for the development of most high-technology clusters were either arbitrary or no longer are of relevance. This certainly is true in Arizona. The development of the aerospace, electronics, and related high-tech clusters in Arizona in the 1950s and 1960s largely was the result of Arizona's climate and the affordability and availability of large parcels of private land. In addition, the federal government and a supportive congressional delegation helped to channel Department of Defense funding into the state, helping to attract Motorola's research division shortly after WWII to develop and manufacture transistors for the U.S. military.

Reasons for the subsequent decline in most high-tech activities are speculative, but Arizona has long compared unfavorably in various business location factors. Correcting these deficiencies was the focus of the early 1990s project "Creating a 21st Century Economy: Arizona's Strategic Plan for Economic Development."

While Arizona's aerospace and semiconductor manufacturing remain among the national leaders, Arizona's other early superlative high-tech activities — communications equipment, electronics other than semiconductors, computing equipment, and instruments — have declined sharply, with shares currently below the national average. Arizona also is below average, and last among the eight states, in the computing services and other professional services categories. These two growing high-tech activities accounted for just more than 70 percent of the total U.S. high-tech employment in 2022. They accounted for only 55 percent in Arizona. Arizona's share of these two services categories combined in 2022 was 18 percent below the national average based on employment and 28 percent below average based on aggregate earnings.

Recent announcements regarding semiconductor manufacturing in Metro Phoenix should result in a rebound in that activity relative to the nation. However, this will only increase the state's dependence on just two high-tech activities. Moreover, many of the new manufacturing jobs will be in production occupations that do not require substantial educational attainment and will not be high-paying jobs. The state needs to diversify its high-tech base, particularly in the growing services categories, with a focus on high-tech jobs that pay well and utilize substantial educational attainment.

Even if the new semiconductor facilities and the activities of its suppliers eventually result in tens of thousands of new jobs, this will represent only a fraction of the state's projected employment of 4 million in 2034. In a state as large as Arizona, and one that is still growing, primarily with mediocre jobs, the new high-tech operations will have only a small positive impact on the various measures on which Arizona compares unfavorably, such as per capita gross domestic product and per capita income.

Other States. A summary of the development of industrial high-tech activities by category in the seven comparison states follows, primarily based on the employment share relative to the

national average; ranks are among the eight selected states. Aggregate earnings information for 2001 to 2022 supplements the employment summary.

California

- Total High Tech. California was one of the early high-tech leaders, ranking no lower than third from 1956 to 1993. It had broad strength; by 1962, its share was higher than the U.S. average in every category except biopharmaceuticals. The employment share was more than double the U.S. average from 1956 to 1962, but gradually dropped to about 50 percent above average, where it has held since 2001. It was 46 percent above average in 2022. Over the last two decades, California has generally ranked third or fourth. Based on aggregate earnings, the share rose from 54 percent higher than the U.S. average in 2002 through 2004 to 72 percent above average in 2022. The rank moved from fourth to third. In 2022, its share exceeded the U.S. average in each of the eight major high-tech categories.
- Biopharmaceuticals. The employment share gradually rose relative to the national average, surpassing it in 1988, and peaking at 48 percent above average in 2017. The share was only 15 percent higher than the U.S. average in 2022. California generally ranked second or third, but dropped to fourth in 2022. Based on aggregate earnings, the share peaked at 67 percent above average in 2009 but was only 18 percent above average in 2022. The rank dropped from first to fourth.
- Computing Equipment. The employment share increased relative to the national average, surpassing it in 1962, rising to 4.3 times the U.S. average in 2022. California generally ranked second or third, but has been first since 2011. Based on aggregate earnings, the share reached to 4.85 times the U.S. average in 2022; the rank improved from third to first.
- Communications Equipment. The employment share gradually advanced relative to the national average, surpassing it in 1959. It reached a level 2.2 times the U.S. average in 2012; it was 83 percent above average in 2022. California mostly ranked second or third, but generally was first starting in 2009. Based on aggregate earnings, the share reached to 2.36 times the U.S. average in 2011, but was down to 92 percent above average in 2022. The rank was first or second starting in 2005.
- Electronics. The employment share, which was already above average in 1959, gradually rose relative to the national average, peaking at a level 2.4 times the U.S. average in 1983. Since then it has ranged from 1.8-to-2.1 times the U.S. average; the ratio was down to 1.82 in 2022. California ranked second or third in every year. Based on aggregate earnings, the share reached to 2.4 times the U.S. average in 2021 and 2022. The rank was second in each year.
- Instruments. The employment share, which was already above average in 1959, rose a little more relative to the U.S. average, peaking at 2.1 in the 2000s. It was 97 percent higher than the U.S. average in 2022. California generally has ranked second or third. Based on aggregate earnings, the share was 2.3 times the U.S. average in 2001, then dropped but rebounded to 2.06 times higher in 2022. The rank slipped from second to fourth but was third in 2022.
- Aerospace. The employment share was 3.8 times the U.S. average in 1956, but gradually fell to 21 percent above average in 2019. It was 30 percent above average in 2022. California ranked second or third before 2000 and fourth since. Based on aggregate

earnings, the share dropped from 37 percent higher than the U.S. average in 2004 to 18 percent above average in 2022. The rank generally was fourth.

- Computer Services. The employment share was highest in 1978 at 1.5 times the U.S. average. It was 36 percent above average in 2022. California ranked as high as third in 1983, but generally has ranked seventh since 2001. Based on aggregate earnings, the share increased from 29 percent above average in 2003 to 66 percent above average in 2022. The rank advanced from seventh to third.
- Other Professional Services. The employment share increased substantially in the late 1950s and 1960s, reaching a peak at 2.8 times the U.S. average in 1968. The relative share dropped back considerably over the next decade. The share has been 20-to-30 percent above average since then. California ranked first or second through 1983, but has ranked fifth or sixth since. Based on aggregate earnings, the share rose from 19 percent above average in 2005 to 44 percent above average in 2022. The rank advanced from sixth to third.

Colorado

- Total High Tech. Colorado was not an early high-tech state. The employment share was considerably below average during the 1950s, then gradually rose to 62 percent above average in 2001; it was 51 percent above average in 2022. Colorado ranked as low as eighth during the 1950s and 1960s; it has ranked between third and sixth since the 1990s. Based on aggregate earnings, the share peaked at 61 percent above average in 2001 but was 41 percent above average in 2022. The rank slipped from third to fourth. In 2022, Colorado's share exceeded the U.S. average in three categories on both employment and aggregate earnings: instruments and the two services categories.
- Biopharmaceuticals. The employment share relative to the national average was quite low through 1983, rose to about 40 percent below average in 1993, held there through 2016, then rose to 17 percent less than the U.S. average in 2022. Colorado generally has ranked fifth. Based on aggregate earnings, the share generally has been 40-to-55 percent below average; it was 47 percent below average in 2022. The rank usually was fifth.
- Computing Equipment. The employment share relative to the national average was quite low through 1965, then jumped to above the national average. It peaked at 3.4 times the U.S. average in 1988, held near that level through 2004, then dropped considerably to 17 percent higher than the U.S. average in 2022. The rank went from tied for last to first; it has been third since 2005. Based on aggregate earnings, the share peaked at 3.25 times the U.S. average in 2003 but was 16 percent below average in 2022. The rank dropped from first to third.
- Communications Equipment. The employment share relative to the national average was quite low through 1968, then gradually advanced relative to the national average, slightly surpassing it at its peak. It was 6 percent below average in 2022. The rank improved from last to as high as third; Colorado has ranked fifth or sixth since 2003. Based on aggregate earnings, the share peaked at 7 percent above average in 2004 but was 20 percent below average in 2022. The rank mostly has been fifth.
- Electronics. The employment share relative to the national average was quite low through 1978, then advanced to 19 percent above average in 1998. It has gradually declined relative to the national average since then, dropping to 34 percent below the U.S. average in 2022. The rank improved from seventh to fourth, but has been sixth since 2014. Based

on aggregate earnings, the share was highest at 2 percent below average in 2002 but was 54 percent below average in 2022. The rank dropped from fourth to sixth.

- Instruments. The employment share relative to the national average was quite low through 1965, then jumped to twice the national average in 1983. The share has fluctuated at a lower level since then; it was 61 percent higher than the U.S. average in 2022. The rank improved from sixth to as high as second, but has been fifth or sixth since 2004. Based on aggregate earnings, the share has varied from 37-to-77 percent above average; it was 63 percent above average in 2022. The rank has been fifth or sixth since 2004.
- Aerospace. The employment share fluctuated at mostly below average until 1983. It was near the U.S. average through the 1990s and has generally been a little below average since then; it was 8 percent below average in 2022. Colorado has ranked fifth or sixth since 1978. Based on aggregate earnings, the share has ranged from near the U.S. average to about 20 percent above average, it was 17 percent above average in 2022. The rank mostly has been fifth.
- Computer Services. The employment share was above the U.S. average in 1978 and rose further, peaking at twice the U.S. average in 2001. It has dropped back since then to 69 percent above average in 2022. The rank improved from sixth to second, dropped to fifth, but was third in 2022. Based on aggregate earnings, the share peaked at twice the U.S. average in 2001 but was 60 percent above average in 2022. The rank slipped from third to fourth.
- Other Professional Services. The employment share was already above the U.S. average in 1956 and rose somewhat higher. It has been 50-to-70 percent above average since the 1990s. The rank varied from second to sixth prior to 2002; since then it has been third or fourth. Based on aggregate earnings, the share peaked at 85 percent above average in 2007 but was 43 percent above average in 2022. The rank dropped from first to fourth.

<u>Maryland</u>

- Total High Tech. In the 1950s, Maryland ranked third, on the strength of its communications equipment and aerospace categories. Aerospace quickly dropped off sharply, lowering the state's overall rank generally to fifth or sixth. The employment share has been above average except in 1962, by 30-to-50 percent since 1983. It was 43 percent above average in 2022. Based on aggregate earnings, the share has ranged from 23-to-38 percent above average since 2001; it was 23 percent above average in 2022. The rank has been sixth or seventh. In 2022, Maryland ranked near the top in four categories (biopharmaceuticals, communications equipment, instruments, and other professional services) but seventh or eighth in the other four categories.
- Biopharmaceuticals. The employment share was below the national average until the 1990s, near the average through 2006, and then rose to 74 percent higher than the U.S. average in 2022. The rank improved from fourth to second. Based on aggregate earnings, the share advanced from 32 percent below average in 2002 to twice the average in 2022. The rank climbed from fifth to first.
- Computing Equipment. The employment share has been much lower than the national average since 1956. It was 92 percent lower than the U.S. average in 2022. The rank has ranged from sixth to eighth since 1965. Based on aggregate earnings, the share dropped

from 76 percent below average in 2007 to 97 percent below average in 2022. The rank slid from sixth to last.

- Communications Equipment. The employment share was higher than the national average from 1956 to 1983 and has been considerably above average since 1998. It was 73 percent above average in 2022. The rank generally has been second or third since 2001. Based on aggregate earnings, the share has ranged from 34-to-98 percent above average; it was 69 percent above average in 2022. The rank has varied from first to third.
- Electronics. The employment share relative to the national average has consistently been quite low. It was 76 percent below the U.S. average in 2022. The rank has been seventh or eighth since 1978. Based on aggregate earnings, the share dropped from 69 percent below average in 2002 and 2003 to 88 percent below average in 2022. The rank was eighth in every year.
- Instruments. The employment share was considerably below the national average through 1983, then jumped to more than twice the national average in 1988 and 1993. After dropping back relative to the average, the share climbed higher in recent years to 2.1 times higher than the U.S. average in 2022. The rank had been as low as sixth but climbed to second in 2021 and 2022. Based on aggregate earnings, the share advanced from 46 percent above average in 2003 to 2.29 times the average in 2022. The rank improved from fifth to second.
- Aerospace. The employment share was more than double the U.S. average in the 1950s but quickly fell to considerably below average, where it has remained. It was 71 percent below average in 2022. The rank dropped from third to seventh. Based on aggregate earnings, the share peaked at 44 percent below average in 2010 but was 76 percent below average in 2022. The rank was seventh in every year.
- Computer Services. The employment share was triple the U.S. average in 1978 but has gradually declined to 47 percent above average in 2022. The rank dropped from first to sixth. Based on aggregate earnings, the share peaked at 69 percent above average in 2004 but was only 18 percent above average in 2022. The rank slid from fifth to seventh.
- Other Professional Services. The employment share was above average in 1956 and has been considerably above the U.S. average since 1962. It was 78 percent above average in 2022. The rank has been first or second in every year since 1962. Based on aggregate earnings, the share peaked at 87 percent above average in 2004 but was 58 percent above average in 2022. The rank slipped from first to second.

Massachusetts

- Total High Tech. Massachusetts ranked fourth from 1956 through 1973, but has since climbed in the rankings to first on employment and second on aggregate earnings in 2022. The employment share has been above average since 1956 and has been 70-to-90 percent above average since 1978. It was 83 percent above average in 2022. Massachusetts has ranked first or second since 1988. Based on aggregate earnings, the share has been between 70-and-86 percent above average; it was 81 percent above average in 2022. The rank was second in every year. In 2022, the share exceeded the national average in each category except aerospace, ranking among the top three in six categories.
- Biopharmaceuticals. The employment share was considerably below the U.S. average through 1988 but has been above average since. The share was 26 percent higher than

average in 2022. The rank has varied from second to fourth since 1993. Based on aggregate earnings, the share has fluctuated from average to about 40 percent above average; it was 35 percent above average in 2022. The rank has varied from first to fourth.

- Computing Equipment. The employment share was less than the national average in the 1950s, but quickly rose to triple the average. It has dropped back in recent years, to 68 percent higher than the U.S. average in 2022. The rank generally has been second since 1962. Based on aggregate earnings, the share peaked at 2.82 times the U.S. average in 2001 but was just 5 percent above average in 2022. The rank has been second in every year since 2002.
- Communications Equipment. The employment share was considerably higher than the national average in 1956 and remained well above average through the 2000s, but was down to 37 percent above average in 2022. The rank generally was first or second, but has been third since 2017. Based on aggregate earnings, the share peaked at 2.6 times the U.S. average in 2004 but was only 27 percent above average in 2022. The rank slipped from first to third.
- Electronics. The employment share was more than triple the national average in the 1950s but has gradually dropped back to 60 percent above the U.S. average in 2022. Massachusetts ranked first in the 1950s but has ranked third since the 1970s. Based on aggregate earnings, the share peaked at 77 percent above average in 2010 but was 23 percent above average in 2022. The rank was third in every year.
- Instruments. The employment share increased from 1.9 times the national average in the 1950s to nearly triple the average; it was 2.66 times higher than the U.S. average in 2022. The rank has been first since 1993. Based on aggregate earnings, the share has been from 2.4-to-2.6 times higher than the U.S. average. The rank was first in every year.
- Aerospace. The employment share was considerably less than the U.S. average in the 20th century, slightly exceeded the average during the 2000s, and has since fallen back to 16 percent below average in 2022. The rank has been fifth or sixth. Based on aggregate earnings, the share peaked at 14 percent above average in 2003 but was 18 percent below average in 2022. The rank slipped from fifth to sixth.
- Computer Services. The employment share has been higher than the U.S. average throughout, peaking at double the average in the 1990s. It was 60 percent above average in 2022. The share has ranged from third to fifth. Based on aggregate earnings, the share peaked at 93 percent above average in 2010 but was 52 percent above average in 2022. The rank slid from third to fifth.
- Other Professional Services. The employment share has been considerably above the U.S. average throughout but has increased in recent years to 2.5 times the average in 2022. The rank generally was third or fourth during the 20th century, but has been first in recent years. Based on aggregate earnings, the share rose from 23 percent below average in 2001 to 49 percent above average in 2022. The rank improved from third to first.

<u>Utah</u>

- Total High Tech. Utah was not an early high-tech state, with its overall high-tech share not exceeding the U.S. average until 1983. The employment share was considerably below average from 1956 through 1962, but then rose to approximately 25 percent above average since 1983. It was 36 percent above average in 2022. The rank edged up from

last to seventh. Based on aggregate earnings, the share generally has been about 15 percent above average since 2001 but was 25 percent above average in 2022. The rank improved from last to sixth. In 2022, the share exceeded the U.S. average in four of the eight categories; Utah was among the leaders in biopharmaceuticals.

- Biopharmaceuticals. The employment share was far below the national average from 1956 through 1988, then quickly rose, surpassing the average in 1998, and reaching to 2.2 times higher than the U.S. average in 2022. The rank went from tied for last to first. Based on aggregate earnings, the share peaked at 51 percent above average in 2016 and was 33 percent above average in 2022. The rank has varied from second to fourth.
- Computing Equipment. The employment share was much less than the national average through 1973, but quickly rose to more than double the average. It dropped back sharply after the 1990s to 39 percent lower than the U.S. average in 2022. The rank improved from tied for last to fourth; it has been between fourth and sixth in the last two decades. Based on aggregate earnings, the share fell from 14 percent above average in 2001 to 85 percent below average in 2022. The rank has varied from fourth to sixth.
- Communications Equipment. The employment share was far lower than the national average from 1956 through 1962; since then it has fluctuated from above average to below average; it was 23 percent below average in 2022. The rank dropped from fourth in the 2000s to sixth. Based on aggregate earnings, the share peaked at 23 percent above average in 2006 but was 46 percent below average in 2022. The rank dropped from fourth to sixth.
- Electronics. The employment share was considerably less than the national average from 1956 to 1978. Since then it has fluctuated from above to below the U.S. average. It was 20 percent below the U.S. average in 2022. The rank has been fourth or fifth. Based on aggregate earnings, the share was near average from 2007 through 2015 but was 41 percent above below average in 2022. The rank has been fourth or fifth.
- Instruments. The employment share was far less than the national average from 1956 through 1983, but it has exceeded the average since 1998. It was 81 percent higher than the U.S. average in 2022. The rank improved from last to as high as second, but was fourth in 2022. Based on aggregate earnings, the share peaked at 2.3 times the U.S. average in 2013 and was 75 percent above average in 2022. The rank improved from seventh to as high as second, but was fourth in 2022.
- Aerospace. The employment share was considerably less than the U.S. average in 1956, but quickly rose to more than double the national average. It was 93 percent above average in 2022. The rank advanced from last to as high as second; it has been third since 2001. Based on aggregate earnings, the share fell but then rebounded to 98 percent above average in 2022. The rank was third in every year from 2001 through 2022.
- Computer Services. The employment share increased from less than the U.S. average in 1978 and 1983 to 55 percent above average in 2022. The rank improved from seventh to fifth. Based on aggregate earnings, the share has been 30-to-50 percent above average since 2001. The rank has been sixth or seventh.
- Other Professional Services. The employment share has risen from below the U.S. average during most of the 20th century to near average. It was 7 percent above average in 2022. The rank inched up from last to seventh. Based on aggregate earnings, the share has been 5-to-15 percent below average. The rank primarily has been seventh.

Virginia

- Total High Tech. Virginia was not an early high-tech state, with its overall high-tech share not exceeding the U.S. average until 1988. The employment share advanced to 58 percent above average in 2010; it was 41 percent above average in 2022. The rank improved from last to third, but was down to sixth in 2022. Based on aggregate earnings, the share reached 60 percent above average in 2009 and 2010; it was 30 percent above average in 2022. The rank slipped from fourth to fifth. In 2022, the share in Virginia exceeded the U.S. average in only three high-tech categories — communications equipment and the two services categories — but it ranked second in computer services.
- Biopharmaceuticals. The employment share was near the national average until 1993. Since then it has fallen to 72 percent lower than the U.S. average in 2022. The rank fell from first or second to last. Based on aggregate earnings, the share slipped from 61 percent below average in the early 2000s to 76 percent less than average in 2022. The rank dropped from sixth to last.
- Computing Equipment. The employment share has been much lower than the national average since 1956. It was 86 percent lower than the U.S. average in 2022. The rank fell from fourth to last, but was sixth in 2022. Based on aggregate earnings, the share was 91 percent below average in 2022. The rank has ranged from sixth to last.
- Communications Equipment. The employment share was considerably less than the national average from 1956 to 1968; since then it has varied from below to above average. It was 6 percent above average in 2022. The rank has slipped from fourth to seventh. Based on aggregate earnings, the share improved from 57 percent below average in 2002 to 10 percent above average in 2022. The rank improved from sixth to fourth.
- Electronics. The employment share has consistently been below average, by 20-to-60 percent since 1959. It was 59 percent below the U.S. average in 2022. The rank generally has been seventh since 1983. Based on aggregate earnings, the share dropped from 53 percent below average in 2008 to 74 percent below average in 2022. The rank was seventh in nearly every year.
- Instruments. The employment share was considerably below the national average through 1988. After getting within 15 percent of the U.S. average, the share declined to 63 percent below average in 2022. The rank has been last since 1998. Based on aggregate earnings, the share has been about 60 percent below average. The rank was last in every year.
- Aerospace. The employment share has been far below average since 1956; it was 85 percent below average in 2022. The rank has been last in every year. Based on aggregate earnings, the share was 84 percent below average in 2022. The rank was last in every year.
- Computer Services. The employment share was at least 2.35 the U.S. average from 1978 through 2014, but declined to 2.01 times the U.S. average in 2022. The rank has been first or second. Based on aggregate earnings, the share fell from 2.77 times the U.S. average in 2009 to 79 percent higher in 2022. The rank has been first or second.
- Other Professional Services. The employment share was considerably below average in 1956 but quickly became above average, peaking at twice the average from 1988 through 1998. It has declined since then, to 33 percent above average in 2022. The rank rose from last to second, then fell to fourth. Based on aggregate earnings, the share peaked at 79

percent above average in 2005 but was 22 percent above average in 2022. The rank slipped from third to fifth.

Washington

- Total High Tech. Washington has been a high-tech leader since 1956, but until the 21st century this was almost entirely due to its extreme strength in aerospace. The employment share has been considerably higher than the U.S. average since 1956. It peaked at more than double the U.S. average from 1959 through 1968, but still was 83 percent above average in 2022. The rank in the 20th century ranged from first to fourth; it has been first or second since 2001. Based on aggregate earnings, the share has been about twice the U.S. average; it was 98 percent above average in 2022. The rank was first in every year from 2001 through 2022. In 2022, Washington ranked first in aerospace and computer services; its share was less than the U.S. average in the other six categories.
- Biopharmaceuticals. The employment share gradually rose relative to the national average, but still was 51 percent below average in 2022. Washington generally ranked seventh or eighth. Based on aggregate earnings, the share has been approximately 70-to-80 percent below average; it was 68 percent below average in 2022. The rank has been seventh or eighth.
- Computing Equipment. The employment share was far below average through 1973, but then increased relative to the national average, surpassing it in 1993. It then fell to 79 percent less than the U.S. average in 2022. The rank climbed from last to third before dropping back to fifth. Based on aggregate earnings, the share fell from 20 percent less than the U.S. average in 2001 to 88 percent less in 2022; the rank has varied from fourth to sixth.
- Communications Equipment. The employment share was far below the U.S. average through 1968, gradually advanced but remained below the national average, then dropped back to 55 percent below average in 2022. The rank went from last to sixth to last. Based on aggregate earnings, the share has been approximately 60 percent less than the U.S. average. The rank generally was seventh or eighth.
- Electronics. The employment share was far less than the U.S. average through 1978, then gradually rose but remained less than the national average. It was 24 percent below average in 2022. The rank improved from eighth to fifth. Based on aggregate earnings, the share has been 50-to-60 percent less than the U.S. average, but was 46 percent less in 2022. The rank edged up from sixth to fifth.
- Instruments. The employment share was considerably below average through 1978, then rose to a little more than average before dropping back to 8 percent less than the U.S. average in 2022. Washington has ranked sixth or seventh since 2002. Based on aggregate earnings, the share was 23 percent higher than the U.S. average in 2002, then dropped to 19 percent below average in 2022. The rank slipped from sixth to seventh.
- Aerospace. The employment share was 3.8 times the U.S. average in 1956, then rose to more than 8 times the U.S. average before dropping back in recent years to 6 times the average in 2022. Washington has by far had the highest share since 1959. Based on aggregate earnings, the share peaked at 9 times higher than the U.S. average in 2014; it was 5.7 times higher in 2022, also first by a wide margin.
- Computer Services. After fluctuating from 1978 through 1998, the employment share has increased to 2.2 times the U.S. average in 2022. After ranking as low as seventh,

Washington ranked first in 2021 and 2022. Based on aggregate earnings, the share has ranged from 2.2-to-2.8 times the U.S. average; it was 2.68 times the average in 2022. The rank advanced from second to first.

- Other Professional Services. The employment share has been somewhat higher than the U.S. average since 1965. It was 10 percent above average in 2022. The rank has been between fifth and seventh since 1978. Based on aggregate earnings, the share fell from 33 percent above average in 2003 to 7 percent below average in 2022. The rank slipped from fifth to sixth.

High Technology in 2022: All States. In Table 6, the ranks among all 51 "states" in each of the 10 high-tech categories are shown for each of the eight comparison states based on the employment share of the overall total in 2022. Other than Arizona, the comparison states rank between first and eight on overall high-tech share. New Hampshire ranked fifth but was not selected as a comparison state due to its small size.

California and Massachusetts have the most diverse high-tech economies, ranking in the top 10 states in nine of the 10 high-tech categories. In contrast, Arizona was in the top 10 in only two categories. Virginia and Washington had rather narrow high-tech profiles, with Virginia ranking in the top 10 only in the three services categories and Washington in the top 10 only in aerospace and two services categories.

Though its employment share was only 4 percent above the national average, Arizona ranked 14th overall in 2022. In addition to the states shown in the table, Connecticut, the District of Columbia, and New Jersey ranked higher. States ranked just behind Arizona were Kansas, Texas, Michigan, Vermont, and North Carolina.

The ranks generally are not much different based on aggregate earnings. Overall, Arizona ranked 12th on this measure.

In terms of the number of workers, Arizona ranked 16th in the nation in 2022. However, it had the fourth-highest number in the electronics and aerospace categories.

Metropolitan Areas

This section focuses first on Metropolitan Phoenix and the 11 other selected large metro areas relative to the national average. Then, Metropolitan Tucson and the seven other southwestern metro areas are examined. County Business Patterns data for 1956 through 1998 are examined, but an extensive amount of the metro area data had to be imputed. While the accuracy of the imputed data is good enough to tell the story of the development of high-tech activity over time, specific estimates are not shown either graphically or tabularly.

Metropolitan Phoenix. Annual industrial data for 2001 through 2022 from Lightcast are displayed in Chart 6 for Metro Phoenix relative to the nation for overall high tech and for each of the eight primary high-tech industrial categories. The percentages of the national average are shown as bars while the ranks among the 12 large metro areas are displayed as lines. Note that the ranks in the graphs are expressed such that a rank of 1 is worst and a rank of 12th is best.

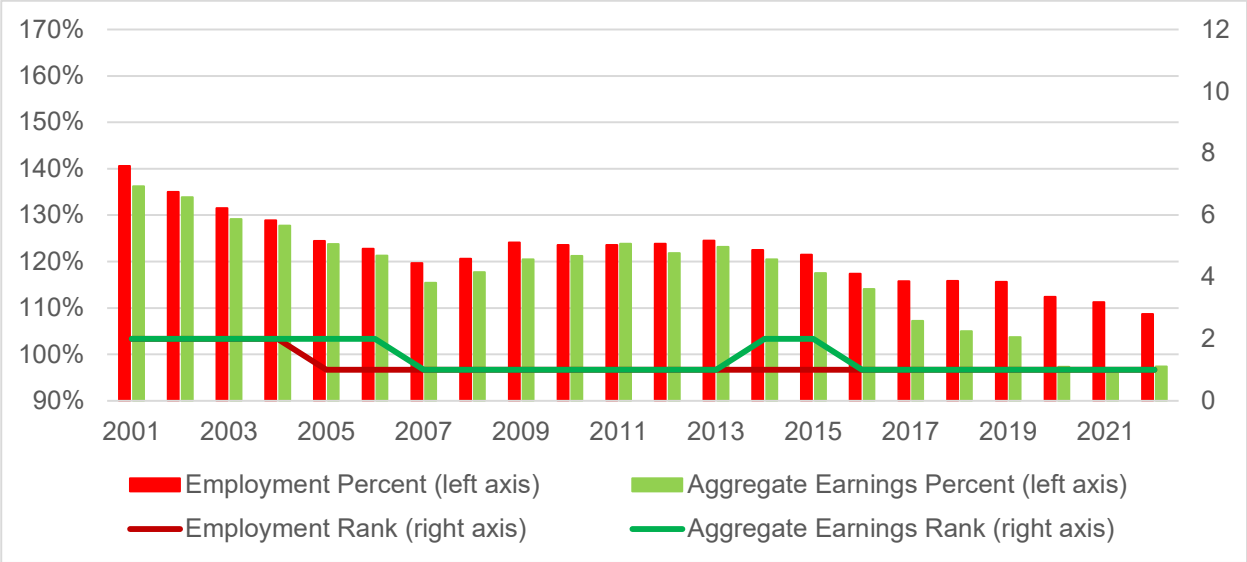
TABLE 6
RANK AMONG ALL STATES ON THE SHARE OF TOTAL EMPLOYMENT BY HIGH-TECHNOLOGY INDUSTRIAL CATEGORY, 2022

	AZ	CA	CO	MD	MA	UT	VA	WA	Other States in Top 10
TOTAL HIGH TECH	14	4	3	6	1	8	7	2	NH NM OR
Biopharmaceuticals	26	14	23	6	10	5	41	33	IN NJ ME NC IL PA SC
Computing Equipment	33	1	8	35	5	19	30	24	MN NC ID NH TX VT AL
Communications Equipment	32	2	16	3	4	23	11	35	KS ID TX NY IA IL AL
Electronics	3	6	23	37	8	16	32	18	OR ID NH VT NM TX MN
Instruments	18	7	11	5	3	8	38	15	NH MN IA RI DE VT
Aerospace	4	9	18	30	20	7	42	1	KS CT OK AL MO VT
Miscellaneous Manufacturing	18	6	16	34	5	26	41	46	NH OR CT WI VT MS MT WY
Computer Services	18	8	3	7	5	6	2	1	DC NH GA
Other Professional Services	33	7	5	3	2	14	6	12	NM MI AL ID NJ
Miscellaneous Services	14	7	2	6	5	35	8	4	DC NM OR VT

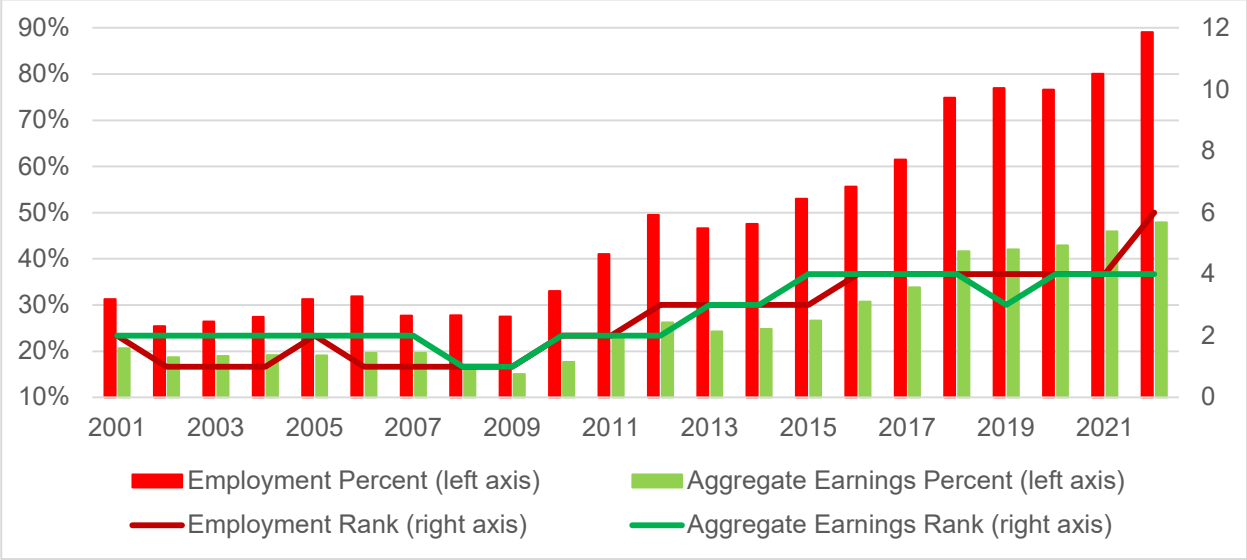
Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. High-technology categories defined by authors.

CHART 6
INDUSTRIAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN PHOENIX AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG 12 LARGE METROPOLITAN AREAS, 2001 TO 2022

ALL HIGH-TECHNOLOGY INDUSTRIES



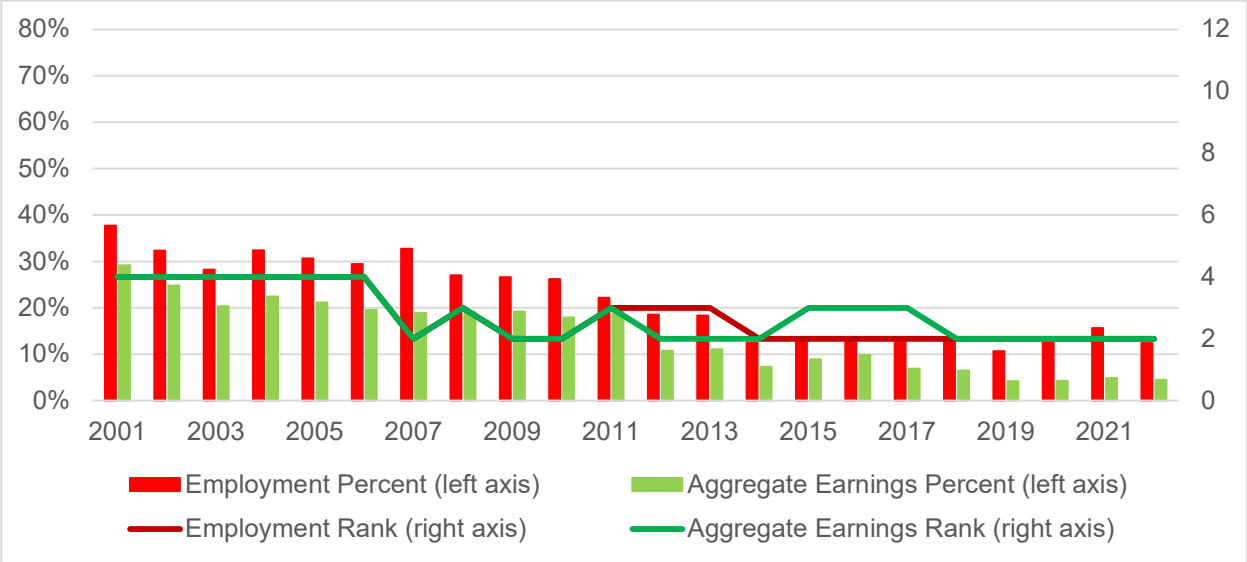
BIOPHARMACEUTICALS



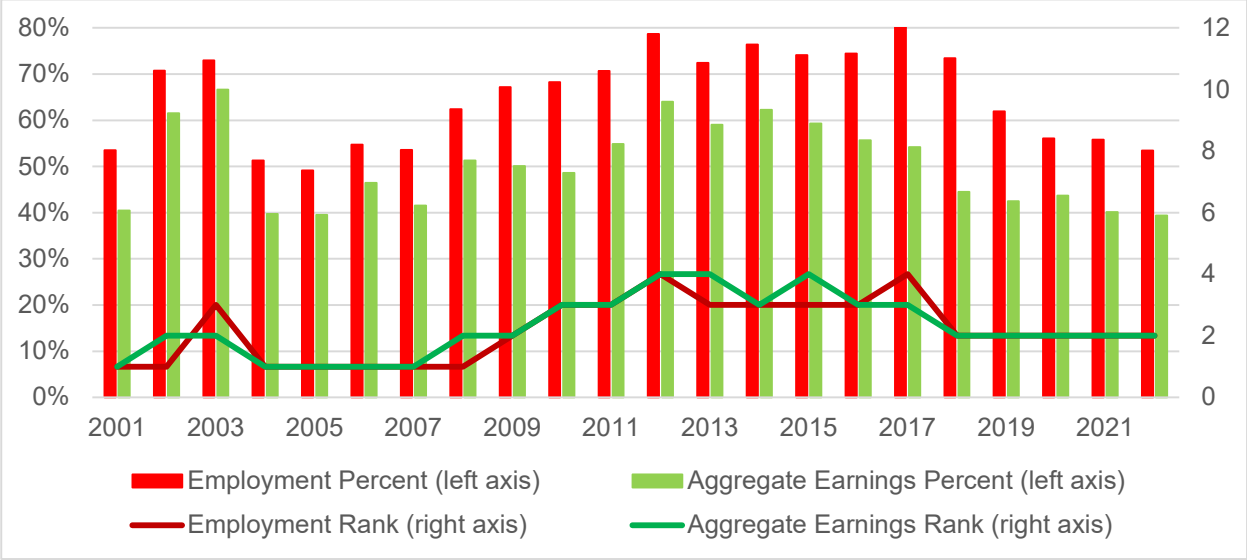
(continued)

CHART 6 (continued)
INDUSTRIAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN PHOENIX AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG 12 LARGE METROPOLITAN AREAS, 2001 TO 2022

COMPUTING EQUIPMENT



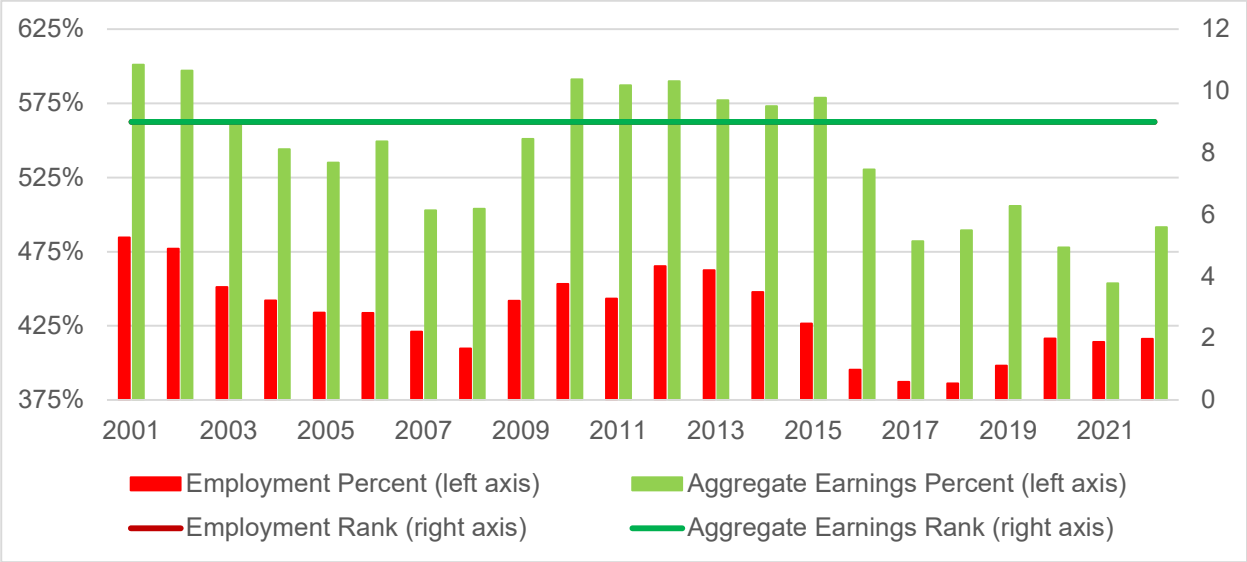
COMMUNICATIONS EQUIPMENT



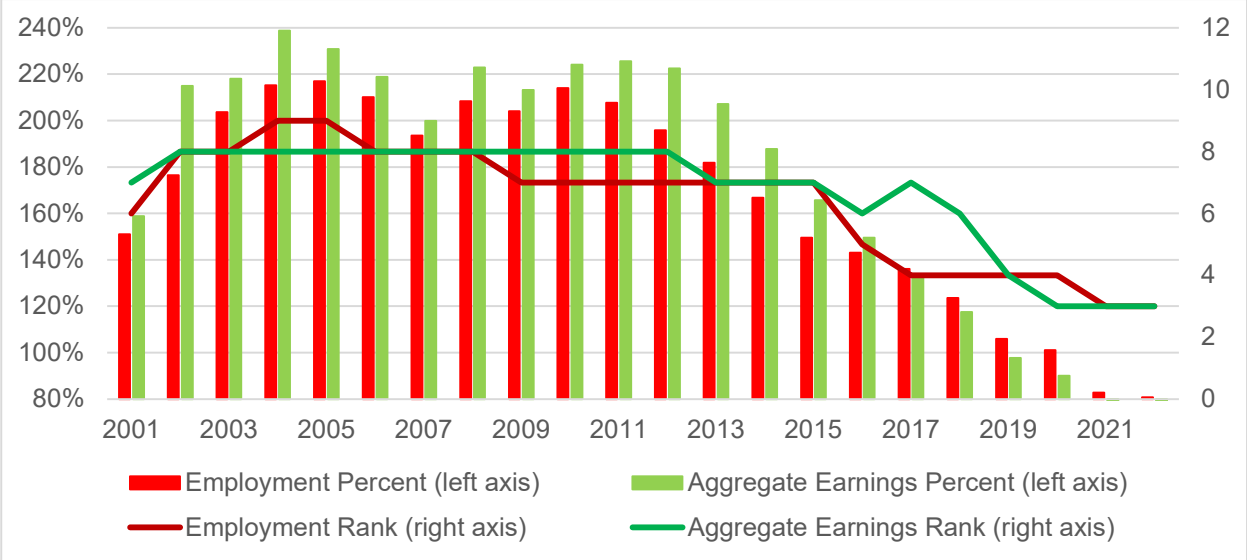
(continued)

CHART 6 (continued)
INDUSTRIAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN PHOENIX AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG 12 LARGE METROPOLITAN AREAS, 2001 TO 2022

ELECTRONICS



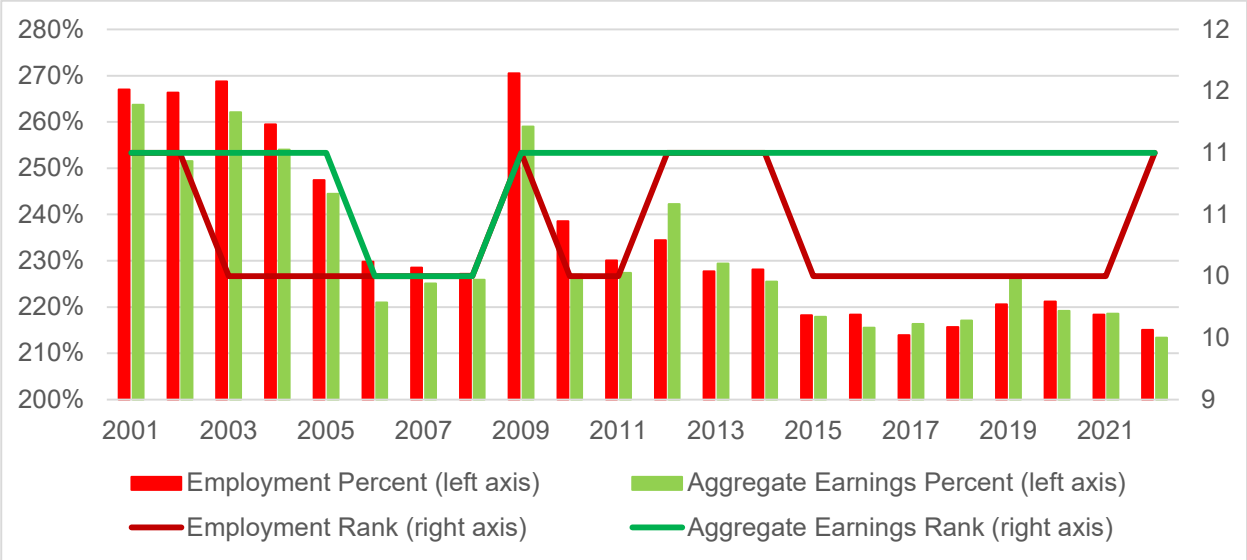
INSTRUMENTS



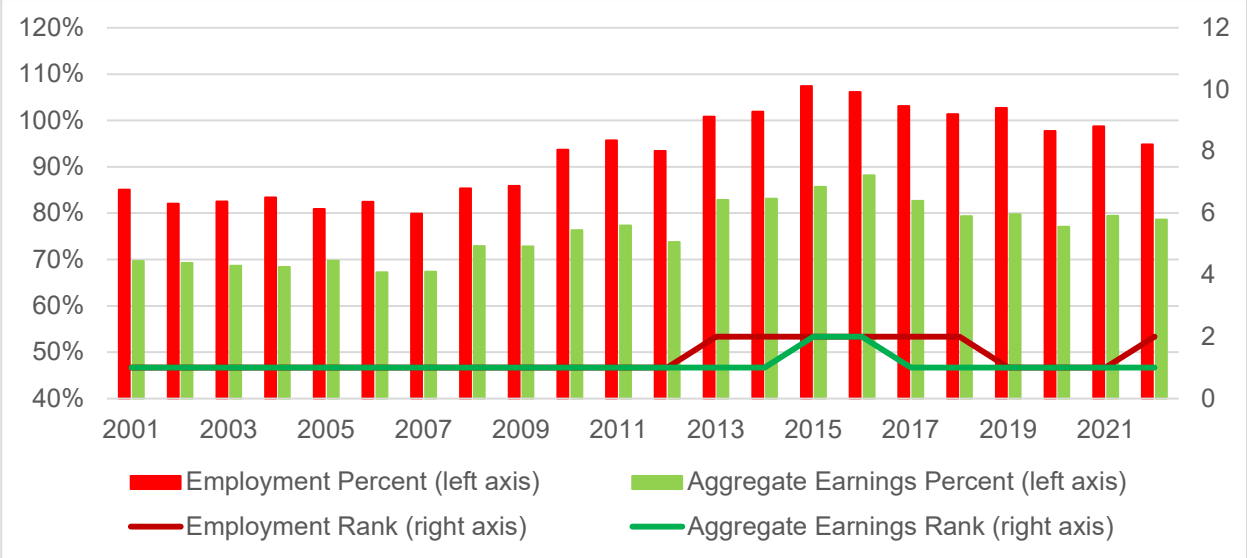
(continued)

CHART 6 (continued)
INDUSTRIAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN PHOENIX AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG 12 LARGE METROPOLITAN AREAS, 2001 TO 2022

AEROSPACE

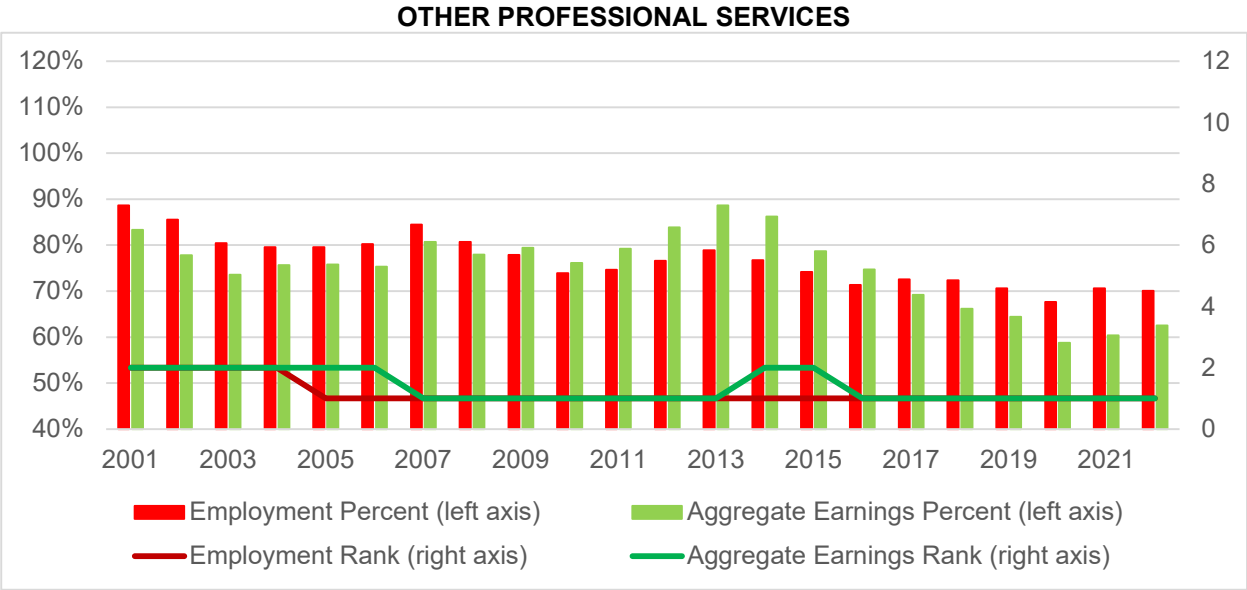


COMPUTER SERVICES



(continued)

CHART 6 (continued)
INDUSTRIAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN PHOENIX AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG 12 LARGE METROPOLITAN AREAS, 2001 TO 2022



Note: Ranks are expressed such that a rank of 1 is worst and a rank of 12th is best.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. High-technology categories defined by authors.

The following summarizes the high-tech share of total employment in Metro Phoenix relative to the national average. County Business Patterns data were used for the 1956-to-1998 period, with Lightcast data used for 2001 through 2022. Aggregate earnings information for 2001 to 2022 supplements the employment summary. Ranks are expressed as among the 12 selected metro areas:

- Total High Tech. The high-tech share in Metro Phoenix in 1956 was 1.5 times the national average and ranked fourth. The share rose to a peak of triple the national average in 1973, when it ranked second. By 1998, the share was down to 1.4 times the average, with Metro Phoenix ranking 10th. Metro Phoenix's employment share slid from 40 percent above average at the beginning of the 21st century to 9 percent above average in 2022. In 2001, the rank was 11th; it has been last since 2005. The aggregate earnings share has declined from 36 percent above average in 2001, when it ranked 11th, to 3 percent below average in 2022, with Metro Phoenix ranking last.
- Biopharmaceuticals. No biopharmaceutical manufacturing occurred in Metro Phoenix until 1978. In 1998, the share was only half the national average, with Metro Phoenix ranking ninth. Metro Phoenix's employment share was 70 percent less than the U.S. average from 2001 through 2010 but the share gradually climbed after that to only 11 percent below average in 2022. The rank improved from 11th or 12th to seventh in 2022. The aggregate earnings share was 80 percent below average through 2010, and still was less than half the U.S. average in 2022. The rank improved from 11th or 12th to ninth.

- Computing Equipment. By 1959, the computing equipment share in Metro Phoenix was triple the national average and ranked second. The share rose to a peak of 6.5 times the national average in 1965, when it ranked first. The share remained quite high through 1978 but then fell rapidly to less than half the national average by 1998, when Metro Phoenix ranked ninth. Metro Phoenix's employment share slid from 60 percent below average at the beginning of the 21st century to 88 percent below average in 2022. The aggregate earnings share declined from 71 percent below average in 2001 to 96 percent below average in 2022. On both measures, the rank slipped from ninth to 11th.
- Communications Equipment. The communications equipment share in Metro Phoenix was more than 1.5 times the national average by 1959 and ranked third. The share rose to a peak of about 2.75 times the national average in 1973, when it ranked first. The share dropped back to 1.5 times the national average by 1998, when Metro Phoenix ranked fifth. The employment share has been below average since 2001; it was 47 percent below average in 2022. The aggregate earnings share in 2022 was 61 percent below average. On both measures, the rank between 2001 and 2022 varied from ninth to 12th.
- Electronics. By 1959, the electronics share in Metro Phoenix was more than 1.3 times the national average and ranked fourth. The share rose to a peak of about 8.75 times the U.S. average in 1973, when it ranked second. The share dropped back but was still 3.7 times the national average in 1998, when Metro Phoenix ranked third. Since 2001, the employment share generally has been just more than four times the U.S. average, ranking fourth. The aggregate earnings share also has ranked fourth at 4.5-to-6 times the national average.
- Instruments. The instruments share in Metro Phoenix in 1959 was slightly more than the national average and ranked second. The share rose to a peak of about 4 times the U.S. average in 1965, when it ranked first. The share dropped back to 1.7 times the national average in 1998, when Metro Phoenix ranked sixth. Since then, the employment share has continued to decline, to 19 percent below average in 2022. The aggregate earnings share also dropped, from more than twice the U.S. average to 32 percent below average in 2022. On each measure, the rank fell to 10th in 2022.
- Aerospace. In the 1950s, the aerospace share in Metro Phoenix was more than double the national average and ranked third. The share dropped to less than half the U.S. average in the 1960s, when it ranked eighth, but then rose in the 1970s, reaching more than 2.5 times the national average in 1988 and 1993. In 1998, the share was twice the average and ranked third. In 2022, the employment and aggregate earnings shares were just more than double the U.S. average; Metro Phoenix ranked second on each measure.
- Computer Services. Between 1978 and 1998, the computer services share in Metro Phoenix generally was a little less than the national average, usually ranking last. The employment share has ranged from less than average to a bit above the national average, ranking 11th or 12th. The aggregate earnings share since 2001 has consistently been below average, by 21 percent in 2022, generally ranking last.
- Other Professional Services. The share in Metro Phoenix from 1956 through 1998 ranged from a little more than the national average to less than average. The rank was as high as sixth in 1956 but was between 10th and 12th from 1965 through 1998. Since 2001, the employment share has decreased relative to the national average, to 30 percent below average in 2022, ranking last in each year. The aggregate earnings share slipped to 37 percent below average in 2022, also ranking last.

Other Large High-Technology Metro Areas. Based on a definition of an overall high-tech industrial employment share at least 50 percent higher than the national average, only four sizable high-tech metro areas were present in the United States in the late 1950s: Boston, Phoenix, San Diego, and Seattle. San Jose joined this exclusive group in the 1960s, followed in the late 1970s by Austin, Raleigh-Durham, and Washington, D.C. In the late 1990s, San Francisco attained a high-tech employment share at least 50 percent higher than the U.S. average, followed shortly after by Portland. Denver recently reached this threshold. Of the 12 metro areas, only Baltimore has never reached this threshold.

Once reaching a high-tech share at least 50 percent higher than the national average, only one large metro — Phoenix — has dropped below this level. By the mid-1990s, Metro Phoenix was below this level and its high-tech employment share has since dropped to only 9 percent above the national average. Based on aggregate earnings, the 2022 share in Metro Phoenix was 3 percent *below* the U.S. average.

The high-tech share of the Metro Phoenix economy is affected by the area's rapid growth in base industries other than high technology. However, this is not the major cause of the area's decline in high-tech share relative to the nation and to other large high-tech metro areas. The percent change in high-tech employment in Metro Phoenix between 1973 and 1978 was the least of the 12 large high-tech metro areas analyzed; since then Metro Phoenix has ranked between eighth and tenth on the percent change.

Other than the Baltimore and Phoenix areas, each of the 10 other metro areas had an overall high-tech employment share at least 55 percent greater than the national average in 2022; each had an aggregate earnings share at least 38 percent above average. Metro San Jose had by far the highest shares at 5.79 times the U.S. average based on employment and 5.57 times the average based on aggregate earnings. Shares were more than double the national average on both measures in the Seattle, San Francisco, Boston, and Austin metro areas.

Most of the 12 large metro areas did not experience much change between 2001 and 2022 in their high-tech share relative to the national average. However, Metro San Francisco registered a large gain and Metro Baltimore a lesser increase. The Raleigh-Durham, Phoenix, and Austin metro areas had the largest losses relative to the U.S. average.

The following summarizes the high-tech share of total employment relative to the national average in each of the 11 comparison metro areas. County Business Patterns data were used for the 1956-to-1998 period, with Lightcast data used for 2001 through 2022. Aggregate earnings information for 2001 to 2022 supplements the employment summary. Ranks are among the 12 selected areas.

<u>Austin</u>
The overall high-tech share in Metro Austin reached the national average in 1968 and was more than twice the national average by 1978. Early strength came from the computing equipment, instruments, and other professional services categories. By 1978, the shares also were well above

average in the communications equipment, electronics, and computer services categories, though instruments had waned. By 1988, biopharmaceuticals also was a strong contributor.

The overall high-tech share in Metro Austin in 2022 was 2.13 times the U.S. average based on both employment and aggregate earnings. Metro Austin ranked fifth on employment and fourth on aggregate earnings in 2022. On each measure, Metro Austin's shares have slipped relative to the U.S. average since the early 2000s.

Metro Austin's shares in 2022 were at least 2.5 times the U.S. average in the computing equipment, communications equipment, electronics, and computer services categories. The other professional services category also was above average. The metro area's highest ranks were third based on employment and aggregate earnings in the computing equipment, communications equipment, and electronics categories.

Baltimore

The overall high-tech share in Metro Baltimore has been above the national average since 1956, but the differential generally has been modest. Early strength came from the aerospace and communications equipment categories, but aerospace shares had dropped considerably by the 1960s and communications equipment dropped way back in the 1980s after ranking first or second from 1965 to 1983. Instruments became a large high-tech contributor during the 1980s. Biopharmaceuticals also was a contributor in the 1990s and 2000s.

The overall high-tech share in Metro Baltimore in 2022 was 31 percent higher than the U.S. average based on employment and 14 percent higher based on aggregate earnings. Metro Baltimore ranked 11th on both measures in 2022. On each measure, Metro Baltimore's shares gained relative to the U.S. average between the early 2000s and early 2010s, but have slipped a bit since.

Metro Baltimore's shares in 2022 exceeded the U.S. average in only two categories: the share was about 4 times higher in instruments and about 50 percent higher in other professional services. Shares were similar to the U.S. average in the computer services category. The metro area's highest rank was second based on employment and aggregate earnings in the instruments category.

Boston

The overall high-tech share in Metro Boston was 50 percent greater than the national average in the late 1950s and double the national average beginning in 1978. Early strength came from the communications equipment, electronics, instruments, and other professional services categories. Metro Boston ranked first or second in instruments from 1959 through 1973. Computing equipment became important during the 1960s, and the computer services category was a strong contributor as soon as data became available in 1978.

The overall high-tech share in Metro Boston in 2022 was 2.19 times the U.S. average based on employment and 2.07 times higher based on aggregate earnings. Metro Boston ranked fourth on employment and fifth on aggregate earnings in 2022. On each measure, Metro Boston's shares have held steady relative to the U.S. average since the early 2000s.

Metro Boston's shares in 2022 were at least 2.5 times the U.S. average in the instruments and other professional services categories. Each of the other categories except aerospace also were well above average. The metro area's highest ranks were first in other professional services.

Denver

The overall high-tech share in Metro Denver did not reach the national average until 1988, when the aerospace category became important. Prior to that, the shares in Metro Denver exceeded the national average only in the two services categories.

The overall high-tech share in Metro Denver in 2022 was 60 percent higher than the U.S. average based on employment and 38 percent higher based on aggregate earnings. Metro Denver ranked ninth on employment and 10th on aggregate earnings in 2022. On each measure, Metro Denver's shares rose a little relative to the U.S. average since 2006.

Metro Denver's shares in 2022 exceeded the U.S. average in the aerospace, computer services, and other professional service categories. The metro area's highest ranks were fourth in the aerospace category.

Portland

The overall high-tech share in Metro Portland reached the national average in 1978, when the computer services and instruments categories became important. Metro Portland ranked first in instruments in 1978 and 1983. Shortly after this, the shares in the computing equipment and electronics categories exceeded the U.S. average.

The overall high-tech share in Metro Portland in 2022 was 55 percent higher than the U.S. average based on employment and 41 percent higher based on aggregate earnings. Metro Portland ranked 10th on employment and eighth on aggregate earnings in 2022. On each measure, Metro Portland's shares have slipped relative to the U.S. average since the early 2000s.

Metro Portland's shares in 2022 were more than 11 times the U.S. average in the electronics category. The shares were only marginally above average in the instruments and computer services categories. The metro area's highest ranks were second in electronics.

Raleigh-Durham

The overall high-tech share in the combination of the Metro Raleigh and Metro Durham areas reached the national average in 1968 and was more than twice the national average by 1983. The computing equipment and other professional services categories were the early high-tech leaders, followed by communications equipment, computer services, and biopharmaceuticals.

The overall high-tech share in Metro Raleigh-Durham in 2022 was 2.05 times the U.S. average based on employment and 1.92 times higher based on aggregate earnings. Metro Raleigh-Durham ranked sixth on each measure in 2022. Metro Raleigh-Durham's shares had been about 2.5 times the U.S. average in the early 2000s.

Metro Raleigh-Durham's shares in 2022 were at least 2.5 times the U.S. average in the biopharmaceuticals, computing equipment, communications equipment, and other professional services categories. Electronics and computer services also were well above average. The metro area's ranks were first in biopharmaceuticals, second in computing equipment, and fourth in other professional services.

San Diego

From 1956 through 1962, the overall high-tech share in Metro San Diego was the highest in the nation at more than 5 times the national average, largely due to aerospace. Metro San Diego ranked first in the aerospace share from 1956 through 1962 and then second through 1983. As aerospace's share declined — but remained more than 2.5 times the U.S. average — the computing equipment category became important. By 1988, the shares were well above average in each of the eight categories. The overall high-tech share was about double the national average from 1978 through 1998.

In 2022, the overall high-tech share in Metro San Diego was 84 percent higher than the U.S. average based on employment and 77 percent higher based on aggregate earnings. Metro San Diego ranked seventh on each measure in 2022. Metro San Diego's shares relative to the U.S. average have not changed much since the early 2000s.

Metro San Diego's shares in 2022 were 6 times the U.S. average in communications equipment, about triple the average in instruments and other professional services, and at least twice the average in biopharmaceuticals and aerospace. The electronics category also was above average. The metro area's ranks were second in other professional services and communications equipment and third in the biopharmaceuticals, instruments, and aerospace categories.

San Francisco

The overall high-tech share in Metro San Francisco did not reach the national average until 1988 but was 1.5 times the national average by 1998. Initially, the high-tech strength came from the two services categories. By 1993, biopharmaceuticals also was a strong contributor.

The overall high-tech share in Metro San Francisco in 2022 was 2.57 times the U.S. average based on employment and 2.47 times based on aggregate earnings. Metro San Francisco ranked third on each measure in 2022. Metro San Francisco's shares have increased substantially relative to the U.S. average on each measure since the early 2000s.

Metro San Francisco's shares in 2022 were at least 2.5 times the U.S. average in the biopharmaceuticals, computer services, and other professional services categories. The instruments and computing equipment category also were well above average. The metro area's ranks were second in biopharmaceuticals, third in computer services, and fourth in computing equipment.

San Jose

The overall high-tech share in Metro San Jose was equal to the national average in 1956 and quickly rose to far above average, peaking in 1983 at 6.25 times the average. Metro San Jose has consistently ranked first since the early 1970s. By 1959, the shares in the electronics and

computing equipment categories were far above average. By 1983, the share was at least 2.5 times the U.S. average in each category other than biopharmaceuticals. In each year from the late 1950s through the end of the 20th century, the metro area ranked first in electronics, and first or second in computing equipment. After 1973, it ranked first or second in instruments and communications equipment, and second in computer services.

The overall high-tech share in Metro San Jose in 2022 was 5.79 times the U.S. average based on employment and 5.57 times based on aggregate earnings. The employment share has slipped relative to the U.S. average but the aggregate earnings share has held steady.

Metro San Jose's employment shares in 2022 were at least 2.5 times the U.S. average in each category except biopharmaceuticals and aerospace. Relative to the U.S. average, the share was 50 times higher in computing equipment, 14 times higher in electronics, and more than 6 times higher in communications equipment and computer services. The metro area ranked first based on employment and aggregate earnings in the computing equipment, communications equipment, electronics, instruments, and computer services categories.

Seattle

The overall high-tech share in Metro Seattle was more than 3 times higher than the national average from 1956 through 1968, ranking first or second. However, the strength was almost entirely due to aerospace, whose share generally was more than 10 times the national average. In aerospace, Metro Seattle ranked second from 1956 through 1962 and first thereafter. After 1968, the overall high-tech share dropped back relative to the U.S. average, as diversification of the high-tech economy was slow to develop.

The overall high-tech share in Metro Seattle in 2022 was 2.59 times the U.S. average based on employment and 2.53 times higher based on aggregate earnings. Metro Seattle ranked second on each measure. Metro Seattle's employment share has fluctuated without trend, while the aggregate earnings share has slipped relative to the U.S. average since the early 2010s.

Metro Seattle's shares in 2022 were more than 8 times the U.S. average in the aerospace category and more than 3 times higher than average in computer services. Shares were near average in the instruments and other professional services categories. The metro area ranked first in aerospace and second in computer services.

Washington, D.C.

The overall high-tech share in Metro Washington, D.C. reached the national average in 1973 and was more than twice the national average by 1993. Early strength came entirely from the two services categories, in which the metro area ranked first in each year of the 20th century.

The overall high-tech share in Metro Washington, D.C. in 2022 was 1.83 times the U.S. average based on employment and 1.41 times higher based on aggregate earnings. Metro Washington, D.C. ranked eighth on employment and ninth on aggregate earnings in 2022. On each measure, the metro area's shares have dropped relative to the U.S. average since the mid-2000s.

Metro Washington, D.C.'s shares in 2022 exceeded the U.S. average in the communications equipment, computer services, and other professional services categories. The share in the biopharmaceuticals category was average. The metro area's highest ranks were fifth in the communications equipment, computer services, and biopharmaceuticals categories.

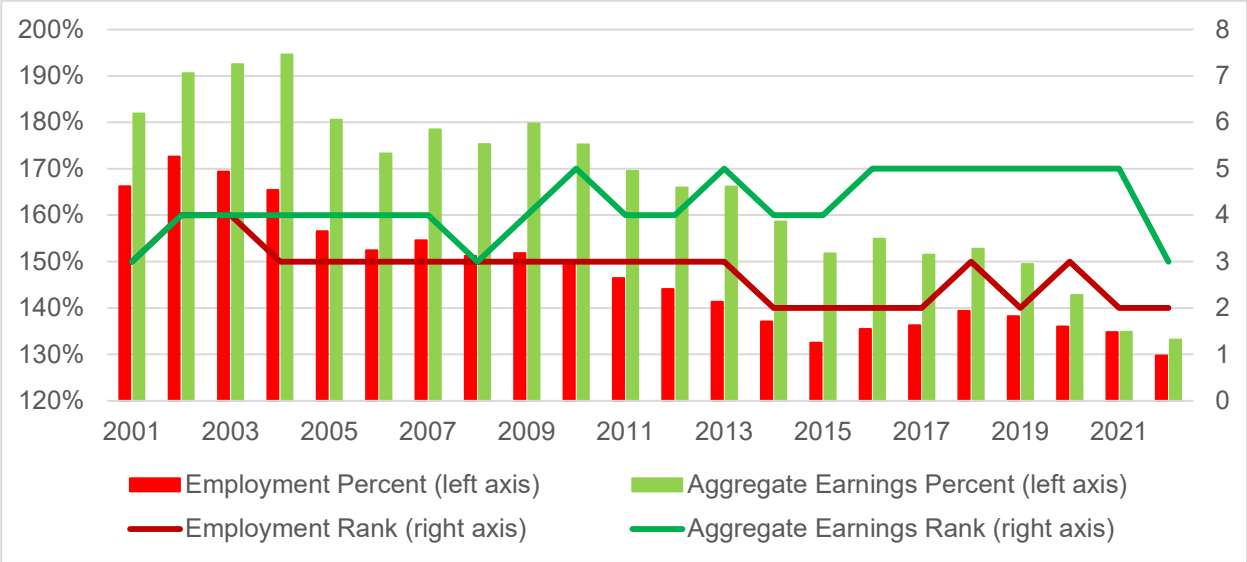
Metropolitan Tucson. Annual industrial data for 2001 through 2022 from Lightcast are displayed in Chart 7 for Metro Tucson relative to the nation for overall high tech and for each of the eight primary high-tech industrial categories. The percentages of the national average are shown as bars while the ranks among the eight southwestern metro areas are displayed as lines. Note that the ranks in the graphs are expressed such that a rank of 1 is worst and a rank of eighth is best.

The following summarizes the high-tech share of total employment in Metro Tucson relative to the national average. County Business Patterns data were used for the 1956-to-1998 period, with Lightcast data used for 2001 through 2022. Aggregate earnings information for 2001 to 2022 supplements the employment summary. Ranks are expressed as among the eight selected metro areas:

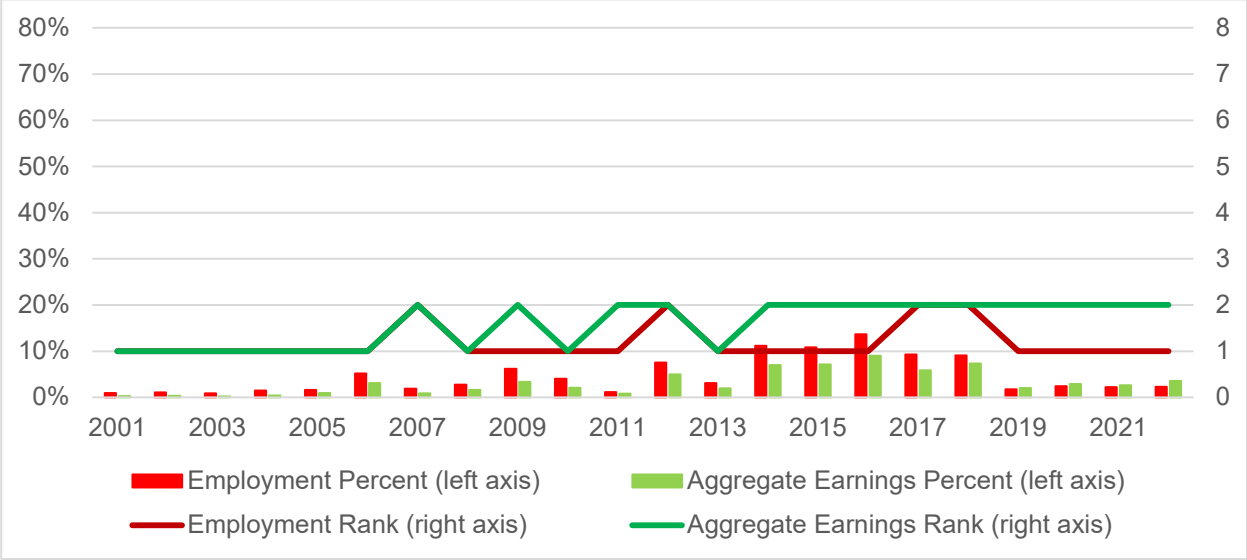
- Total High Tech. The high-tech employment share in Metro Tucson generally was less than the national average until 1978. The share rose to a peak of double the national average in 1983 and 1988, but its highest rank was fourth. Thereafter, the share steadily declined relative to the U.S. average, down to 30 percent above average in 2022. The ranked dropped to seventh, ahead of only Metro El Paso. The aggregate earnings share declined from 95 percent above average in 2004 to 33 percent above average in 2022, when Metro Tucson ranked sixth.
- Biopharmaceuticals. No biopharmaceutical manufacturing occurred in Metro Tucson until 1998 and little has occurred since then, with the employment and aggregate earnings shares remaining less than 10 percent of the national average. The rank on each measure has been seventh or eighth.
- Computing Equipment. Computing equipment was the primary cause of Metro Tucson's overall high-tech surge in the 1980s, with the category's share reaching a rank of third. The share peaked at more than 3.5 times the U.S. average in the early 2000s, but after 2006 limited activity has occurred. Since 2016, the employment and aggregate earnings shares have been more than 90 percent below average, ranking seventh or eighth.
- Communications Equipment. Little communications equipment manufacturing occurred in Metro Tucson during the 20th century. While activity has since increased, shares have never reached the national average. The employment share was 32 percent below average in 2022. The aggregate earnings share in 2022 was 49 percent below average. However, the rank was third on each measure.
- Electronics. The electronics share in Metro Tucson gradually rose to a peak of 3.2 times the national average in 1988, when it ranked fourth. Activity then quickly dropped off but remained higher than the national average into the 21st century. In 2022, the employment share was 8 percent below average and the aggregate earnings share equaled the national average, each ranking sixth.

CHART 7
INDUSTRIAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN TUCSON AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG EIGHT SOUTHWESTERN METROPOLITAN AREAS, 2001 TO 2022

ALL HIGH-TECHNOLOGY INDUSTRIES



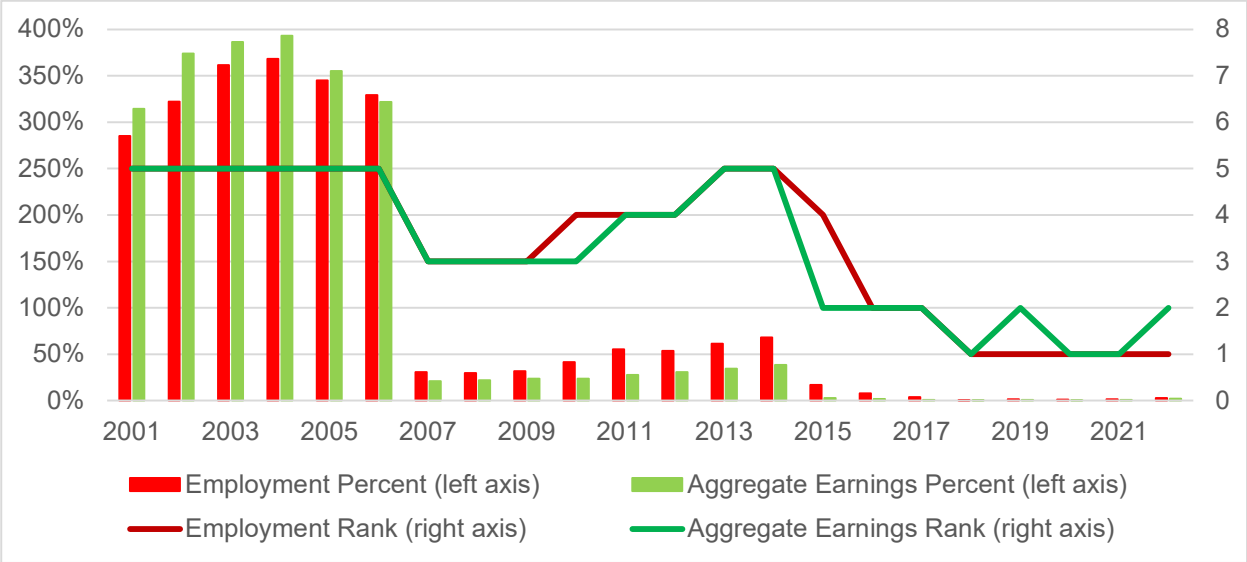
BIOPHARMACEUTICALS



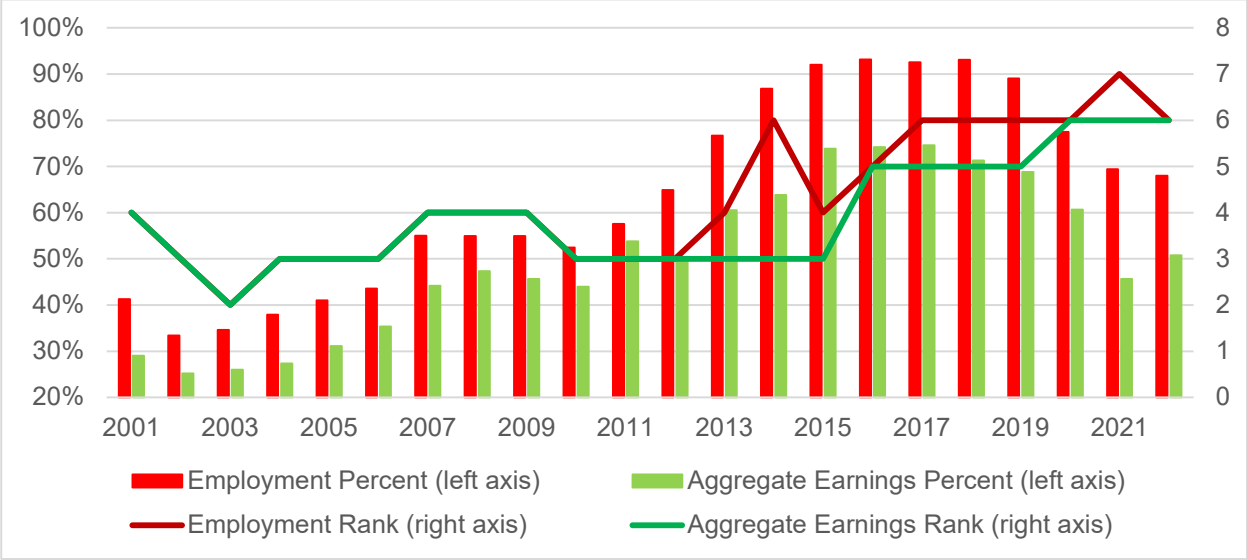
(continued)

CHART 7 (continued)
INDUSTRIAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN TUCSON AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG EIGHT SOUTHWESTERN METROPOLITAN AREAS, 2001 TO 2022

COMPUTING EQUIPMENT



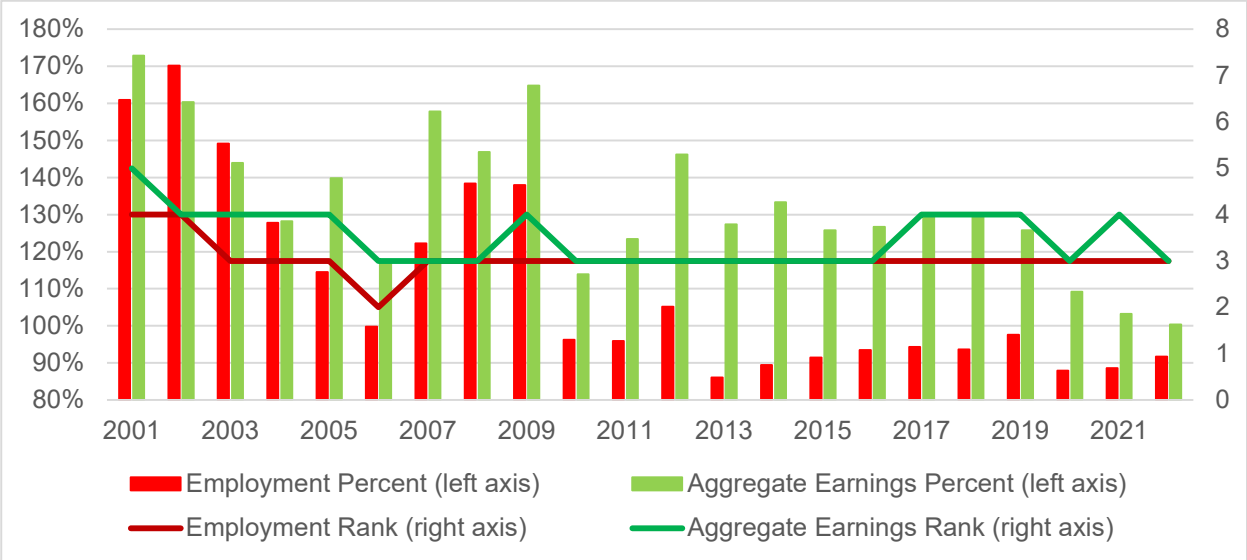
COMMUNICATIONS EQUIPMENT



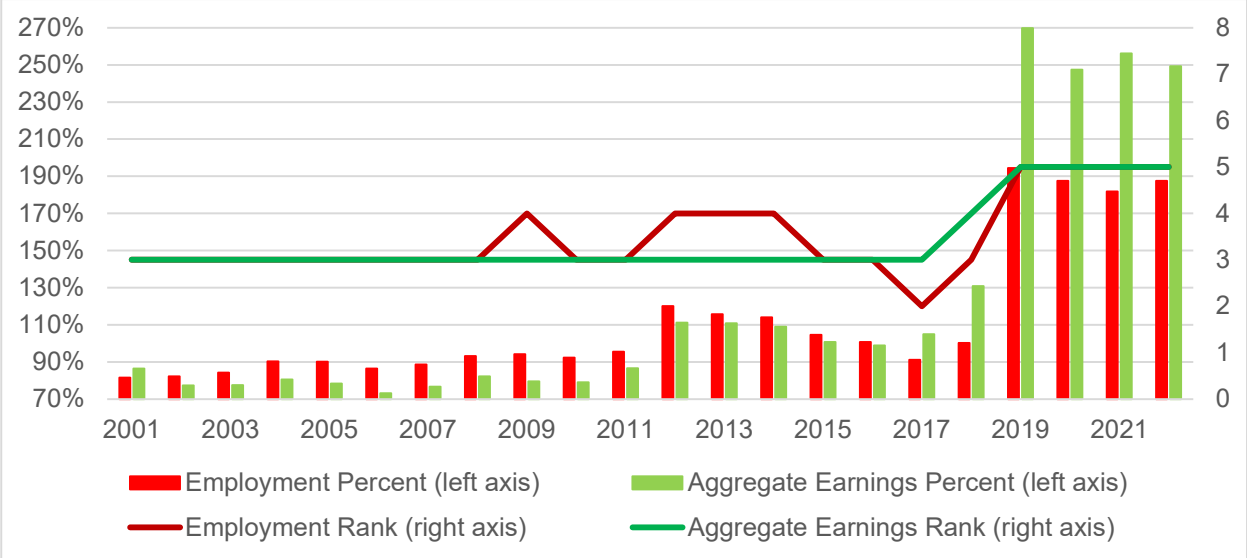
(continued)

CHART 7 (continued)
INDUSTRIAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN TUCSON AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG EIGHT SOUTHWESTERN METROPOLITAN AREAS, 2001 TO 2022

ELECTRONICS



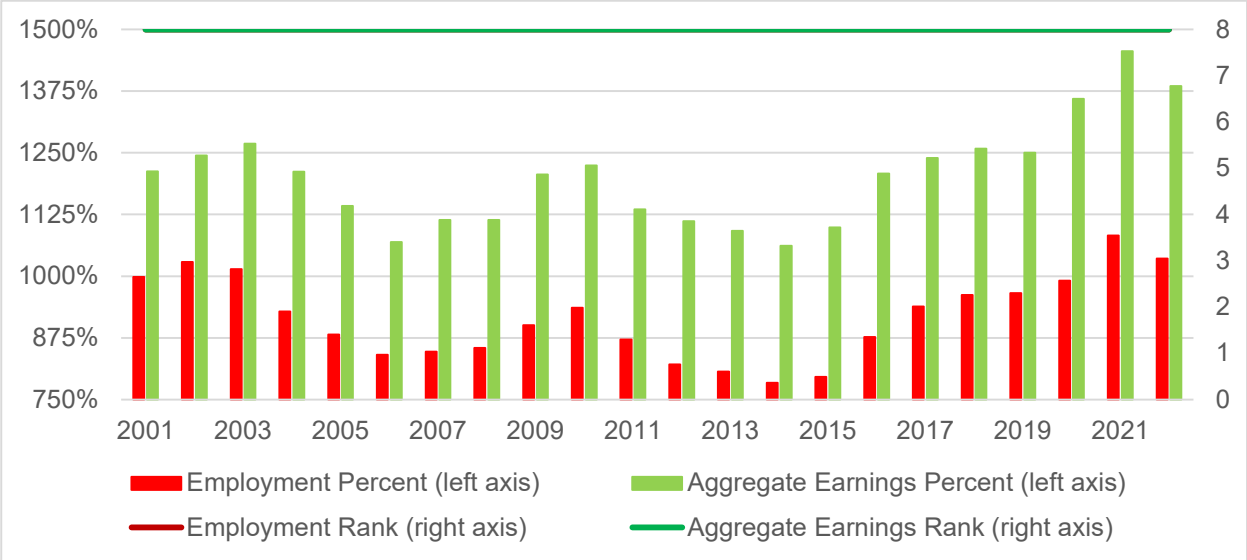
INSTRUMENTS



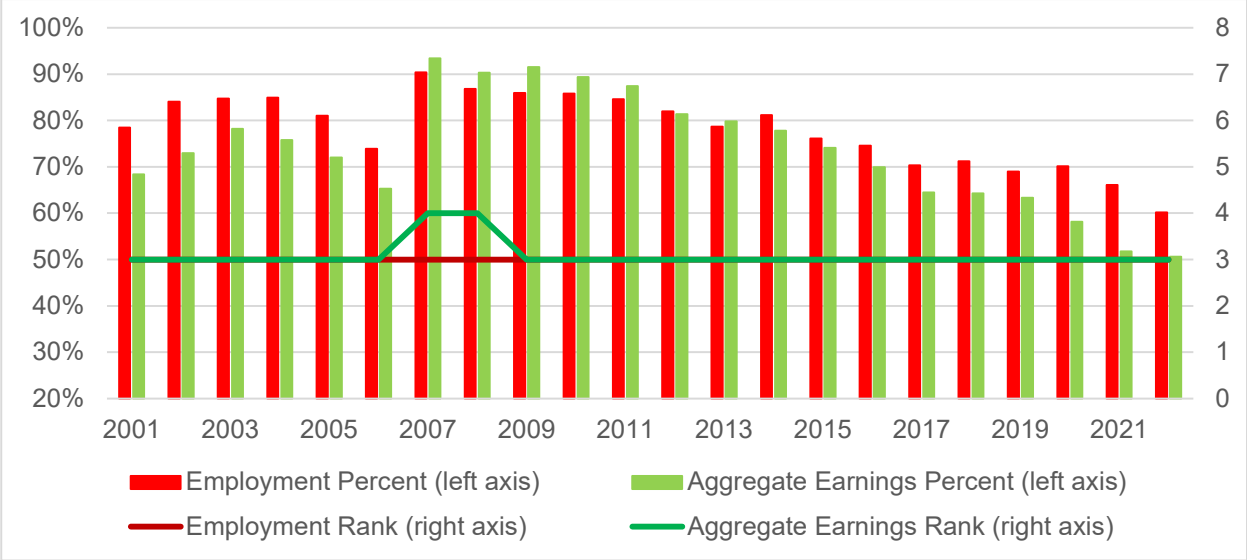
(continued)

CHART 7 (continued)
INDUSTRIAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN TUCSON AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG EIGHT SOUTHWESTERN METROPOLITAN AREAS, 2001 TO 2022

AEROSPACE

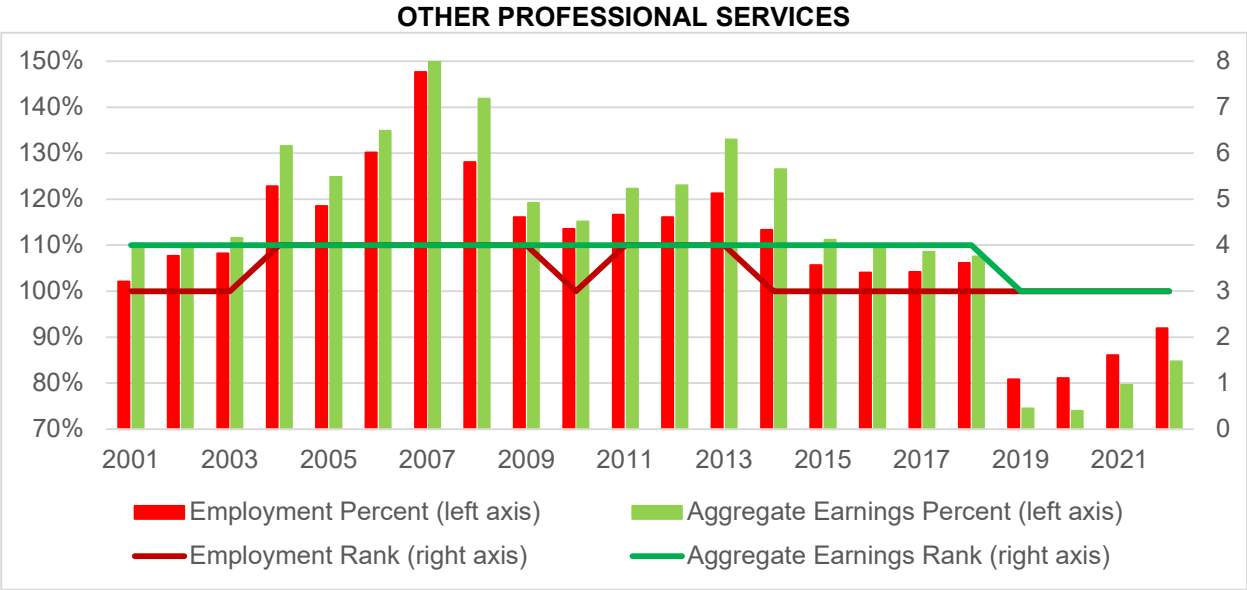


COMPUTER SERVICES



(continued)

CHART 7 (continued)
INDUSTRIAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN TUCSON AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG EIGHT SOUTHWESTERN METROPOLITAN AREAS, 2001 TO 2022



Note: Ranks are expressed such that a rank of 1 is worst and a rank of eighth is best.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. High-technology categories defined by authors.

- Instruments. The instruments share in Metro Tucson somewhat exceeded the national average during the 1990s, when it ranked fifth or sixth. After dropping below average, shares generally have been above average since 2012, with a significant increase in the share in 2019. In 2022, the employment share was 88 percent above average and the aggregate earnings share was 2.5 times the U.S. average. On each measure, the rank was fourth in 2022.
- Aerospace. Aerospace became an important part of the high-tech economy in Metro Tucson during the 1970s; by 1998, its share was more than 6 times that of the nation. The share has increased further since then to more than 10 times the U.S. average in 2022 based on employment and to nearly 14 times the average based on aggregate earnings. Metro Tucson has ranked first since 1978.
- Computer Services. The computer services share in Metro Tucson first exceeded the national average in 1993, reaching a rank of fourth. It has since dropped back. In 2022, the employment share was 40 percent less than the national average; the aggregate earnings share was 49 percent below average. In 2022, Metro Tucson ranked sixth on each measure.
- Other Professional Services. The share in Metro Tucson from 1962 through 1978 was considerably more than the national average, and the rank reached as high as second. However, the share then dropped back to barely above average and remained there until

recently. In 2022, the employment share was 8 percent less than the national average; the aggregate earnings share was 15 percent below average. In 2022, Metro Tucson ranked sixth on each measure.

Other Southwestern Metro Areas. Six southwestern metro areas have reached a high-tech share at least 50 percent higher than the U.S. average. Albuquerque reached this level by 1959, followed by Boulder in 1968. Colorado Springs, Fort Collins, Provo, and Tucson reached the mark between the late 1970s and late 1980s. Salt Lake City has not reached this threshold, and El Paso has never come close to the national average.

Subsequently, Colorado Springs, Fort Collins, and Tucson dropped below the threshold of 1.5 times the national average, but in 2022 the high-tech employment share and the aggregate earnings share remained at least 30 percent above average in each. Metro Salt Lake City had similar shares at 46 percent above average on employment and 25 percent above average on aggregate earnings.

Metro Boulder had by far the highest shares in 2022 at 3.97 times the U.S. average based on employment and 3.49 times the average based on aggregate earnings. Shares were next highest in Metro Provo at 88 percent above average on employment and 100 percent above average on aggregate earnings.

Five of the eight metro areas — Albuquerque, Boulder, Colorado Springs, Fort Collins, and Tucson — experienced a significant decrease between 2001 and 2022 in their high-tech share relative to the national average. In contrast, the two Utah metro areas experienced small gains.

The following summarizes the high-tech share of total employment relative to the national average in each of the seven comparison metro areas. County Business Patterns data were used for the 1956-to-1998 period, with Lightcast data used for 2001 through 2022. Aggregate earnings information for 2001 to 2022 supplements the employment summary. Ranks are among the eight selected areas.

Albuquerque

Metro Albuquerque was one of the early smaller high-tech centers, ranking first from 1959 through 1965, due to very high shares in other professional services. As shares in this category declined relative to the U.S. average, the metro area developed strengths in other categories, mostly instruments and electronics.

The overall high-tech share in Metro Albuquerque has declined relative to the nation, falling to less than twice the average after the mid-2000s. The employment share in 2022 was 51 percent more than the U.S. average based on employment and 33 percent higher based on aggregate earnings. Metro Albuquerque ranked third on employment and fifth on aggregate earnings.

Metro Albuquerque's high-tech strength in 2022 was limited to two categories in which its shares were more than triple the U.S. average: electronics and other professional services. The metro area ranked first in electronics. In other professional services, it was first based on aggregate earnings and second based on employment.

Boulder

Metro Boulder was not a high-tech center during the 1950s, but by 1968 its high-tech share was more than 4 times higher than the national average and it ranked first among the comparison areas. Early strength came from the computing equipment, instruments, and other professional services categories. By the late 1980s, shares were above average in each high-tech category except aerospace.

While the overall high-tech share in Metro Boulder declined relative to the nation after the mid-2000s, the employment share in 2022 was 3.97 times the U.S. average based on employment and 3.49 times higher based on aggregate earnings. Metro Boulder ranked first on each measure.

Metro Boulder's shares in 2022 based on employment and aggregate earnings were at least 3 times the U.S. average in the biopharmaceuticals, communications equipment, instruments (in which it was 12 times higher based on employment), computer services, and other professional services categories. Computing equipment also was a strength. The metro area ranked first on employment and aggregate earnings in the biopharmaceuticals, communications equipment, instruments, and computer services categories and first or second in computing equipment and other professional services.

Colorado Springs

The overall high-tech share in Metro Colorado Springs reached the national average in 1973 and peaked in 1988 at nearly 2.5 times the national average. Its earliest strength was in communications equipment, in which it ranked first from 1973 through 1988, but soon after, computing equipment, electronics, instruments, computer services, and other professional services were contributing.

The overall high-tech share in Metro Colorado Springs has declined relative to the nation, falling to less than twice the average after the early 2000s. The employment share in 2022 was 44 percent more than the U.S. average based on employment and 41 percent higher based on aggregate earnings. Metro Colorado Springs e ranked fifth on employment and fourth on aggregate earnings.

Metro Colorado Springs did not have a dominant high-tech category in 2022, but was above the U.S. average in four: electronics, instruments, computer services, and other professional services. The metro area ranked third in other professional services and second based on employment in electronics.

El Paso

Metro El Paso has never been a high-tech center, with its best comparison to the nation coming in 1988 at 45 percent below average. It has nearly always ranked last overall. The only times it had a categorical share in excess of the national average was from 1988 to 1993 in computer equipment and during the early 2000s in electronics.

Fort Collins

The overall high-tech share in Metro Fort Collins jumped from far below the national average in 1973 to 2.5 times the national average in 1978. The metro area ranked second from 1978 through 1993. Very high shares in computing equipment and instruments were present starting in 1978, and in electronics beginning in 1983.

The overall high-tech share in Metro Fort Collins has dropped considerably. In 2022, it was 42 percent higher than the U.S. average based on employment and 50 percent higher based on aggregate earnings. Metro Fort Collins ranked sixth on employment but third on aggregate earnings in 2022.

Metro Fort Collins's shares in 2022 were more than 7 times the U.S. average in computing equipment and more than 3.5 times higher in instruments. The biopharmaceuticals, electronics, and other professional services categories also were above average. The metro area ranked first in computing equipment and second in instruments.

Provo

The overall high-tech share in Metro Provo did not exceed the national average until 1988 and peaked at twice the average in 1993. Electronics was the initial high-tech leader, but its share fell to far below average in the 1990s. Computer services and biopharmaceuticals were the leading high-tech activities late in the 20th century.

The overall high-tech share in Metro Provo has held steady. In 2022, it was 88 percent higher than the U.S. average based on employment and twice the average based on aggregate earnings. Metro Provo ranked second on each measure.

Metro Provo's shares in 2022 were triple the U.S. average in computer services and in biopharmaceuticals based on employment. The electronics category also was above average. The metro area ranked second in computer services, second and third in biopharmaceuticals, and third in electronics.

Salt Lake City

The overall high-tech share in Metro Salt Lake City did not exceed the national average until 1973 and has not reached 50 percent above average. Communications equipment was the initial high-tech leader, followed by computing equipment.

The overall high-tech share in Metro Salt Lake City has increased somewhat, peaking in 2022 at 46 percent higher than the U.S. average based on employment and 25 percent above average based on aggregate earnings. Metro Salt Lake City ranked fourth on employment but only seventh on aggregate earnings.

Metro Salt Lake City's shares in 2022 were more than 2.5 times the U.S. average in instruments. Biopharmaceuticals and computer services also were above average. The metro area ranked third in computer services and instruments.

Metro Phoenix Relative to Metro Tucson. The overall high-tech employment share of the total economy was substantially higher in Metro Phoenix than in Metro Tucson from 1956 through 1978. Since 1998, the share has been somewhat higher in Metro Tucson than in Metro Phoenix. The comparison between the two metro areas is summarized below by industrial category:

- Biopharmaceuticals. Though the Metro Phoenix share has never reached the national average, it has been higher than the share in Metro Tucson since 1978.
- Computing Equipment. The share was much higher in Metro Phoenix from 1959 through 1978 but much higher in Metro Tucson during the 1980s and early-to-mid-2000s. The share has been quite low in each metro area since 2007.
- Communications Equipment. For most of the 1959-to-1998 period, the share was much higher in Metro Phoenix. Since then, shares have been below the national average in each metro area.
- Electronics. The share has been substantially higher in Metro Phoenix since 1959.
- Instruments: The share was considerably higher in Metro Phoenix from 1959 through 2017 but the share has been higher in Metro Tucson since 2019.
- Aerospace. From 1956 through 1962, the share was much higher in Metro Phoenix. Since 1978, the share has been much higher in Metro Tucson.
- Computer Services. Shares generally have not been much different between the two metro areas, though Metro Phoenix has had a slight edge since 2010.
- Other Professional Services. The share has been higher in Metro Tucson since 1962, but the magnitude of the differential generally has not been large since 1978.

Large Metro Areas Versus Moderately Large Southwestern Metro Areas

Total high-tech shares in 2022 as a percentage of the U.S. average were on average higher in the 12 selected large metro areas than in the eight southwestern metro areas. Of the eight southwestern metro areas examined, only Boulder and Provo ranked among the top 10 of the 20 metro areas examined. The large metro areas also did better on the change in the share over time, with only Provo and Salt Lake City ranking in the top 10 of the 20 total areas.

Occupational Analysis, 2001 to 2022

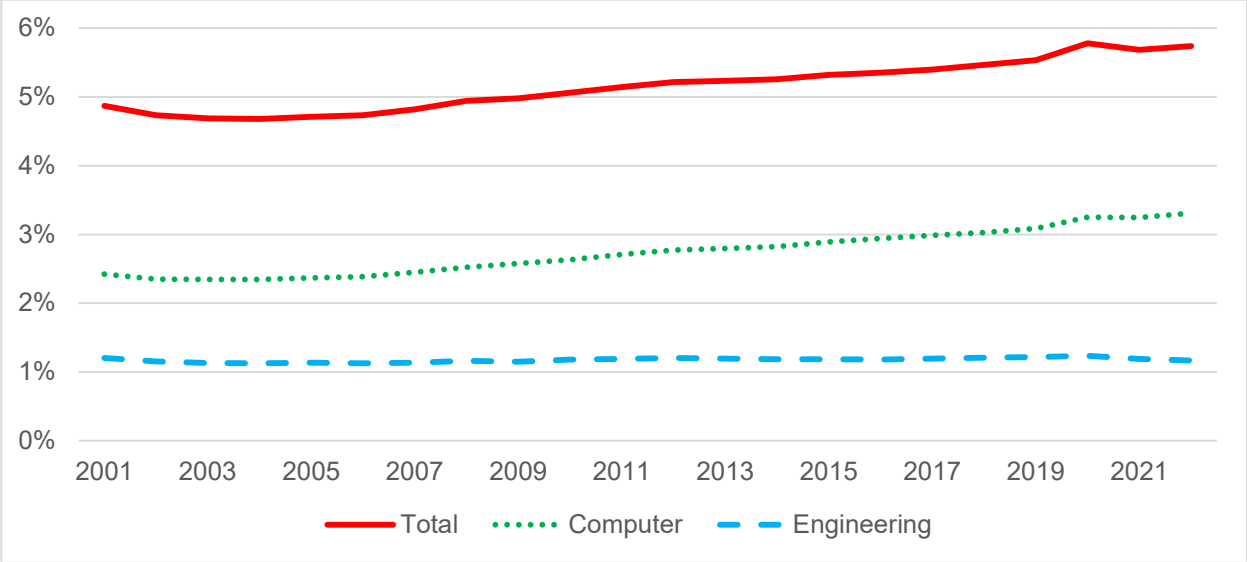
The occupational analysis is limited to data produced by Lightcast. Occupational employment estimates are available since 2001; occupational earnings data are available since 2005.

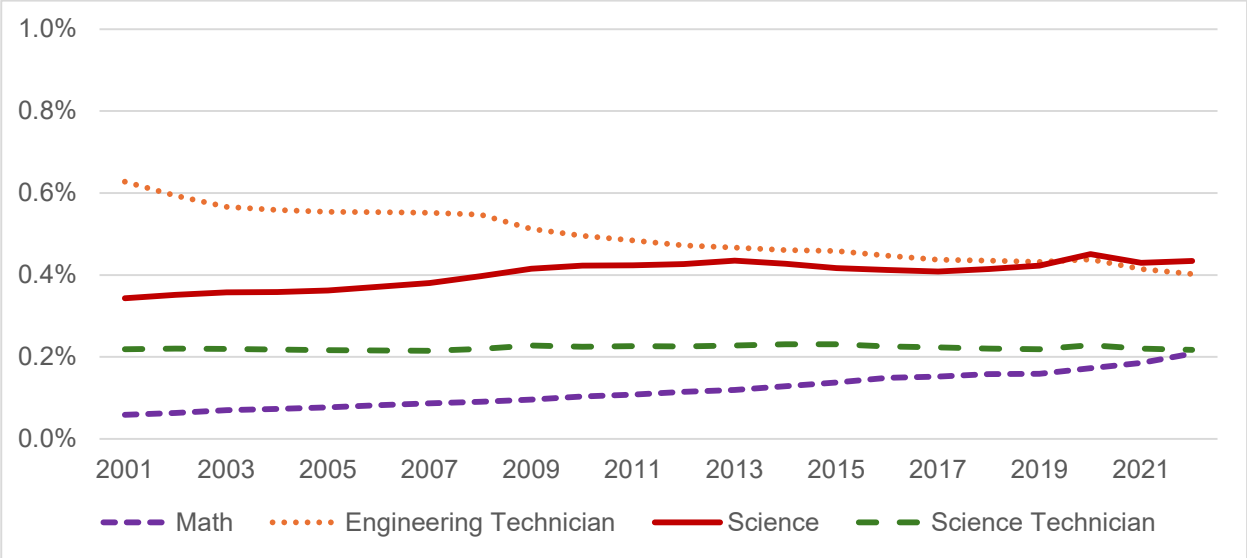
Occupational High-Tech Activities in the Nation

Annual employment data for 2001 through 2022 from Lightcast are displayed in Chart 8 for the nation for each of six high-tech categories. Aggregate earnings information for 2005 to 2022 supplements the following summary:

- Total High Tech. The employment share dipped a bit to 4.71 percent in 2005, then gradually rose to 5.74 percent in 2022. The aggregate earnings share increased from 8.11 percent in 2005 to 9.94 percent in 2022.
- Computer. The employment share rose steadily from about 2.4 percent in 2001 through 2006 to 3.31 percent in 2022. The aggregate earnings share rose steadily from 4.10 percent in 2005 to 6.10 percent in 2022.
- Math. The employment share rose steadily from 0.06 percent in 2001 and 2002 to 0.21 percent in 2022. The aggregate earnings share similarly advanced from 0.27 percent in 2005 and 2006 to 0.45 percent in 2022.

CHART 8
OCCUPATIONAL HIGH-TECHNOLOGY SHARES OF TOTAL EMPLOYMENT NATIONALLY, 2001 TO 2022





Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. High-technology categories defined by authors.

- Engineering. The employment share was nearly steady from 2001 through 2022, ranging from 1.12-to-1.24 percent. The aggregate earnings share increased from 2.25 percent in 2005 to a peak of 2.39 percent in 2013 and 2014, then fell to 2.09 percent in 2022.
- Engineering Technology. The employment share gradually decreased from 0.63 percent in 2001 to 0.40 percent in 2022. The aggregate earnings share similarly declined from 0.62 percent in 2005 to 0.38 percent in 2022.
- Science. The employment share increased from 0.34 percent in 2001 to 0.42 percent in 2010 and has since held nearly constant. The aggregate earnings share rose from 0.63 percent in 2005 to a high of 0.76 percent in 2013, then dropped back to 0.64 percent in 2022.
- Science Technology. The employment share has been steady at 0.22-to-0.23 percent since 2001. The aggregate earnings share increased a bit from 0.26 percent in 2005 and 2006 to 0.31 percent from 2017 to 2020, but the 2022 share was 0.29 percent.

The computer category dominates occupational high-tech activity in the nation. As a share of total high tech, its employment share increased from 50.6 percent in 2001 to 61.4 percent in 2022; its aggregate earnings share rose from 49.7 percent in 2005 to 57.7 percent in 2022.

States

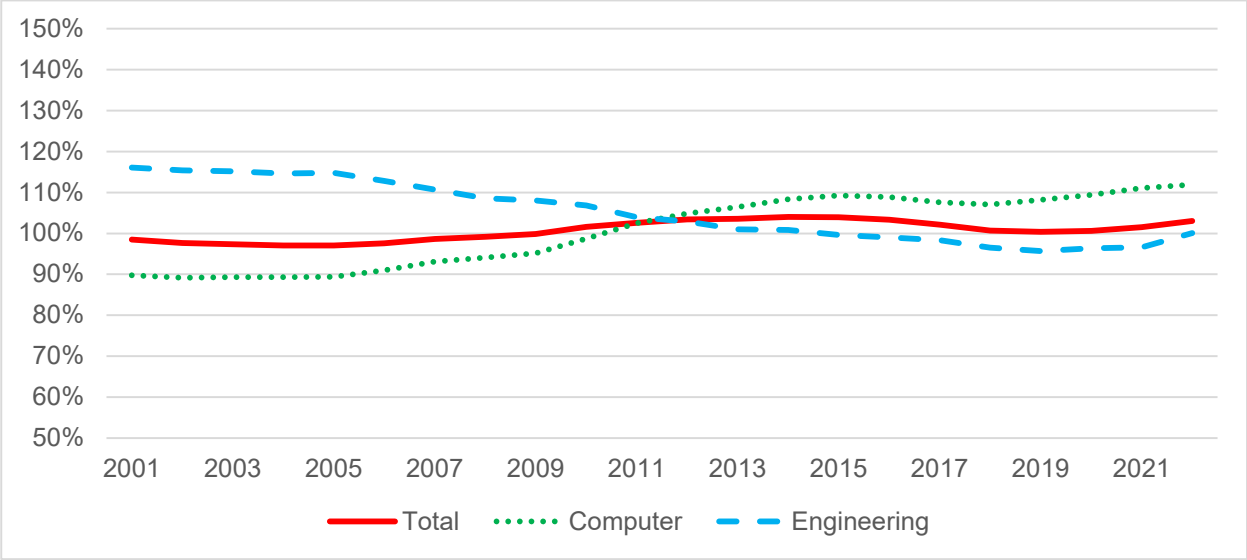
This section focuses on Arizona and the seven other selected states relative to the national average.

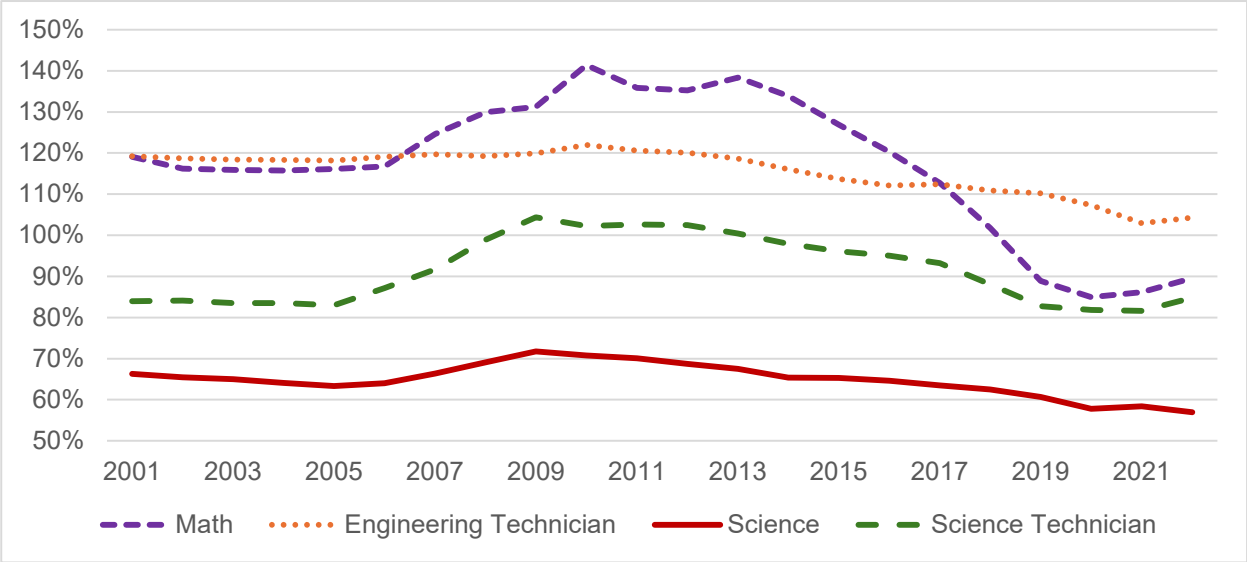
Arizona. Annual occupational employment data for 2001 through 2022 from Lightcast are displayed in Chart 9 for Arizona relative to the nation for each of the six high-tech occupational categories. The following summarizes the high-tech share of total employment in Arizona relative to the national average. Aggregate earnings information for 2005 to 2022 supplements the employment summary. Ranks and leading states are expressed as among the eight selected states:

- Total High Tech. Arizona's employment share has ranged from 3 percent below average in 2003 through 2005 to 4 percent above average in 2013 through 2015. It was 3 percent above average in 2022. The aggregate earnings share has varied from 7 percent below average in 2008 to 1 percent above average in 2016. It was 4 percent below average in 2022. Arizona's rank was last in each year on each measure. Maryland, Virginia, and Washington have been the leaders.

  Computer. Arizona's employment share was about 10 percent below the U.S. average from 2001 through 2005, then gradually improved to 12 percent above average in 2022. The aggregate earnings share also increased, from more than 10 percent below average before 2010 to 2 percent above average in 2015 and 2016. However, it was 3 percent below average in 2022. Arizona ranked seventh or eighth in each year on each measure. Virginia and Washington have been the leaders since 2010.
- Math. Arizona's employment share rose from 16 percent above the U.S. average from 2002 through 2005 to 41 percent above average in 2010. Since then, the share has dropped to 10 percent below average in 2022. The aggregate earnings share did not increase as much, from 6 percent above average in 2007 to 16 percent above average in 2013. It then dropped to 17 percent below average in 2022. Arizona's employment rank

CHART 9
OCCUPATIONAL HIGH-TECHNOLOGY SHARES OF TOTAL EMPLOYMENT IN ARIZONA AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES OF TOTAL EMPLOYMENT NATIONALLY, 2001 TO 2022





Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. High-technology categories defined by authors.

fell from fourth to last; the aggregate earnings rank went from fifth to last. Maryland and Virginia have been the leaders.

- Engineering. Arizona's employment share was 16 percent above the U.S. average in 2001, then dropped to 4 percent below average in 2019 and 2020. The share was equal to the U.S. average in 2022. The aggregate earnings share declined from 18 percent above average in 2005 to 1 percent below average in 2019. The 2022 share was 7 percent above average. Arizona's employment rank slipped from seventh to last; the aggregate earnings rank has fluctuated between fifth and eighth. In recent years, Colorado has been the leader.
- Engineering Technician. Arizona's employment share rose a bit to 22 percent above the U.S. average in 2010, then dropped to 4 percent above average in 2022. The aggregate earnings share similarly increased slightly to 27 percent above average in 2010, then decreased to 5 percent above average in 2022. Arizona's rank fell from second to fourth on each measure. Utah has been the leader since 2011.
- Science. Arizona's employment share has been considerably below the U.S. average throughout. It advanced a little to 28 percent below average in 2009 but then fell to 43 percent below average in 2022. The aggregate earnings share was highest at 38 percent below average in 2007, but was 45 percent below average in 2022. Arizona ranked last in every year on each measure. Maryland and Massachusetts have been the leaders.
- Science Technician. Arizona's employment share improved from 17 percent less than the national average in 2005 to 4 percent above average in 2009, but was 15 percent below the average in 2022. The aggregate earnings share also increased, from 22 percent lower than the national average in 2005 to 3 percent below average in 2009, but then fell to 11 percent below average in 2022. Arizona generally has ranked seventh or eighth on each measure. Colorado, Maryland, and Massachusetts have been the leading states.

Other States. A summary of the occupational high-tech activities by category in the seven comparison states from 2001 through 2022 follows, based on the employment share relative to the national average. Aggregate earnings information for 2005 to 2022 supplements the employment summary. Ranks are among the eight selected states:

<u>California</u>

- Total High Tech. A small gain in the share relative to the nation has occurred in each measure. In 2022, the employment share was 17 percent above average; the aggregate earnings share was 22 percent higher than the national average. The rank was sixth on each measure in each year.
- Computer. A slight gain in the share relative to the nation has occurred in each measure. In 2022, the employment share was 18 percent above average; the aggregate earnings share was 24 percent higher than the national average. The rank generally has been sixth on each measure.
- Math. A gain in the share relative to the nation has occurred in each measure. In 2022, the employment share was 6 percent above average; the aggregate earnings share was 22 percent higher than the national average. The rank generally has been sixth or seventh on each measure, but climbed to fourth in 2022 based on aggregate earnings.
- Engineering. The share relative to the nation has decreased in each measure. In 2022, the employment share was 17 percent above average; the aggregate earnings share was 16

percent higher than the national average. The employment rank consistently has been fifth, while the aggregate earnings rank generally has been second or third.

- Engineering Technician. A small gain in the share relative to the nation has been lost in each measure. In 2022, the employment share was 2 percent below average; the aggregate earnings share was 2 percent higher than the national average. The employment rank generally has been seventh or eighth, while the aggregate earnings rank generally has been sixth or seventh.
- Science. The employment share relative to the nation increased but then fell back somewhat, while the aggregate earnings share rose then held steady. In 2022, the employment share was 29 percent above average; the aggregate earnings share was 30 percent higher than the national average. The employment rank consistently has been fifth, while the aggregate earnings rank generally has been fourth.
- Science Technician. A gain in the share relative to the nation has occurred in each measure. In 2022, the employment share was 21 percent above average; the aggregate earnings share was 7 percent higher than the national average. The rank generally has been fifth or sixth on each measure.

Colorado

- Total High Tech. Little change in the share relative to the nation has occurred in each measure. In 2022, the employment share was 37 percent above average; the aggregate earnings share was 29 percent higher than the national average. The employment rank was fifth in each year; aggregate earnings has ranked fourth or fifth.
- Computer. A small decline in the employment share relative to the nation has occurred, while the aggregate earnings share rose then fell relative to the nation. In 2022, the employment share was 36 percent above average; the aggregate earnings share was 29 percent higher than the national average. The rank generally has been fourth or fifth on each measure.
- Math. A loss in the share relative to the nation was followed by a rebound in each measure. In 2022, the employment share was 6 percent above average; the aggregate earnings share was 12 percent higher than the national average. The employment rank went from fifth to last to sixth, while the aggregate earnings rank has varied from fourth to seventh.
- Engineering. The share relative to the nation decreased then rebounded in each measure. In 2022, the employment share was 47 percent above average; the aggregate earnings share was 33 percent higher than the national average. The employment rank improved from third or fourth to first, while the aggregate earnings rank generally has been first.
- Engineering Technician. A small gain in the share relative to the nation has occurred in each measure. In 2022, the employment share was 15 percent above average; the aggregate earnings share was 2 percent higher than the national average. The employment rank generally improved from seventh or eighth to second, while the aggregate earnings rank generally has been seventh or eighth.
- Science. The share relative to the nation dropped but then partially recovered in each measure. In 2022, the employment share was 50 percent above average; the aggregate earnings share was 44 percent higher than the national average. The rank on each measure generally has been third or fourth.

- Science Technician. A loss in the employment share relative to the nation has occurred, while the relative aggregate earnings share dropped then partially recovered. In 2022, the employment share was 32 percent above average; the aggregate earnings share was 24 percent higher than the national average. The rank generally has ranged from second to fourth on each measure.

Maryland

- Total High Tech. Little change in the share relative to the nation has occurred in aggregate earnings, while a small increase has occurred in employment. In 2022, the employment share was 52 percent above average; the aggregate earnings share was 42 percent higher than the national average. The employment rank was first or second in each year; aggregate earnings has ranked between first and third.
- Computer. The share relative to the nation has fluctuated in a narrow range in each measure. In 2022, the employment share was 53 percent above average; the aggregate earnings share was 42 percent higher than the national average. The employment rank has been fourth or fifth; the aggregate earnings rank has varied from third to fifth.
- Math. A large loss in the share relative to the nation has occurred in each measure, but the 2022 share remained well above average, by 85 percent based on employment and 65 percent based on aggregate earnings. The rank generally has been first on each measure.
- Engineering. The share relative to the nation decreased somewhat in each measure. In 2022, the employment share was 28 percent above average; the aggregate earnings share was 12 percent higher than the national average. The employment rank has been between first and third, while the aggregate earnings rank generally has been second or third.
- Engineering Technician. A decrease in the share relative to the nation has occurred in each measure. In 2022, the employment share was 6 percent less than average; the aggregate earnings share was 8 percent higher than the national average. The employment rank has ranged from third to last, while the aggregate earnings rank has been between third and fifth.
- Science. The share relative to the nation has increased in each measure. In 2022, the employment share was 2.43 times the U.S. average; the aggregate earnings share was 2.51 times higher than the national average. The rank on each measure has been first or second.
- Science Technician. A gain in the employment share relative to the nation has occurred, while the relative aggregate earnings share has dropped. In 2022, the employment share was 57 percent above average; the aggregate earnings share was 26 percent higher than the national average. The employment rank improved from third to first, while the aggregate earnings rank generally has been first or second.

Massachusetts

- Total High Tech. A decline in the share relative to the nation has occurred in each measure. In 2022, the employment share was 38 percent above average; the aggregate earnings share was 28 percent higher than the national average. The employment rank slipped from third to fourth; the aggregate earnings rank dropped from second to fifth.
- Computer. The share relative to the nation has declined in each measure. In 2022, the employment share was 32 percent above average; the aggregate earnings share was 27

percent higher than the national average. The rank has dropped from second to fifth on each measure.

- Math. A loss in the share relative to the nation has occurred in each measure. The 2022 employment share was 34 percent above average; the aggregate earnings share was 21 percent above average. The rank generally has been third on each measure.
- Engineering. The share relative to the nation decreased in each measure. In 2022, the employment share was 17 percent above average; the aggregate earnings share was 2 percent lower than the national average. The employment rank has been third or fourth, while the aggregate earnings rank has dropped from fourth to seventh.
- Engineering Technician. A decrease in the share relative to the nation has occurred in each measure. In 2022, the employment share was 2 percent more than average; the aggregate earnings share was 12 percent lower than the national average. The employment rank has fallen from third to sixth, while the aggregate earnings rank has dropped from sixth to last.
- Science. The share relative to the nation has increased substantially in each measure. In 2022, the employment share was 2.75 times the U.S. average; the aggregate earnings share was 2.66 times higher than the national average. The rank on each measure has improved from third to first.
- Science Technician. A loss in the share relative to the nation was followed by a bounce-back in each measure. In 2022, the employment share was 43 percent above average; the aggregate earnings share was 31 percent higher than the national average. The rank has fluctuated from first to fourth on each measure.

<u>Utah</u>

- Total High Tech. A small decline in the share relative to the nation was followed by a somewhat larger increase in each measure. In 2022, the employment share was 16 percent above average; the aggregate earnings share was 11 percent higher than the national average. The rank has been seventh in every year in each measure.
- Computer. The share relative to the nation dipped then more than recovered in each measure. In 2022, the employment share was 37 percent above average; the aggregate earnings share was 20 percent higher than the national average. The employment rank has varied from sixth to eighth; the aggregate earnings rank has mostly been seventh.
- Math. A loss in the share relative to the nation was followed by a strong gain in each measure. The 2022 employment share was 34 percent above average; the aggregate earnings share was 21 percent above average. The employment rank has improved from eighth to third; the aggregate earnings rank rose from eighth to sixth.
- Engineering. The share relative to the nation has held in a narrow range in each measure. In 2022, the employment share was 3 percent above average; the aggregate earnings share was equal to the national average. The rank improved from eighth to sixth in each measure.
- Engineering Technician. An increase in the share relative to the nation has occurred in each measure. In 2022, the employment share was 38 percent more than average; the aggregate earnings share was 29 percent higher than the national average. The rank improved from fifth to first in each measure.
- Science. The share relative to the nation has decreased in each measure. In 2022, the employment share was 10 percent less than the U.S. average; the aggregate earnings

share was 17 percent less than the national average. The rank on each measure generally has been seventh.

- Science Technician. The employment share decreased relative to the national average. A loss in the share relative to the nation was followed by a bounce-back based on aggregate earnings. In 2022, the employment share was 31 percent above average; the aggregate earnings share was 21 percent higher than the national average. The employment rank dropped from first to fourth, while the rank on aggregate earnings has mostly been fourth or fifth.

Virginia

- Total High Tech. A decline in the employment share relative to the nation has occurred, while the aggregate earnings share has held in a narrow range. In 2022, the employment share was 44 percent above average; the aggregate earnings share was 45 percent higher than the national average. The employment rank dropped from first to third, while the aggregate earnings rank has ranged from first to third.
- Computer. The employment share relative to the nation dropped, while the aggregate earnings share went up-down-up to the same level as 2005. In 2022, the employment share was 73 percent above average; the aggregate earnings share was 70 percent higher than the national average. The rank has been first or second in each year in each measure.
- Math. A loss in the share relative to the nation has occurred in each measure. The 2022 employment share was 55 percent above average and the aggregate earnings share was 71 percent above average. The rank in each measure generally has been second.
- Engineering. A decrease in the share relative to the nation has occurred in each measure. In 2022, the employment share was 2 percent above average; the aggregate earnings share was 5 percent less than the national average. The rank generally has been sixth or seventh in each measure.
- Engineering Technician. The employment share relative to the nation dropped, while the aggregate earnings relative share has held in a narrow range. In 2022, the employment share was 5 percent more than average; the aggregate earnings share was 16 percent higher than the national average. The rank generally has been between second and fourth in each measure.
- Science. The share relative to the nation has decreased based on aggregate earnings but has held in a narrow range based on employment. In 2022, the employment share was 5 percent less than the U.S. average; the aggregate earnings share was 4 percent less than the national average. The rank in each measure has been sixth or seventh.
- Science Technician. The share increased relative to the national average in each measure. In 2022, the employment share was 13 percent below average; the aggregate earnings share was 4 percent lower than the national average. The rank in each measure generally has been sixth or seventh.

Washington

- Total High Tech. A gain in the share relative to the nation has occurred in each measure. In 2022, the employment share was 51 percent above average; the aggregate earnings share was 44 percent higher than the national average. The rank improved from fourth to second in each measure.

- Computer. The share relative to the nation increased in each measure. In 2022, the employment share was 68 percent above average; the aggregate earnings share was 63 percent higher than the national average. The employment rank improved from fifth to second. The aggregate earnings rank generally has been first or second.
- Math. An increase in the share relative to the nation was followed by a smaller decrease in each measure. The 2022 share was 20 percent above average based on employment and 24 percent above average based on aggregate earnings. The employment rank improved from eighth to fifth and the aggregate earnings rank from sixth to third.
- Engineering. A decrease in the share relative to the nation has occurred in each measure. In 2022, the employment share was 33 percent above average; the aggregate earnings share was 9 percent more than the national average. The employment rank generally has been first or second, while the aggregate earnings rank generally has been fourth or fifth.
- Engineering Technician. The employment and aggregate earnings shares relative to the nation have dropped. In 2022, each share was 4 percent more than average. The rank fell from first to fifth in each measure.
- Science. The employment share relative to the nation has decreased; the aggregate earnings share dropped more but partially rebounded. In 2022, the employment share was 51 percent more than the U.S. average; the aggregate earnings share was 30 percent more than the national average. The employment rank has varied from second to fourth, while the aggregate earnings rank has been fourth or fifth.
- Science Technician. The share decreased relative to the national average in each measure. In 2022, the employment share was 9 percent above average; the aggregate earnings share was 7 percent lower than the national average. The employment rank has been fifth or sixth, while the aggregate earnings rank dropped from third to seventh.

High Technology in 2022: All States. In Table 7, the ranks among all 51 "states" in each of the six occupational high-tech categories are shown for each of the eight comparison states based on second and ninth on overall high-tech share. The District of Columbia ranked first and New Hampshire ranked fifth, but were not selected as comparison states due to their small size.

Colorado, Maryland, and Massachusetts have the most diverse high-tech economies, ranking in the top 10 states in at least four of the six high-tech categories. Based on a rank in the top 15 states, California joins this group. Other than Arizona, Virginia had the narrowest high-tech base, ranking in the top 15 only in the computer and math categories. Arizona was in the top 15 in only the computer category.

Arizona ranked 17th overall. In addition to the states shown in the table, New Jersey, Oregon, Delaware, Minnesota, New Mexico, and Connecticut ranked higher than Arizona. North Carolina and Texas ranked just behind Arizona.

While the overall ranks based on aggregate earnings were similar to those based on employment, some of the aggregate earnings ranks in the categories were noticeably different from the employment ranks. Overall, Arizona ranked 18th based on aggregate earnings.

TABLE 7
RANK AMONG ALL STATES ON THE SHARE OF TOTAL EMPLOYMENT BY HIGH-TECHNOLOGY OCCUPATIONAL CATEGORY, 2022

	AZ	CA	CO	MD	MA	UT	VA	WA	Other States in Top 10
TOTAL HIGH TECH	17	7	6	2	5	9	4	3	DC NH MI
Computer	11	8	5	4	6	7	2	3	DC NJ NH
Math	25	15	13	2	6	5	3	9	DC DE NJ NY IL
Engineering	23	13	3	9	12	18	21	7	MI NM AL CT NH OR AK
Engineering Technology	21	29	11	34	24	4	20	22	AK NM MI NH OR MN TX ME SC
Science	51	13	9	3	1	27	23	8	AK DC DE MT NJ NM
Science Technology	42	14	10	6	8	12	41	20	AK MT WY ID OR SD HI

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. High-technology categories defined by authors.

Metropolitan Areas
This section focuses first on Metropolitan Phoenix and the 11 other selected large metro areas relative to the national average. Then, Metropolitan Tucson and the seven other southwestern metro areas are examined.

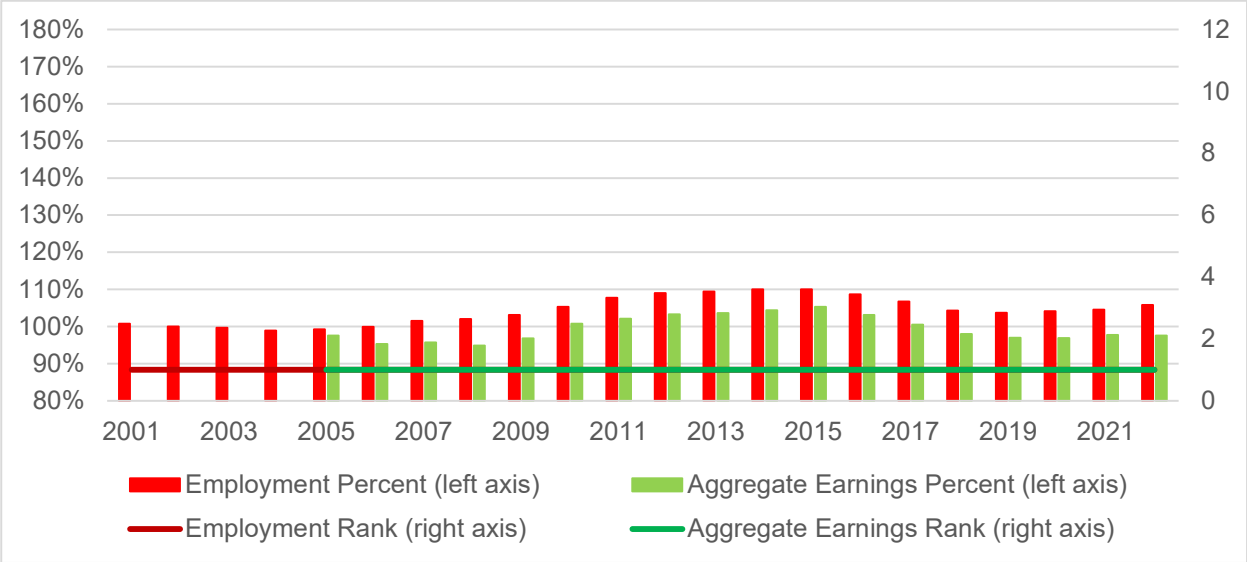
Metropolitan Phoenix. Annual occupational employment data for 2001 through 2022 from Lightcast are displayed in Chart 10 for Metro Phoenix relative to the nation for each of the six high-tech occupational categories. Note that the ranks are expressed such that a rank of 1 is worst and a rank of 12th is best.

The following summarizes the high-tech share of total employment in Metro Phoenix relative to the national average. Aggregate earnings information for 2005 to 2022 supplements the employment summary. Ranks are expressed as among the 12 selected metro areas:

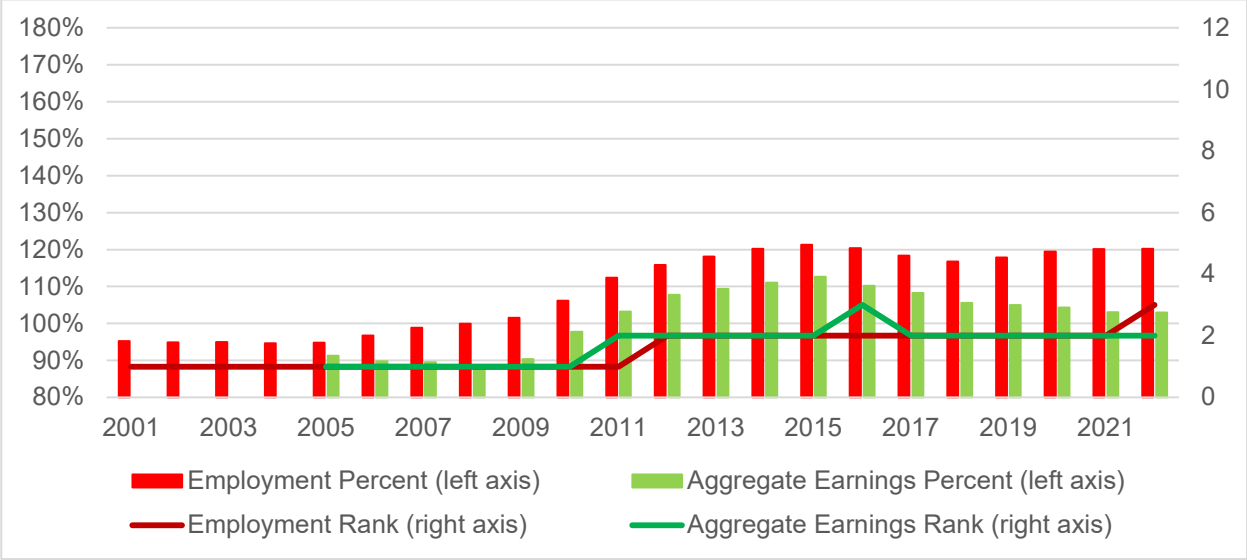
- Total High Tech. Metro Phoenix's employment share has varied from 1 percent below average to 10 percent above average; it was 6 percent above average in 2022. The aggregate earnings share has been in a range from 5 percent below average to 5 percent above average; it was 2 percent below average in 2022. Metro Phoenix ranked last in each year on each measure.
- Computer. Metro Phoenix's share relative to the U.S. average improved from the early 2000s to 2015 but then slipped a bit in each measure. In 2022, the employment share was 20 percent above average but the aggregate earnings share was only 3 percent above average. Metro Phoenix's rank improved modestly, from last to 10th on employment and to 11th on aggregate earnings.
- Math. Metro Phoenix's shares relative to the U.S. average have decreased considerably. The employment share fell from 75 percent more than the U.S. average to 8 percent below average and the aggregate earnings share dropped from 34 percent above average to 18 percent below average. Metro Phoenix's rank fell to last in each measure.
- Engineering. Relative to the U.S. average, Metro Phoenix's shares have decreased, from 20 percent more than the U.S. average to 1 percent below average based on employment and from 17 percent above average to 4 percent above average based on aggregate earnings. The employment share ranked last in each year; the aggregate earnings rank generally has been between 10th and last.
- Engineering Technician. Metro Phoenix's shares have decreased relative to the U.S. average, from 34 percent more than the U.S. average to 6 percent above average based on employment and from 40 percent above average to 5 percent above average based on aggregate earnings. The employment share generally has ranked from fifth to eighth; the aggregate earnings rank mostly has been fifth or sixth.
- Science. Metro Phoenix's shares have been far below average. In 2022, the employment share was 55 percent below average; the aggregate earnings share was 58 percent below average. Metro Phoenix ranked last in each year in each measure.
- Science Technician. Metro Phoenix's shares have been considerably below average. In 2022, the employment share was 42 percent below average; the aggregate earnings share was 25 percent below average. Metro Phoenix ranked last in each year on employment and usually 11th or 12th on aggregate earnings.

CHART 10
OCCUPATIONAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN PHOENIX AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG 12 LARGE METROPOLITAN AREAS, 2001 TO 2022

ALL HIGH-TECHNOLOGY OCCUPATIONS



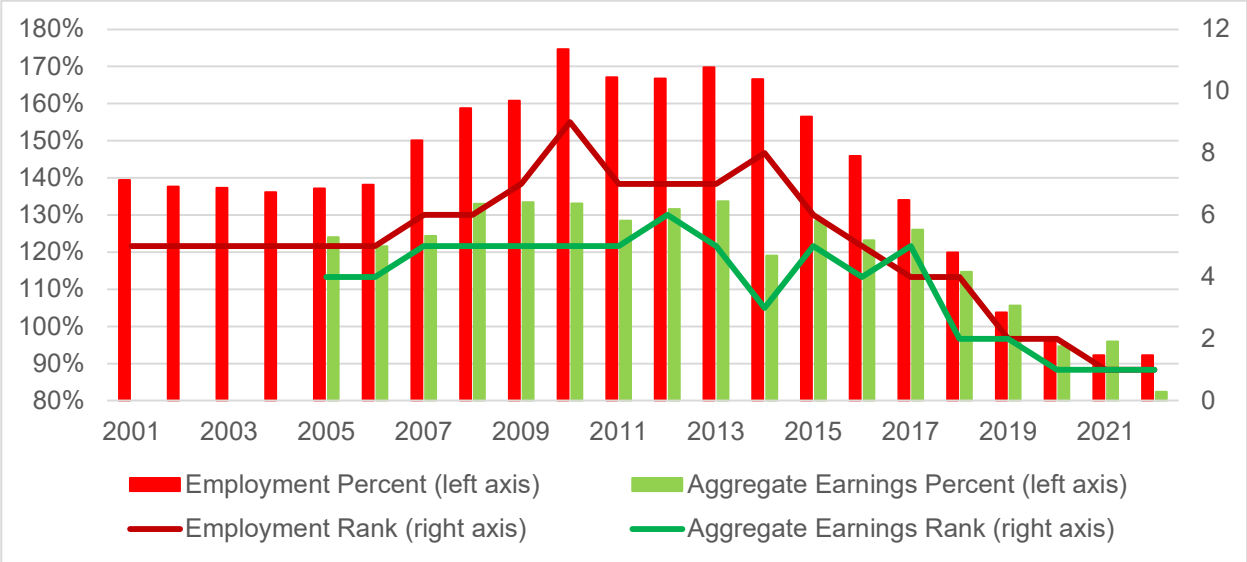
COMPUTER OCCUPATIONS



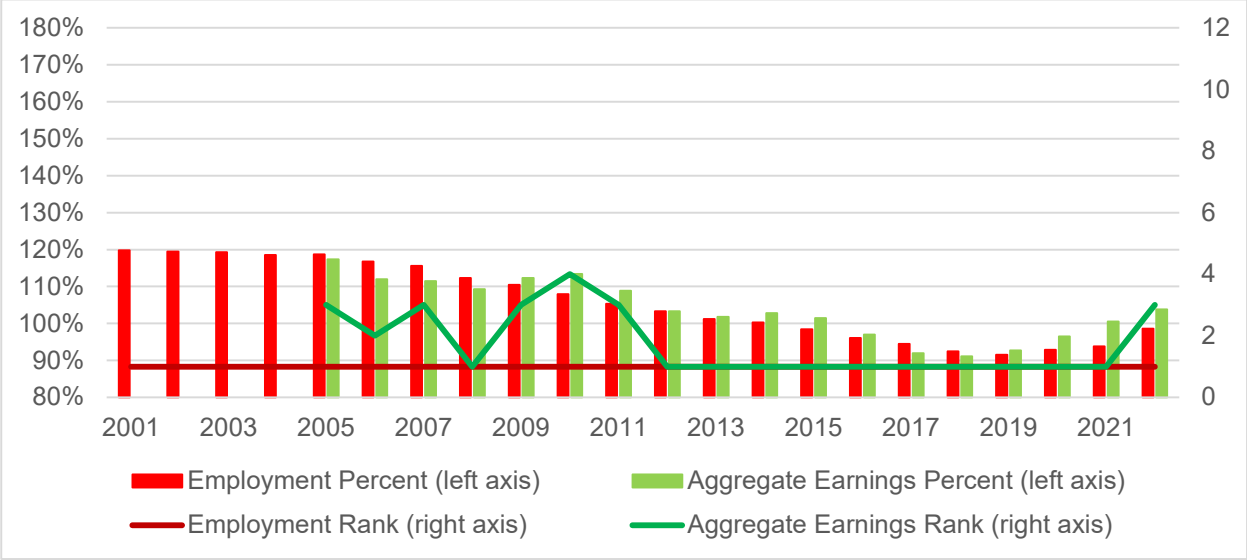
(continued)

CHART 10 (continued)
OCCUPATIONAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN PHOENIX AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG 12 LARGE METROPOLITAN AREAS, 2001 TO 2022

MATHEMATICAL OCCUPATIONS



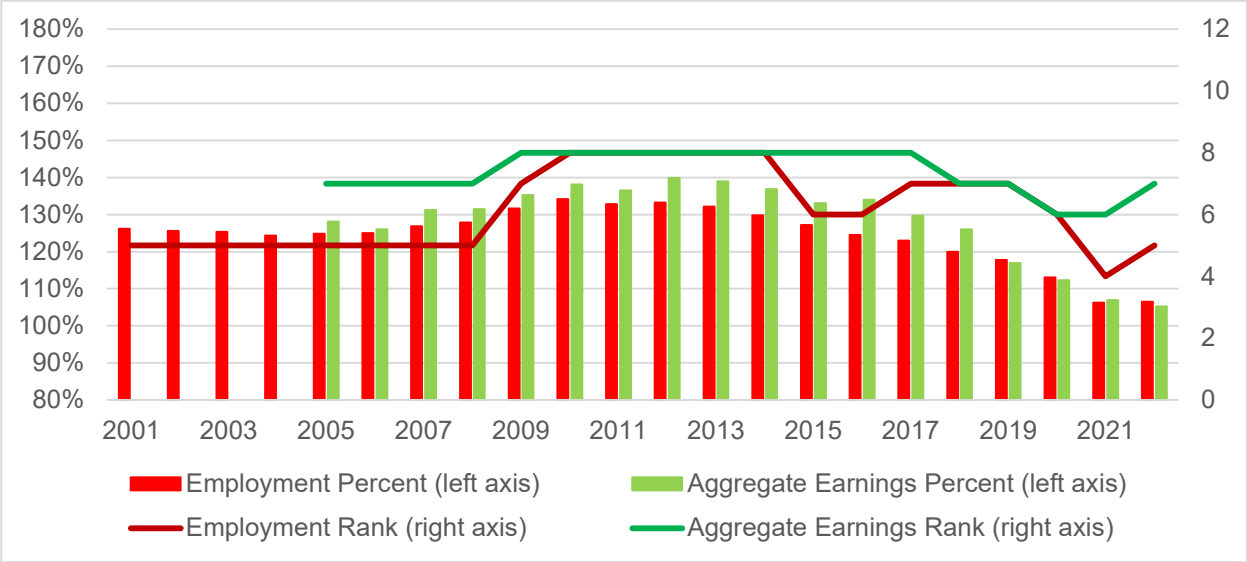
ENGINEERING OCCUPATIONS



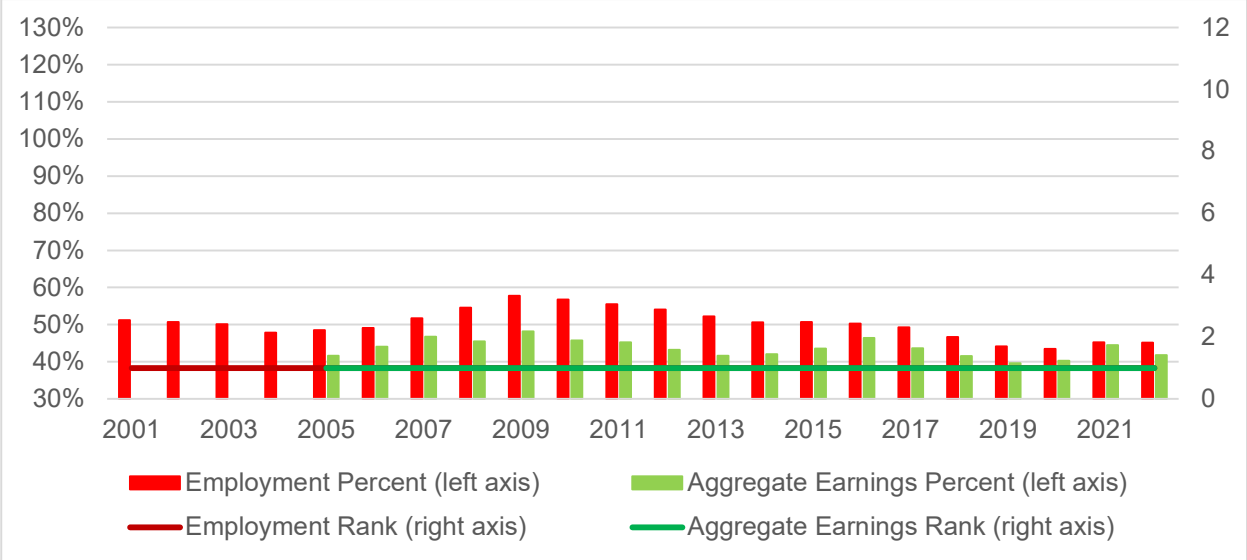
(continued)

CHART 10 (continued)
OCCUPATIONAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN PHOENIX AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG 12 LARGE METROPOLITAN AREAS, 2001 TO 2022

ENGINEERING TECHNICIAN OCCUPATIONS

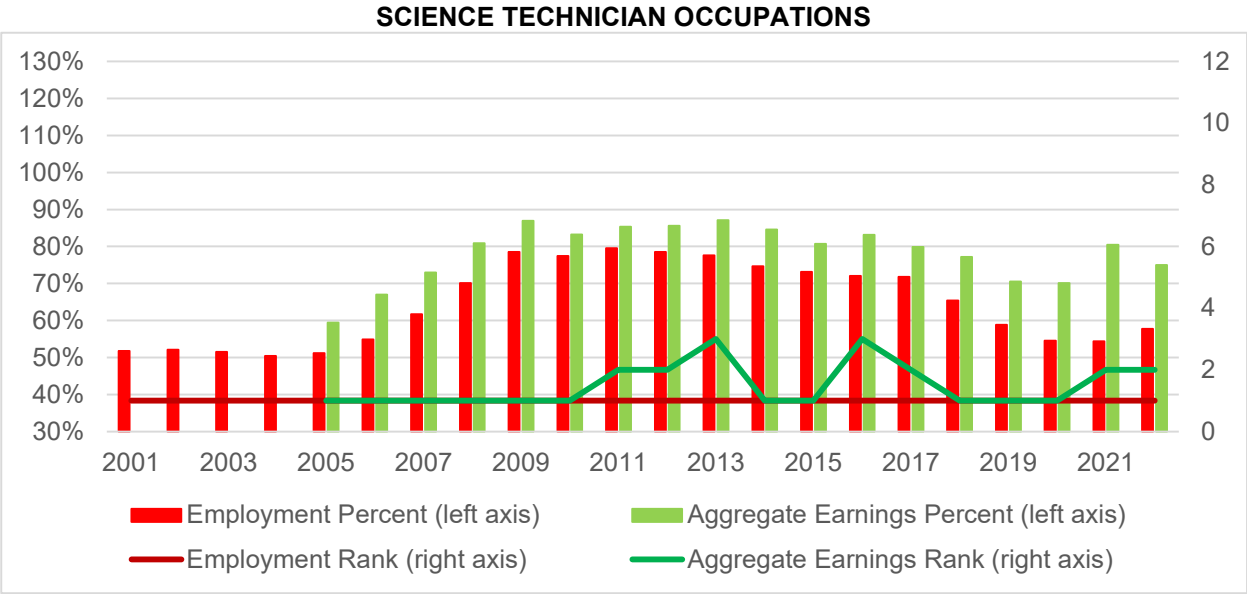


SCIENCE OCCUPATIONS



(continued)

CHART 10 (continued)
OCCUPATIONAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN PHOENIX AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG 12 LARGE METROPOLITAN AREAS, 2001 TO 2022



Note: Ranks are expressed such that a rank of 1 is worst and a rank of 12th is best.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. High-technology categories defined by authors.

Other Large High-Technology Metro Areas. Each of the 11 other metro areas had an overall high-tech employment share greater than the national average in 2022, ranging from 37 percent higher in Metro Portland to 3.38 times the U.S. average in Metro San Jose. The differential from the U.S. average was a little lower in each area based on aggregate earnings; with a range of 19 percent higher in Metro Portland to 2.97 times the U.S. average in Metro San Jose. Seven of the metro areas experienced an increase in the employment share relative to the U.S. average between 2001 and 2022, but most of the advances were small. The San Francisco, San Jose, and Seattle metro areas had the greatest gains. The Washington, D.C. and Raleigh-Durham metro areas had somewhat sizable losses, though the aggregate earnings decrease was not significant in the Washington, D.C. area.

A summary of the occupational high-tech activities by category from 2001 through 2022 follows for the 11 comparison areas, based on the employment share relative to the national average. Aggregate earnings information for 2005 to 2022 supplements the employment summary. Ranks are among the 12 selected areas.

Austin

The overall high-tech employment share in Metro Austin in 2022 was 67 percent above the U.S. average; the aggregate earnings share was 45 percent above average. Metro Austin ranked sixth

on both employment and aggregate earnings in 2022. On each measure, Metro Austin's shares have slipped relative to the U.S. average since the early 2000s.

Metro Austin's shares in 2022 were above average in the computer, math, engineering, and engineering technician categories. Its highest ranks of third based on employment and fourth based on aggregate earnings were in the engineering technician category. It has lost ground to the nation on high-tech share except in the computer category.

Baltimore

The overall high-tech share in Metro Baltimore in 2022 was 39 percent above the U.S. average based on employment and 31 percent above average based on aggregate earnings. Metro Baltimore ranked ninth on both employment and aggregate earnings in 2022. On each measure, Metro Baltimore's shares have increased a little relative to the U.S. average since the early 2000s.

Metro Baltimore's shares in 2022 were above average in the computer, math, science, and science technician categories and approximately average in the two engineering categories. Its highest rank was fourth based on employment in the science technician category. It has lost ground to the nation on high-tech share in the math, engineering, and engineering technician categories, but has experienced an increase in the computer category.

Boston

The overall high-tech share in Metro Boston in 2022 was 56 percent above the U.S. average based on employment and 42 percent above average based on aggregate earnings. Metro Boston ranked seventh in each measure in 2022. Metro Boston's shares have slipped relative to the U.S. average since the late 2000s in each measure.

Metro Boston's shares in 2022 were above average except based on aggregate earnings in the engineering technician category. It ranked first in the science category, with shares more than triple the U.S. average, and third in the science technician category. It has lost ground to the nation in high-tech share except in the two science categories.

Denver

The overall high-tech share in Metro Denver in 2022 was 50 percent above the U.S. average based on employment and 36 percent above average based on aggregate earnings. Metro Denver ranked eighth in each measure in 2022. Metro Denver's shares have been stable relative to the U.S. average in each measure.

Metro Denver's shares in 2022 were above average in each category. Its highest ranks were fourth in the engineering category. Its shares relative to the nation have not changed much in any category.

Portland

The overall high-tech share in Metro Portland in 2022 was 37 percent above the U.S. average based on employment and 19 percent above average based on aggregate earnings. Metro

Portland ranked 11th in each measure in 2022. Metro Portland's shares have fluctuated relative to the U.S. average in each measure.

Metro Portland's shares in 2022 were average to above average in each category, highest in engineering and engineering technician, in which its ranks were first and second. Its shares have improved relative to the nation in the engineering and science technician categories.

Raleigh-Durham

The overall high-tech share in Metro Raleigh-Durham in 2022 was 71 percent above the U.S. average based on employment and 53 percent above average based on aggregate earnings. Metro Raleigh-Durham ranked fifth in each measure in 2022. Metro Raleigh-Durham's shares fell relative to the U.S. average but have stabilized in recent years in each measure.

Metro Raleigh-Durham's shares in 2022 were above average in each category and more than double the U.S. average in the science category. Its highest ranks of first and second were in the science technician category; it ranked third and fourth in the science category. It has lagged a little behind the nation in the change in the high-tech share in each category.

San Diego

The overall high-tech share in Metro San Diego in 2022 was 38 percent above the U.S. average based on employment and 29 percent above average based on aggregate earnings. Metro San Diego ranked tenth in each measure in 2022. Metro San Diego's shares have been stable relative to the U.S. average in each measure.

Metro San Diego's shares in 2022 were average to above average in each category, highest in the science category at more than twice the U.S. average. Its highest rank was first and second in the science technician category, but it also ranked high in the engineering and engineering technician categories. Metro San Diego has gained relative to the nation on the high-tech share in the engineering technician, science, and science technician categories.

San Francisco

The overall high-tech share in Metro San Francisco in 2022 was 89 percent above the U.S. average based on employment and 72 percent above average based on aggregate earnings. Metro San Francisco ranked third in each measure in 2022. Metro San Francisco's shares have increased relative to the U.S. average in each measure.

Metro San Francisco's shares in 2022 were above average in each category except engineering technician, including double the national average in the computer and math categories and more than twice the U.S. average in the science category. Its highest rank was second in the science category, but it also ranked high in the math category. Metro San Francisco has gained relative to the nation on the high-tech share in the computer, math, science, and science technician categories.

San Jose

The overall high-tech share in Metro San Jose in 2022 was 3.38 times the U.S. average based on employment and 2.97 times the average based on aggregate earnings. Metro San Jose ranked first

in each measure in every year from 2001 through 2022. Metro San Jose's shares have increased relative to the U.S. average in each measure.

Metro San Jose's shares in 2022 were above average in each category except in the science and science technician categories based on the aggregate earnings measure. The shares were more than 3.5 times the U.S. average in the computer category and more than double the national average in the math and engineering categories. The highest rank was first in the computer and engineering categories, but it also ranked high in the math and engineering technician categories. Metro San Jose has gained relative to the nation on the high-tech share in the computer and math categories, but has lost ground in the other categories.

Seattle

The overall high-tech share in Metro Seattle in 2022 was 95 percent above the U.S. average based on employment and 75 percent above average based on aggregate earnings. Metro Seattle ranked second in each measure in 2022. Metro Seattle's shares have increased relative to the U.S. average since the early 2000s in each measure.

Metro Seattle's shares in 2022 were above average except in the two technician categories. The shares were more than double the national average in the computer category. Its highest rank was second in the computer category. It has gained relative to the nation on the high-tech share in the computer and math categories.

Washington, D.C.

The overall high-tech share in Metro Washington, D.C. in 2022 was 87 percent above the U.S. average based on employment and 67 percent above average based on aggregate earnings. The metro area ranked fourth in each measure in 2022. The shares have fallen relative to the U.S. average since the early 2000s in each measure.

Metro Washington, D.C.'s shares in 2022 were approximately double the U.S. average in the computer, math, and science categories, but average to below average in the other categories. Its highest ranks were first in the math category; it ranked third in the computer category. It has lagged behind the nation in the change in the high-tech share except in the science category.

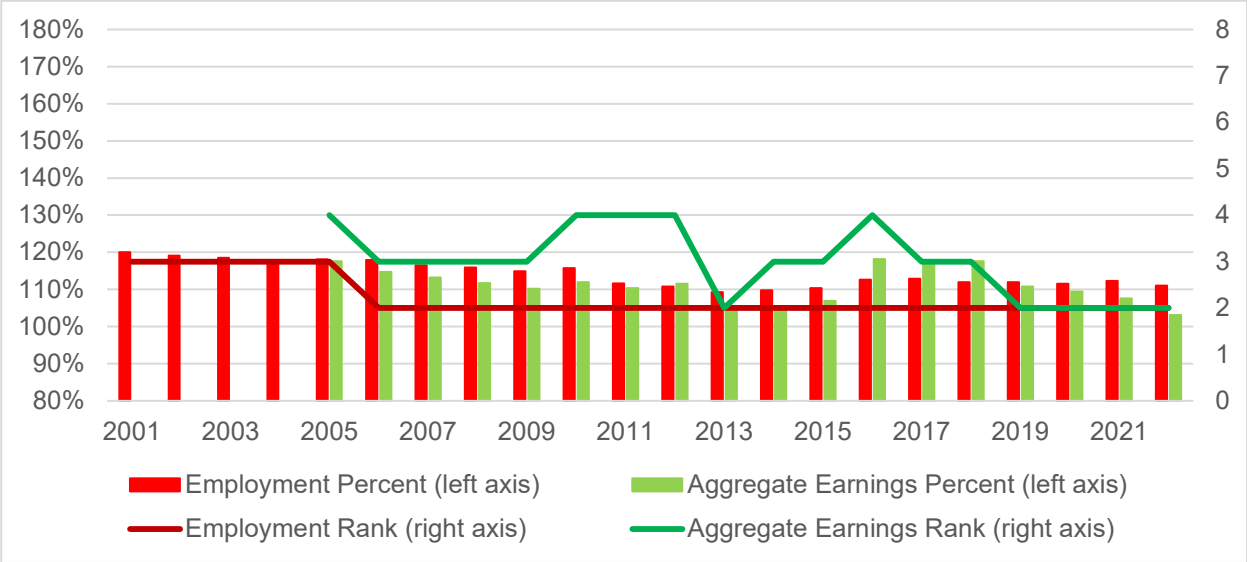
Metropolitan Tucson. Annual occupational employment data for 2001 through 2022 from Lightcast are displayed in Chart 11 for Metro Tucson relative to the nation for each of the six high-tech occupational categories. Note that the ranks are expressed such that a rank of 1 is worst and a rank of eighth is best.

The following summarizes the high-tech share of total employment in Metro Tucson relative to the national average from 2001 through 2022. Aggregate earnings information for 2005 to 2022 supplements the employment summary. Ranks are expressed as among the eight selected metro areas:

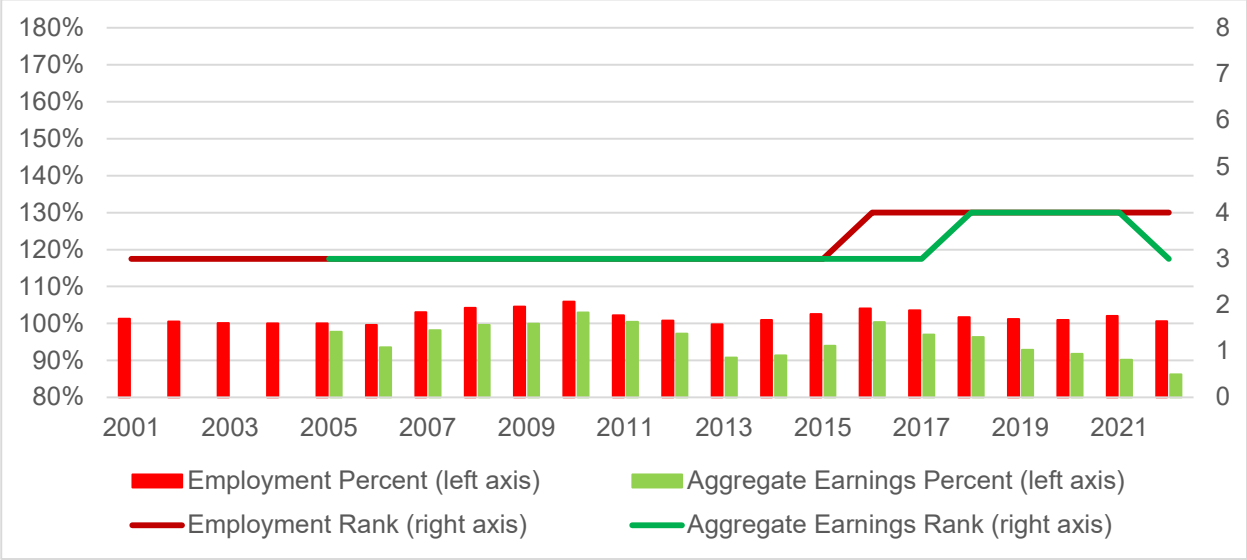
- Total High Tech. Metro Tucson's employment share has slipped from 20 percent above the U.S. average in 2001 to 11 percent above average in 2022. The aggregate earnings share has dropped from 18 percent above average in 2005 to 3 percent above average in

CHART 11
OCCUPATIONAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN TUCSON AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG EIGHT SOUTHWESTERN METROPOLITAN AREAS, 2001 TO 2022

ALL HIGH-TECHNOLOGY OCCUPATIONS



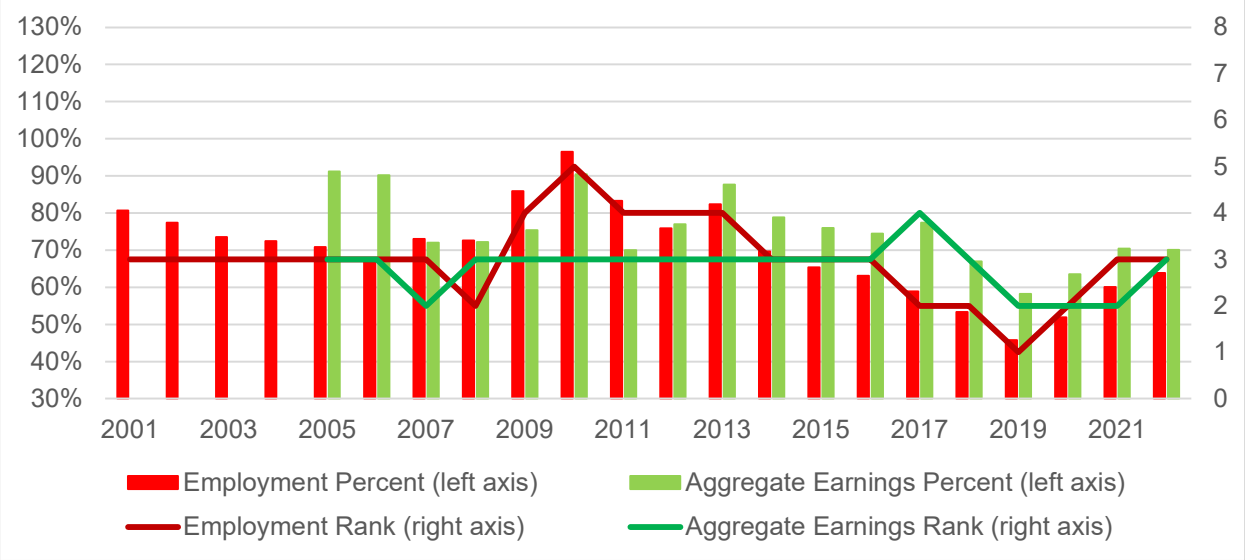
COMPUTER OCCUPATIONS



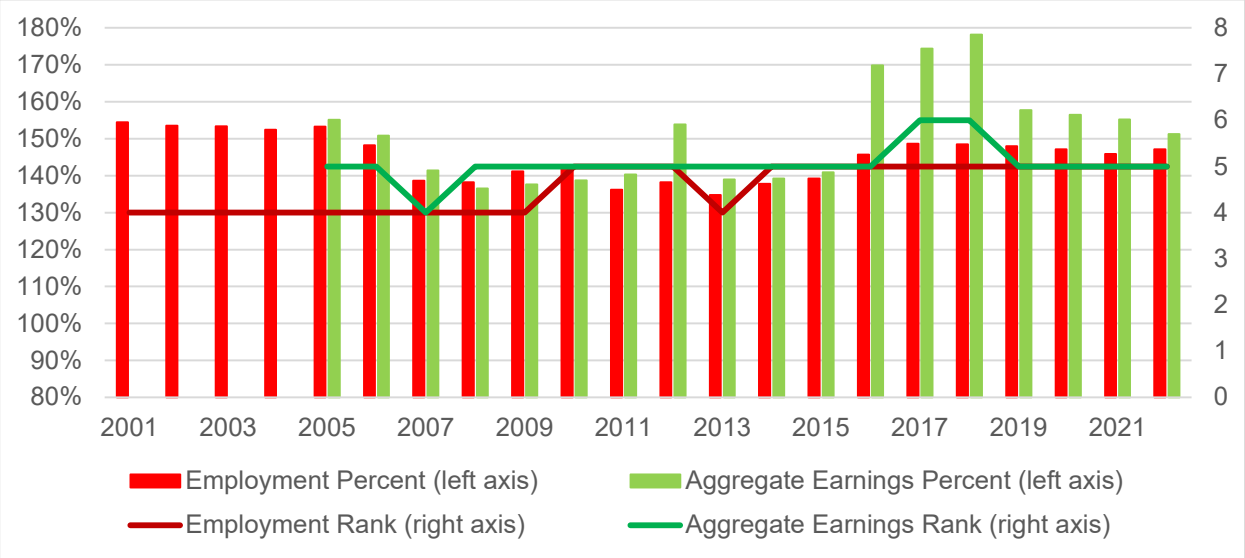
(continued)

CHART 11 (continued)
OCCUPATIONAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN TUCSON AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG EIGHT SOUTHWESTERN METROPOLITAN AREAS, 2001 TO 2022

MATHEMATICAL OCCUPATIONS



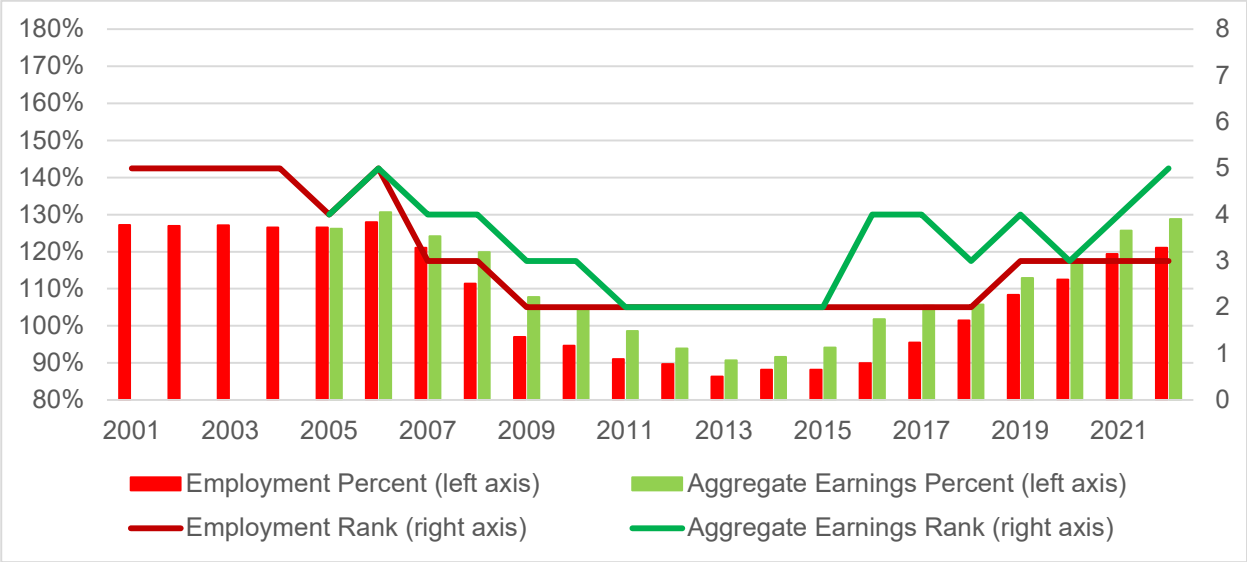
ENGINEERING OCCUPATIONS



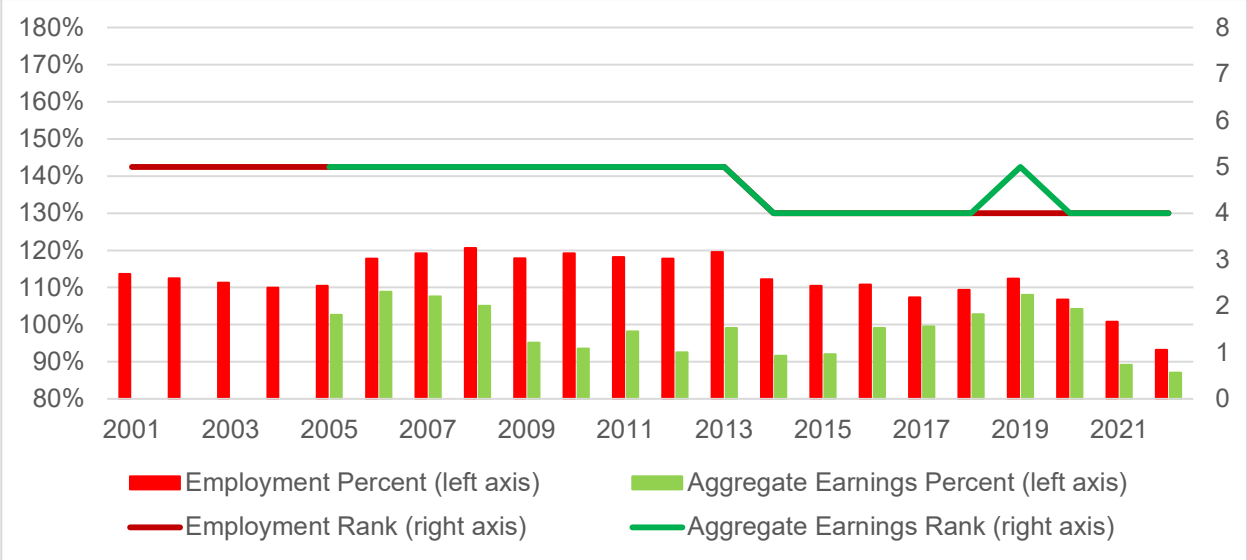
(continued)

CHART 11 (continued)
OCCUPATIONAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN TUCSON AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG EIGHT SOUTHWESTERN METROPOLITAN AREAS, 2001 TO 2022

ENGINEERING TECHNICIAN OCCUPATIONS



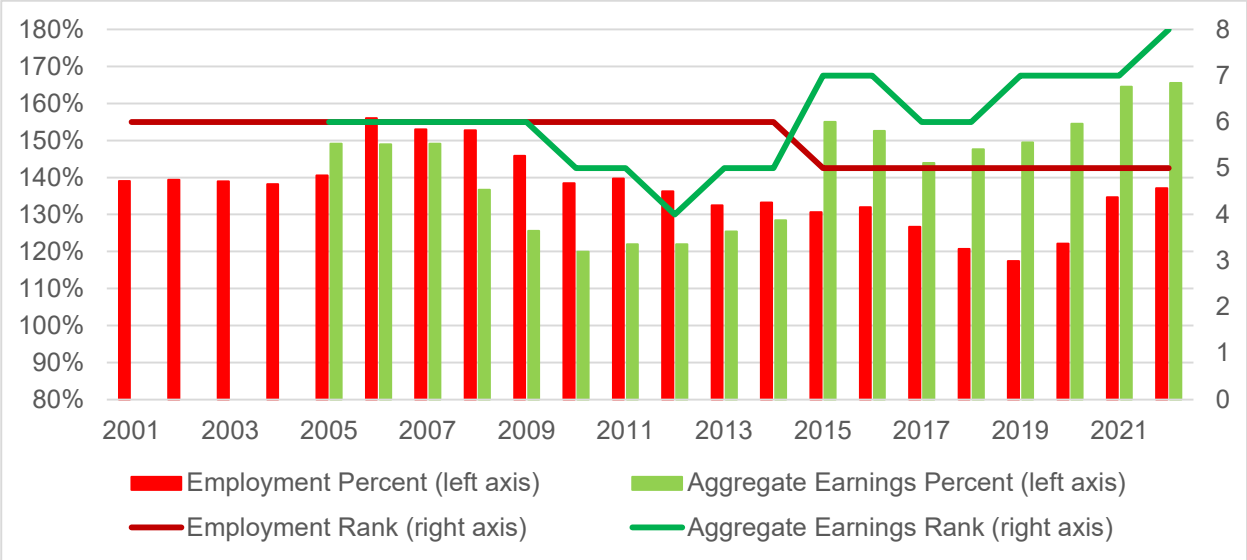
SCIENCE OCCUPATIONS



(continued)

CHART 11 (continued)
OCCUPATIONAL HIGH-TECHNOLOGY SHARES IN METROPOLITAN TUCSON AS A PERCENTAGE OF HIGH-TECHNOLOGY SHARES NATIONALLY, AND RANKS AMONG EIGHT SOUTHWESTERN METROPOLITAN AREAS, 2001 TO 2022

SCIENCE TECHNICIAN OCCUPATIONS



Note: Ranks are expressed such that a rank of 1 is worst and a rank of eighth is best.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. High-technology categories defined by authors.

2022. Metro Tucson's employment rank slipped from sixth to seventh and its aggregate earnings rank slid from fifth or sixth to seventh.

- Computer. Metro Tucson's employment share has varied in a narrow range from 6 percent more than the U.S. average to equal to the average. The aggregate earnings share has declined, from 3 percent above average in 2010 to 14 percent below average in 2022. Metro Tucson ranked fifth or sixth in each year on each measure.
- Math. Metro Tucson's employment share has decreased considerably, from 3 percent less than the U.S. average in 2010 to 36 percent below average in 2022. The aggregate earnings share also has dropped, from 9 percent below average in 2005 to 30 percent below average in 2022. Metro Tucson generally has ranked sixth or seventh.
- Engineering. Metro Tucson's employment share fell but then rebounded; it was 47 percent above the U.S. average in 2022. The aggregate earnings share has fluctuated; the 2022 share was 51 percent above average. Metro Tucson's employment rank improved from fifth to fourth; the aggregate earnings rank generally has been fourth.
- Engineering Technician. Metro Tucson's employment share fell but then rebounded; it was 21 percent above the U.S. average in 2022. The aggregate earnings share also dropped then improved; the 2022 share was 29 percent above average. Metro Tucson's rank fell from fourth to seventh on each measure, but in 2022 was sixth on employment and fourth on aggregate earnings.

- Science. Metro Tucson's employment share has decreased, from 20 percent above average in 2013 to 7 percent below the U.S. average in 2022. The aggregate earnings share dropped from 9 percent above average in 2006 to 13 percent below average in 2022. Metro Tucson's rank slid from fourth to fifth on each measure.
- Science Technician. Metro Tucson's employment share relative to the U.S. average was about the same in 2022 — 37 percent higher than average — as in the early 2000s. The aggregate earnings share peaked in 2022 at 66 percent higher than the national average. The employment share slipped from third to fourth, but the aggregate earnings share improved from generally third or fourth to first in 2022.

Other Moderately Large Southwestern Metro Areas. Each of the seven other metro areas except El Paso had an overall high-tech employment share greater than the national average in 2022, ranging from 20 percent higher in Metro Albuquerque to 2.68 times the U.S. average in Metro Boulder. Based on aggregate earnings, the range was from 20 percent higher in Metro Provo to 2.23 times the U.S. average in Metro Boulder. Only two of the metro areas — Salt Lake City and Provo — experienced an increase in the employment share relative to the U.S. average between 2001 and 2022. Results were similar based on the change in the aggregate earnings share between 2005 and 2022.

A summary of the occupational high-tech activities by category from 2001 through 2022 follows for the seven comparison metro areas, based on the employment share relative to the national average. Aggregate earnings information for 2005 to 2022 supplements the employment summary. Ranks are among the eight selected areas.

Albuquerque

The overall high-tech share in Metro Albuquerque in 2022 was 20 percent above the U.S. average based on employment and 24 percent above average based on aggregate earnings. Metro Albuquerque ranked sixth on employment and fourth on aggregate earnings in 2022. On each measure, Metro Albuquerque's shares have slipped relative to the U.S. average since the early 2000s.

Metro Albuquerque's major strength is in the engineering category, where it has ranked first or second and its share has gained relative to the U.S. average. It also compares favorably in the engineering technician and science categories. It has lost ground to the nation on high-tech share except in the engineering category.

Boulder

The overall high-tech share in Metro Boulder in 2022 was 2.68 times the U.S. average based on employment and 2.23 times the average based on aggregate earnings, each by far the highest among the eight comparison areas. On each measure, Metro Boulder's share fell relative to the U.S. average during the late 2000s and early 2010s, but has since recovered some of the losses.

Metro Boulder compares favorably in each of the six categories, generally ranking in the top two. Its share in 2022 was more than five times the U.S. average in the science category and at least twice the U.S. average in the computer and engineering categories. It has lost ground to the

nation in the computer and science technician categories, but has gained in the engineering category.

Colorado Springs

The overall high-tech share in Metro Colorado Springs in 2022 was 29 percent above the U.S. average based on employment and 28 percent above average based on aggregate earnings. Metro Colorado Springs ranked fourth on employment and second on aggregate earnings. On each measure, Metro Colorado Springs has declined relative to the U.S. average since the early 2000s.

Shares in 2022 were above average in the computer, engineering, and engineering technician categories in Metro Colorado Springs. The highest rank was second in the engineering technician category based on aggregate earnings. The metro area has lost ground to the nation in the computer, math, engineering, and science technician categories.

El Paso

Metro El Paso is not a high-tech center and by far ranks last among the eight metro areas on high-tech share. In 2022, its overall high-tech share was 47 percent below the U.S. average based on both employment and aggregate earnings. Its relative shares have been stable over time.

The shares in Metro El Paso in 2022 were close to the national average in the engineering technician category, but considerably below average in each of the other categories. Metro El Paso's relative shares have fallen in the computer and math categories and risen in the other categories.

Fort Collins

The overall high-tech share in Metro Fort Collins in 2022 was 38 percent above the U.S. average based on employment and 21 percent above average based on aggregate earnings. Metro Fort Collins ranked second on employment and fifth on aggregate earnings. On each measure, the metro area has declined relative to the U.S. average since the early 2000s; the magnitude of the decrease was the greatest of the eight metro areas.

Shares in 2022 were considerably above average in the science, science technician, and engineering categories and also above average in the engineering technician category in Metro Fort Collins. Its highest ranks were first and second in the two science categories. It has lost ground to the nation except in the two science categories.

Provo

The overall high-tech share in Metro Provo in 2022 was 27 percent above the U.S. average based on employment and 20 percent above average based on aggregate earnings. Metro Provo ranked fifth on employment and sixth on aggregate earnings. On each measure, Metro Provo has improved somewhat relative to the U.S. average.

Shares in 2022 were considerably above average in the computer and math categories, in which Metro Provo ranked second. The shares were well below average in the other categories. The metro area has posted relative gains in the computer and math categories, but has lost ground to the nation in the other categories.

Salt Lake City

The overall high-tech share in Metro Salt Lake City in 2022 was 34 percent above the U.S. average based on employment and 25 percent above average based on aggregate earnings. On each measure, the metro area ranked third in 2022 and its share has increased somewhat relative to the U.S. average.

Shares in Metro Salt Lake City in 2022 were above average in all six categories, ranking first in the math category. Relative gains have occurred in each category except engineering.

Metro Phoenix Relative to Metro Tucson. The overall high-tech share of the total economy has been slightly higher in Metro Tucson than in Metro Phoenix, based on employment and aggregate earnings. Metro Phoenix has gained relative to Metro Tucson in the computer category and has had a somewhat higher share since 2011. The share also has been higher in Metro Phoenix than Metro Tucson in the math category, though the differential has narrowed considerably. The share in 2022 was higher in Metro Tucson than Metro Phoenix in each of the other four categories, with wide differentials in the engineering, science, and science technician categories.

Large Metro Areas Versus Moderately Large Southwestern Metro Areas

Total high-tech shares in 2022 as a percentage of the U.S. average, based on both employment and aggregate earnings, exceeded 140 percent in seven of the 12 selected large metro areas but in only one of the eight selected smaller metro areas. The large metro areas also did better on the change in the share over time — two-thirds of the large areas had a gain in the percentage of the U.S. average, compared to only one-fourth of the smaller metro areas.

Industrial and Occupational Summary, All States, 2022

In 2022, the overall high-tech share exceeded the national average in 18 states based on occupational employment, 14 states on occupational aggregate earnings, 16 states on industrial employment, and 11 states on industrial aggregate earnings. Nine states were above average on each of the four measures; the following figure in parentheses are the average differences from the U.S. average across the four measures: California (39 percent), Colorado (40 percent), Maryland (40 percent), Massachusetts (58 percent), New Hampshire (26 percent), New Jersey (8 percent), New Mexico (11 percent), Utah (22 percent), and Washington (69 percent). Despite being below average on the occupational aggregate earnings measure, Virginia averaged 24 percent above the national figure.

Based on these averages, the District of Columbia and eight states — California, Colorado, Maryland, Massachusetts, New Hampshire, Utah, Virginia, and Washington — have been assigned to first-tier high-tech status. Eight states — Arizona, Connecticut, Michigan, New Jersey, New Mexico, North Carolina, Oregon, and Texas — are in the second tier.

High-tech activity was concentrated in a minority of states in each of the eight primary industrial categories in 2022; the first figure is the number of states in which the high-tech share exceeded the U.S. average based on employment, the second the number based on aggregate earnings:

- Biopharmaceuticals: 20, 12. Only four of the comparison states were above average on each measure. Based on each measure, values were at least twice the national average in Indiana, New Jersey, Maine, and North Carolina.
- Computing Equipment: 9, 6. The most geographically concentrated of the categories, California dominated with a figure more than four times the national average on each measure. Only three of the comparison states were above average based on employment and only two based on aggregate earnings.
- Communications Equipment: 14, 11. Kansas dominated with a figure more than four times the U.S. average; four of the comparison states were above average.
- Electronics: 12, 9. Oregon's figure was more than six times the U.S. average on each measure, with Idaho, Arizona, New Hampshire, and Vermont more than double the average on each measure. Only three of the comparison states were above average on each measure.
- Instruments: 14, 13. New Hampshire, Minnesota, Massachusetts, Iowa, and Maryland had figures more than double the U.S. average on each measure. Five of the comparison states were above average on each measure.
- Aerospace: 14, 16. Washington, Kansas, Connecticut, Arizona, and Oklahoma had figures more than double the U.S. average on each measure. Four of the comparison states were above average based on employment and five were above average based on aggregate earnings.
- Computer Services: 12, 9. Washington had a figure more than double the U.S. average on each measure. Each of the comparison states except Arizona was above average on each measure.
- Other Professional Services: 15, 12. New Mexico and Massachusetts had figures more than double the U.S. average on each measure. Each of the comparison states except Arizona was above average based on employment; five were above average based on aggregate earnings.

High-tech activity was not as geographically concentrated using the occupational data and fewer states had figures far above the national average:

- Computer occupations: 16, 13. Each of the comparison states was above average based on employment; Arizona and Virginia were below average based on aggregate earnings.
- Math occupations: 16, 15. The District of Columbia's figures were more than twice the U.S. average on each measure. Each of the comparison states except Arizona was above average based on employment; Virginia also was below average based on aggregate earnings.
- Engineering occupations: 23, 21. Each of the comparison states was above average based on employment; Massachusetts and Virginia were below average based on aggregate earnings.
- Engineering Technician occupations: 28, 36. Six of the comparison states were above average based on employment, with seven above average based on aggregate earnings.
- Science occupations: 20, 17. Alaska, the District of Columbia, Maryland, and Massachusetts had figures more than double the U.S. average on each measure. Five of the comparison states were above average on each measure.

- Science Technician occupations: 22, 27. Six of the comparison states were above average on employment, with five above average on aggregate earnings.

Each of the first-tier and second-tier states are summarized by industrial and occupational category below; the states are listed in order of the average difference from the national average across the four industrial and occupational measures in 2022:

- Washington: Among the industrial categories, Washington was far above average in aerospace and computer services, and above average in miscellaneous services and in other professional services based on employment. Washington was above average in each of the occupational categories except science technician based on aggregate earnings.
- Massachusetts: Among the industrial categories, Massachusetts was above average except in aerospace, and particularly strong in instruments and other professional services. Massachusetts was above average in each of the occupational categories except engineering and engineering technician based on aggregate earnings.
- Colorado: Among the industrial categories, Colorado was above average in instruments, computer services, other professional services, and miscellaneous services. Based on employment, it also was above average in computing equipment and miscellaneous manufacturing; based on aggregate earnings, it was above average in aerospace. Colorado was above average in each of the occupational categories.
- Maryland: Among the industrial categories, Maryland was above average in biopharmaceuticals, communications equipment, instruments, computer services, other professional services, and miscellaneous services. Maryland was above average in each of the occupational categories, especially science.
- California. California was above average in each of the industrial categories and in each of the occupational categories except engineering technician based on employment.
- New Hampshire: Among the industrial categories, New Hampshire was far above average in electronics, instruments, and miscellaneous manufacturing. It also was above average in computer services, and in computing equipment and other professional services based on employment. New Hampshire was above average in only three of the occupational categories: computer, engineering, and engineering technician.
- Utah. Among the industrial categories, Utah was above average in biopharmaceuticals, instruments, aerospace, and computer services. It also was above average in other professional services based on employment. Utah was above average in each of the occupational categories except science.
- Virginia: Among the industrial categories, Virginia was above average in communications equipment, computer services, other professional services, and miscellaneous services. Among the occupational categories, Virginia was above average only in engineering technician, and in computer, math, and engineering based on employment.
- New Mexico: Among the industrial categories, New Mexico was above average in electronics, miscellaneous services, and especially other professional services. Among the occupational categories, New Mexico was above average in engineering, engineering technician, science, and science technician.
- New Jersey: Among the industrial categories, New Jersey was above average in instruments, other professional services, electronics, and especially biopharmaceuticals. It also was above average in computer services based on employment. Among the

occupational categories, New Jersey was above average in computer, math, science, and science technician.

- Oregon: Among the industrial categories, Oregon was far above average in electronics and miscellaneous manufacturing, and also above average in miscellaneous services. Among the occupational categories, Oregon was above average in engineering, engineering technician, science, and science technician.
- Connecticut: Among the industrial categories, Connecticut was far above average in aerospace and miscellaneous manufacturing, and also above average in instruments based on employment. Among the occupational categories, Connecticut was above average in engineering, in math based on employment, and in computer based on aggregate earnings.
- Arizona: Among the industrial categories, Arizona was far above average in electronics and aerospace, and also above average in miscellaneous services and in miscellaneous manufacturing based on aggregate earnings. Among the occupational categories, Arizona was above average in engineering and engineering technician, and also in computer based on employment.
- Michigan. Among the industrial categories, Michigan was considerably above average in other professional services and also above average in biopharmaceuticals based on employment. Among the occupational categories, Michigan was considerably above average in engineering and engineering technician.
- North Carolina. Among the industrial categories, North Carolina was above average in computing equipment and other professional services, electronics, and especially biopharmaceuticals. Among the occupational categories, North Carolina was above average in computer and science. It also was above average based on aggregate earnings in math, engineering technician, and science technician.
- Texas. Among the industrial categories, Texas was above average in computing equipment, communications equipment, electronics, aerospace, and miscellaneous services; it also was above average in computer services based on employment. Among the occupational categories, Texas was considerably above average in engineering technician, in computer based on employment, and in engineering based on aggregate earnings.

A BROADER LOOK AT THE OCCUPATIONAL AND INDUSTRIAL MIXES IN SELECTED STATES AND METRO AREAS

While the prior section was devoted to the analysis of high-technology activities, this section takes a broader look at the economy in the selected states and metropolitan areas. It is entirely based on Lightcast data from 2001 through 2022.

Particular attention is still paid to high-tech activities but they are measured differently. The occupational analysis is conducted at the two-digit SOC major group level. The industrial analysis is based on industrial clusters.

Occupational Comparison

To analyze the occupational structure of the regions, major occupational groups (two-digit Standard Occupational Classification categories) are used. Employment and earnings data for the 23 major occupational groups were obtained from Lightcast for 2001 through 2022. In addition to 2022, the analysis focuses on the change between 2012 and 2022.

The 23 groups have been aggregated into three categories — high paying, mid paying, and low paying — based on median earnings per worker nationally in 2022. Three groups — computer and mathematical; architecture and engineering; and life, physical, and social science — are of particular interest since they account for nearly all of the occupations defined as STEM (see Appendix A).

All of the computer and mathematical occupations are defined as STEM. In the architecture and engineering group, all of the occupations except for the four related to architecture are defined as STEM; the STEM occupations accounted for 92 percent of the group's employment total nationally in 2022. The life and physical science portion of its group accounted for 66 percent of the group's total employment nationally in 2022.

United States

The 23 occupational groups are widely divergent is size, as measured by employment and aggregate earnings, and in median earnings per worker, as seen in Table 8. The variation in earnings per worker across the 23 groups is highly correlated to the educational attainment requirements of each occupation. Each of the three STEM groups have an earnings per worker figure well above the overall median.

In 2022 nationally, median earnings per worker in seven groups was at least 38 percent above the overall median. The aggregate of these seven groups accounted for just more than one-fourth of total employment but for nearly 43 percent of aggregate earnings. In six groups, median earnings per worker ranged from 9 percent below to 1 percent above the overall figure. The aggregate of these six groups accounted for a little less than 20 percent of total employment and aggregate earnings. In 10 groups, median earnings per worker was at least 20 percent below the overall figure. The aggregate of these 10 groups accounted for nearly 55 percent of total employment but for less than 40 percent of aggregate earnings.

The 2012-to-2022 changes in share and in median earnings per worker are displayed in Table 9. Over this decade, the national economy shifted toward the high-paying occupational groups and

TABLE 8
EARNINGS PER WORKER AND SHARES, MAJOR OCCUPATIONAL GROUPS, UNITED STATES, 2022

	Share of Total Employment	Share of Total Aggregate Earnings	Median Earnings Per Worker	
			Dollars	Percentage of Total
Total	100.00%	100.00%	$55,567	
High Paying	25.81	42.79	92,138	166%
Legal	0.86	1.63	105,797	190
Management	7.16	13.34	103,466	186
Computer and Mathematical	3.19	5.80	101,098	182
Healthcare Practitioners and Technical	5.70	9.38	91,394	164
Architecture and Engineering	1.58	2.53	88,728	160
Life, Physical, and Social Science	0.91	1.26	77,246	139
Business and Financial Operations	6.40	8.85	76,791	138
Subtotal of Three STEM Groups	5.68	9.59	93,832	169
Mid Paying	19.76	18.95	53,288	96
Arts/Design/Entertainment/Sports/Media	1.85	1.87	56,263	101
Educational Instruction and Library	5.60	5.66	56,160	101
Installation, Maintenance, and Repair	3.92	3.71	52,650	95
Construction and Extraction	4.50	4.16	51,350	92
Community and Social Service	1.73	1.59	50,948	92
Protective Service	2.16	1.96	50,375	91
Low Paying	54.43	38.26	39,057	70
Sales and Related	8.78	6.91	43,759	79
Office and Administrative Support	11.87	9.13	42,713	77
Production	5.48	4.20	42,571	77
Transportation and Material Moving	8.69	6.62	42,325	76
Military-Only Occupations	0.60	0.40	37,077	67
Healthcare Support	4.50	2.78	34,318	62
Building/Grounds Cleaning/Maintenance	3.47	2.07	33,155	60
Farming, Fishing, and Forestry	0.70	0.41	32,142	58
Personal Care and Service	2.65	1.52	31,933	57
Food Preparation and Serving	7.69	4.23	30,521	55

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

away from the low-paying groups, especially based on employment. Each of the high-paying groups other than architecture and engineering realized a gain in share of employment and aggregate earnings. However, inflation-adjusted median earnings per worker fell slightly over the 10 years in the high-paying and mid-paying categories, but increased in the low-paying category. Overall, inflation-adjusted median earnings per worker increased 5.2 percent.

States: Median Earnings Per Worker

Overall median earnings per worker adjusted for the cost of living was 4.3 percent less in Arizona than the national figure in 2022, the lowest of the eight comparison states. Adjusted median earnings per worker in Arizona was less than the national figure in 19 of the 23 groups.

TABLE 9
EARNINGS PER WORKER AND SHARES, MAJOR OCCUPATIONAL GROUPS, UNITED STATES, 2012-TO-2022 CHANGE

	Share of Total Employment	Share of Total Aggregate Earnings	Median Earnings Per Worker*
High Paying	3.90	3.61	-2.5%
Legal	0.02	-0.12	-4.3
Management	1.63	1.86	-5.6
Computer and Mathematical	0.52	1.02	6.7
Healthcare Practitioners and Technical	0.33	0.03	-0.6
Architecture and Engineering	-0.08	-0.48	-7.1
Life, Physical, and Social Science	0.02	-0.10	-4.1
Business and Financial Operations	1.46	1.40	-3.6
Subtotal of Three STEM Groups	0.46	0.44	1.4
Mid Paying	-0.47	-1.82	-1.8
Arts/Design/Entertainment/Sports/Media	0.05	0.00	2.4
Educational Instruction and Library	-0.56	-1.33	-6.3
Installation, Maintenance, and Repair	0.03	-0.16	0.1
Construction and Extraction	0.10	-0.01	2.6
Community and Social Service	0.03	-0.09	-2.4
Protective Service	-0.12	-0.24	-1.1
Low Paying	-3.43	-1.78	6.8
Sales and Related	-1.38	-1.06	5.5
Office and Administrative Support	-1.96	-2.01	0.4
Production	-0.52	-0.46	3.6
Transportation and Material Moving	1.12	1.19	11.7
Military-Only Occupations	-0.14	-0.13	-2.5
Healthcare Support	0.63	0.47	8.7
Building/Grounds Cleaning/Maintenance	-0.49	-0.10	14.4
Farming, Fishing, and Forestry	-0.06	0.00	15.6
Personal Care and Service	-0.44	-0.11	14.0
Food Preparation and Serving	-0.20	0.44	20.4

* The inflation-adjusted percent change.

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/ (employment and earnings) and U.S. Department of Commerce, Bureau of Economic Analysis (gross domestic product implicit price deflator).

Arizona ranked last in nine groups and second lowest in five others. It ranked higher than fourth only in food preparation and serving.

Arizona's low earnings per worker could result from several factors. Most notably, the state's popularity due to its climate may depress wages. The state's occupational mix even within an occupational group may be tilted to lower-wage occupations or may be filled by individuals with lesser work experience and/or education.

As seen in Table 10, Arizona also compared unfavorably on the change in cost-of-living-adjusted median earnings per worker between 2012 and 2022. Arizona lost ground to the nation overall, in the high-paying category, and in the mid-paying category, ranking last among the comparison states.

States: Occupational Mix

Table 11 displays 2022 employment and aggregate earnings data by group in Arizona. Though the state's share in the high-paying category was near the national average on both measures,

TABLE 10
MEDIAN EARNINGS PER WORKER ADJUSTED FOR THE COST OF LIVING, MAJOR OCCUPATIONAL GROUPS, ARIZONA

	2022		2012-to-2022 Change	
	Percentage of Nation	Rank*	Percentage of Nation	Rank*
TOTAL	95.7%	8	-2.6	7
High Paying	92.8	8	-4.5	8
Legal	84.9	7	-3.0	7
Management	89.0	8	-5.5	7
Computer and Mathematical	90.7	8	-4.9	7
Healthcare Practitioners and Technical	101.7	7	-5.6	8
Architecture and Engineering	99.5	6	0.5	5
Life, Physical, and Social Science	90.4	8	8.0	1
Business and Financial Operations	90.0	8	-3.5	5
Subtotal of Three STEM Groups	93.9	7	-1.6	7
Mid Paying	92.0	8	-5.7	8
Arts/Design/Entertainment/Sports/Media	87.9	8	0.5	3
Educational Instruction and Library	87.4	8	-8.0	8
Installation, Maintenance, and Repair	93.9	8	-7.9	8
Construction and Extraction	94.2	7	-1.8	6
Community and Social Service	94.9	8	-4.0	8
Protective Service	98.8	6	-11.1	8
Low Paying	100.1	5	0.2	4
Sales and Related	99.3	6	3.6	3
Office and Administrative Support	97.0	7	-3.5	7
Production	99.3	7	-0.8	6
Transportation and Material Moving	98.3	6	-5.7	8
Military-only Occupations	94.8	5	-0.1	5
Healthcare Support	102.1	5	-4.6	5
Building/Grounds Cleaning/Maintenance	99.0	6	2.1	4
Farming, Fishing, and Forestry	96.3	5	-0.2	3
Personal Care and Service	103.2	4	1.6	3
Food Preparation and Serving Related	111.2	2	8.4	3

* Among eight comparison states

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/ (earnings) and the U.S. Department of Commerce, Bureau of Economic Analysis (regional price parities),

TABLE 11
EMPLOYMENT AND AGGREGATE EARNINGS, MAJOR OCCUPATIONAL GROUPS, ARIZONA, 2022

	Employment			Aggregate Earnings		
	Share of Total	Ratio to Nation	Rank*	Share of Total	Ratio to Nation	Rank*
High Paying	26.26%	1.02	8	42.20%	0.99	6
Legal	0.74	0.86	6	1.25	0.77	5
Management	7.37	1.03	5	12.76	0.96	5
Computer and Mathematical	3.52	1.11	8	6.08	1.05	7
Healthcare Practitioners and Technical	5.65	0.99	3	9.87	1.05	2
Architecture and Engineering	1.59	1.01	8	2.64	1.04	5
Life, Physical, and Social Science	0.71	0.78	8	0.93	0.74	8
Business and Financial Operations	6.67	1.04	6	8.66	0.98	5
Subtotal of Three STEM Groups	5.83	1.03	8	9.65	1.01	7
Mid Paying	19.42	0.98	8	17.90	0.94	7
Arts/Design/Entertainment/Sports/Media	1.52	0.82	8	1.42	0.76	8
Educational Instruction and Library	4.73	0.85	8	4.36	0.77	8
Installation, Maintenance, and Repair	4.14	1.06	1	3.85	1.04	1
Construction and Extraction	5.06	1.12	4	4.60	1.11	4
Community and Social Service	1.57	0.90	8	1.42	0.89	8
Protective Service	2.40	1.11	3	2.25	1.15	2
Low Paying	54.32	1.00	1	39.90	1.04	2
Sales and Related	9.01	1.03	2	7.35	1.06	3
Office and Administrative Support	13.43	1.13	2	10.46	1.15	3
Production	3.80	0.69	6	3.02	0.72	3
Transportation and Material Moving	8.41	0.97	1	6.57	0.99	2
Military-Only Occupations	0.54	0.90	5	0.36	0.89	6
Healthcare Support	4.25	0.95	4	2.80	1.01	5
Building/Grounds Cleaning/Maintenance	3.56	1.03	2	2.20	1.06	2
Farming, Fishing, and Forestry	0.54	0.77	4	0.32	0.78	3
Personal Care and Service	2.55	0.96	7	1.58	1.04	4
Food Preparation and Serving Related	8.22	1.07	2	5.24	1.24	2

* Among eight comparison states

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

Arizona ranked last among the comparison states based on employment and sixth based on aggregate earnings. In contrast, in the low-paying category, Arizona ranked first on employment and second on aggregate earnings.

In Table 12, the employment shares in 2022 are shown for the nation and for each of the comparison states. The 2022 shares of aggregate earnings are displayed in Table 13.

Focusing on the 10-year time period between 2012 and 2022, Table 14 depicts changes in employment and aggregate earnings shares in Arizona relative to the nation. Between 2012 and 2022, Arizona had the greatest change in share in the low-paying category, based on both

TABLE 12
EMPLOYMENT SHARE OF TOTAL, MAJOR OCCUPATIONAL GROUPS, ARIZONA AND SELECTED STATES, 2022

	US	AZ	CA	CO	MA	MD	UT	VA	WA
High Paying	25.81%	26.26%	26.49%	28.63%	32.30%	31.97%	26.43%	29.91%	27.86%
Legal	0.86	0.74	0.91	0.94	1.00	0.98	0.69	0.96	0.73
Management	7.16	7.37	7.59	6.11	9.79	8.50	7.97	6.29	6.04
Computer and Mathematical	3.19	3.52	3.65	4.36	4.09	4.98	3.89	5.70	5.41
Healthcare Practitioners and Technical	5.70	5.65	4.93	5.10	6.66	5.85	4.47	5.36	4.92
Architecture and Engineering	1.58	1.59	1.74	2.33	1.78	1.90	1.81	1.68	2.02
Life, Physical, and Social Science	0.91	0.71	1.11	1.27	1.77	1.69	0.94	1.01	1.21
Business and Financial Operations	6.40	6.67	6.57	8.52	7.20	8.05	6.65	8.91	7.53
Subtotal of Three STEM Groups	5.68	5.83	6.49	7.96	7.64	8.58	6.65	8.38	8.64
Mid Paying	19.76	19.42	19.62	20.37	19.98	20.41	21.15	20.21	19.63
Arts/Design/Entertainment/Sports/Media	1.85	1.52	2.72	1.97	1.95	1.65	1.94	1.66	1.94
Educational Instruction and Library	5.60	4.73	5.50	5.39	6.63	6.13	6.08	5.84	5.04
Installation, Maintenance, and Repair	3.92	4.14	3.09	3.77	2.89	3.68	3.73	4.04	3.76
Construction and Extraction	4.50	5.06	4.24	5.32	4.05	4.41	6.20	4.40	5.25
Community and Social Service	1.73	1.57	1.89	1.93	2.39	1.97	1.73	1.81	1.79
Protective Service	2.16	2.40	2.17	2.00	2.08	2.57	1.46	2.47	1.85
Low Paying	54.43	54.32	53.89	50.99	47.72	47.63	52.43	49.88	52.51
Sales and Related	8.78	9.01	8.21	10.22	7.79	8.42	8.02	8.68	8.90
Office and Administrative Support	11.87	13.43	10.54	10.98	10.98	11.24	13.87	10.81	10.72
Production	5.48	3.80	4.31	3.45	3.89	2.46	5.99	4.07	4.38
Transportation and Material Moving	8.69	8.41	8.23	7.05	6.11	7.87	7.73	7.57	7.90
Military-only Occupations	0.60	0.54	0.52	0.96	0.24	0.88	0.49	1.45	0.92
Healthcare Support	4.50	4.25	6.28	3.37	5.10	3.39	3.06	3.60	5.01
Building/Grounds Cleaning/Maintenance	3.47	3.56	3.66	3.33	3.36	3.46	3.38	3.48	3.12
Farming, Fishing, and Forestry	0.70	0.54	1.63	0.57	0.32	0.28	0.29	0.33	1.49
Personal Care and Service	2.65	2.55	2.89	2.84	2.82	2.89	2.63	2.67	2.46
Food Preparation and Serving Related	7.69	8.22	7.62	8.23	7.11	6.73	6.97	7.24	7.61

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

TABLE 13
AGGREGATE EARNINGS SHARE OF TOTAL, MAJOR OCCUPATIONAL GROUPS, ARIZONA AND SELECTED STATES, 2022

	US	AZ	CA	CO	MA	MD	UT	VA	WA
High Paying	42.79%	42.20%	45.12%	45.96%	50.87%	31.97%	41.34%	50.08%	44.54%
Legal	1.63	1.25	1.87	1.74	1.80	0.98	1.06	1.87	1.14
Management	13.34	12.76	14.44	12.00	18.61	8.50	13.78	12.82	11.01
Computer and Mathematical	5.80	6.08	7.15	7.70	6.59	4.98	6.58	10.82	10.30
Healthcare Practitioners and Technical	9.38	9.87	8.91	7.99	9.98	5.85	7.54	8.06	8.05
Architecture and Engineering	2.53	2.64	2.90	3.63	2.43	1.90	2.77	2.61	2.99
Life, Physical, and Social Science	1.26	0.93	1.57	1.66	2.51	1.69	1.19	1.41	1.50
Business and Financial Operations	8.85	8.66	8.28	11.23	8.96	8.05	8.41	12.50	9.56
Subtotal of Three STEM Groups	9.59	9.65	11.62	13.00	11.53	8.58	10.55	14.83	14.79
Mid Paying	18.95	17.90	19.75	18.31	18.56	20.41	20.37	17.70	18.89
Arts/Design/Entertainment/Sports/Media	1.87	1.42	2.99	1.83	1.84	1.65	1.75	1.60	1.86
Educational Instruction and Library	5.66	4.36	6.17	4.80	6.59	6.13	6.03	5.38	4.93
Installation, Maintenance, and Repair	3.71	3.85	2.79	3.48	2.50	3.68	3.65	3.62	3.45
Construction and Extraction	4.16	4.60	3.94	4.70	3.97	4.41	5.92	3.57	5.26
Community and Social Service	1.59	1.42	1.74	1.67	1.89	1.97	1.72	1.54	1.59
Protective Service	1.96	2.25	2.12	1.83	1.77	2.57	1.30	2.00	1.81
Low Paying	38.26	39.90	35.13	35.73	30.58	47.63	38.29	32.22	36.57
Sales and Related	6.91	7.35	6.26	8.56	5.79	8.42	6.47	6.34	7.30
Office and Administrative Support	9.13	10.46	7.89	8.16	7.93	11.24	10.53	7.57	7.92
Production	4.20	3.02	2.96	2.52	2.59	2.46	4.77	2.93	3.33
Transportation and Material Moving	6.62	6.57	5.63	5.42	3.89	7.87	6.39	5.44	6.03
Military-only Occupations	0.40	0.36	0.27	0.49	0.22	0.88	0.40	1.10	0.47
Healthcare Support	2.78	2.80	3.42	2.10	2.80	3.39	2.04	1.90	3.14
Building/Grounds Cleaning/Maintenance	2.07	2.20	2.13	1.99	1.95	3.46	2.10	1.84	1.82
Farming, Fishing, and Forestry	0.41	0.32	0.82	0.30	0.16	0.28	0.17	0.17	0.77
Personal Care and Service	1.52	1.58	1.63	1.67	1.55	2.89	1.49	1.38	1.48
Food Preparation and Serving Related	4.23	5.24	4.12	4.52	3.69	6.73	3.93	3.55	4.30

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

TABLE 14
EMPLOYMENT AND AGGREGATE EARNINGS, MAJOR OCCUPATIONAL GROUPS, ARIZONA, 2012-TO-2022 CHANGE IN SHARE RELATIVE TO THE NATIONAL AVERAGE

	Employment		Aggregate Earnings	
	Share of Total	Rank*	Share of Total	Rank*
High Paying	0.56	5	0.02	7
Legal	-0.05	8	-0.08	7
Management	0.03	4	-0.49	6
Computer and Mathematical	0.15	6	0.08	6
Healthcare Practitioners and Technical	0.33	1	0.37	2
Architecture and Engineering	-0.12	5	-0.13	4
Life, Physical, and Social Science	-0.10	8	0.02	4
Business and Financial Operations	0.31	5	0.25	5
Subtotal of Three STEM Groups	-0.06	7	-0.03	7
Mid Paying	-0.53	8	-1.12	8
Arts/Design/Entertainment/Sports/Media	-0.22	7	-0.15	8
Educational Instruction and Library	-0.35	8	-0.52	8
Installation, Maintenance, and Repair	0.18	1	-0.04	1
Construction and Extraction	0.39	3	0.38	2
Community and Social Service	-0.19	8	-0.20	8
Protective Service	-0.34	8	-0.60	8
Low Paying	-0.03	1	1.10	1
Sales and Related	-0.53	7	0.08	5
Office and Administrative Support	0.11	2	-0.10	6
Production	0.30	1	0.30	1
Transportation and Material Moving	0.72	1	0.41	1
Military-Only Occupations	0.03	3	0.04	3
Healthcare Support	-0.12	4	-0.09	4
Building/Grounds Cleaning/Maintenance	-0.16	5	0.02	4
Farming, Fishing, and Forestry	-0.12	6	-0.06	7
Personal Care and Service	-0.08	5	0.02	3
Food Preparation and Serving Related	-0.19	8	0.49	1

* Among eight comparison states

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

employment and aggregate earnings. In contrast, Arizona had the least change in share in the mid-paying category, based on both employment and aggregate earnings. In the high-paying category, Arizona ranked fifth on employment and seventh on aggregate earnings.

The changes in employment shares between 2012 and 2022 are shown for the nation and each of the comparison states in Table 15. The 2012-to-2022 changes in shares of aggregate earnings are displayed in Table 16.

TABLE 15
CHANGE IN EMPLOYMENT SHARE OF TOTAL, MAJOR OCCUPATIONAL GROUPS, ARIZONA AND SELECTED STATES, 2012 TO 2022

	US	AZ	CA	CO	MA	MD	UT	VA	WA
High Paying	3.90	4.46	3.89	4.58	4.44	4.84	5.77	4.64	4.08
Legal	0.02	-0.04	0.02	0.04	0.05	0.00	-0.01	-0.03	-0.01
Management	1.63	1.66	1.55	1.08	2.79	2.48	2.77	1.18	0.55
Computer and Mathematical	0.52	0.67	0.69	0.61	0.18	0.90	1.13	0.82	1.16
Healthcare Practitioners and Technical	0.33	0.66	0.55	0.44	0.08	-0.08	0.12	0.52	0.36
Architecture and Engineering	-0.08	-0.20	-0.15	0.22	-0.28	-0.22	-0.06	-0.26	-0.20
Life, Physical, and Social Science	0.02	-0.08	0.00	0.07	0.27	0.07	0.00	0.09	0.06
Business and Financial Operations	1.46	1.77	1.23	2.11	1.35	1.69	1.82	2.32	2.16
Subtotal of Three STEM Groups	0.46	0.40	0.55	0.91	0.17	0.75	1.07	0.65	1.02
Mid Paying	-0.47	-1.00	-0.35	-0.64	-0.81	-0.43	-0.57	-0.58	-0.17
Arts/Design/Entertainment/Sports/Media	0.05	-0.17	0.11	-0.17	-0.02	-0.02	0.03	-0.01	-0.03
Educational Instruction and Library	-0.56	-0.92	-0.65	-0.42	-0.64	-0.24	-0.76	-0.23	-0.72
Installation, Maintenance, and Repair	0.03	0.21	-0.15	-0.09	-0.11	-0.14	-0.25	-0.10	-0.17
Construction and Extraction	0.10	0.49	0.28	-0.16	0.16	-0.24	0.63	-0.25	0.82
Community and Social Service	0.03	-0.16	0.04	0.38	-0.14	0.24	0.04	0.19	-0.07
Protective Service	-0.12	-0.46	0.01	-0.17	-0.06	-0.04	-0.26	-0.18	0.00
Low Paying	-3.43	-3.46	-3.54	-3.94	-3.63	-4.40	-5.20	-4.06	-3.91
Sales and Related	-1.38	-1.91	-1.80	-0.79	-1.38	-1.10	-2.41	-1.26	-0.55
Office and Administrative Support	-1.96	-1.86	-2.54	-1.91	-2.11	-2.48	-2.29	-1.93	-1.45
Production	-0.52	-0.22	-0.55	-0.49	-0.38	-0.50	-0.30	-0.35	-0.93
Transportation and Material Moving	1.12	1.84	1.11	0.80	0.19	1.07	0.87	0.50	0.55
Military-only Occupations	-0.14	-0.10	-0.15	-0.16	-0.06	-0.06	-0.16	-0.39	-0.39
Healthcare Support	0.63	0.52	2.60	0.04	0.99	-0.14	0.37	0.27	1.20
Building/Grounds Cleaning/Maintenance	-0.49	-0.65	-0.96	-0.68	-0.49	-0.42	-0.38	-0.49	-0.84
Farming, Fishing, and Forestry	-0.06	-0.18	-0.23	-0.04	0.07	-0.02	-0.06	-0.06	-0.64
Personal Care and Service	-0.44	-0.51	-0.80	-0.50	-0.36	-0.50	-0.59	-0.31	-0.90
Food Preparation and Serving Related	-0.20	-0.38	-0.21	-0.22	-0.11	-0.25	-0.26	-0.05	0.05

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

TABLE 16
CHANGE IN AGGREGATE EARNINGS SHARE OF TOTAL, MAJOR OCCUPATIONAL GROUPS, ARIZONA AND SELECTED STATES, 2012 TO 2022

	US	AZ	CA	CO	MA	MD	UT	VA	WA
High Paying	3.61	3.63	3.84	4.09	5.02	4.49	5.45	4.15	3.37
Legal	-0.12	-0.20	-0.14	-0.04	0.18	-0.06	-0.29	-0.13	-0.10
Management	1.86	1.38	1.81	1.73	4.66	2.24	3.16	1.13	0.13
Computer and Mathematical	1.02	1.10	1.74	0.76	0.12	1.70	1.98	1.40	2.48
Healthcare Practitioners and Technical	0.03	0.40	0.75	0.09	-0.58	-0.45	-0.11	0.34	0.06
Architecture and Engineering	-0.48	-0.62	-0.62	-0.19	-0.76	-0.73	-0.55	-0.80	-0.95
Life, Physical, and Social Science	-0.10	-0.08	-0.12	-0.15	0.39	-0.12	-0.09	-0.06	-0.07
Business and Financial Operations	1.40	1.65	0.42	1.88	1.01	1.93	1.35	2.27	1.81
Subtotal of Three STEM Groups	0.44	0.41	1.00	0.42	-0.24	0.85	1.34	0.54	1.46
Mid Paying	-1.82	-2.95	-1.89	-2.31	-2.01	-1.95	-1.98	-1.85	-1.36
Arts/Design/Entertainment/Sports/Media	0.00	-0.15	-0.04	-0.13	-0.01	-0.09	-0.12	-0.07	0.00
Educational Instruction and Library	-1.33	-1.85	-1.03	-1.27	-1.37	-1.22	-1.28	-0.99	-1.06
Installation, Maintenance, and Repair	-0.16	-0.21	-0.39	-0.36	-0.32	-0.31	-0.71	-0.27	-0.57
Construction and Extraction	-0.01	0.38	-0.05	-0.37	0.15	-0.35	0.32	-0.27	0.61
Community and Social Service	-0.09	-0.29	-0.12	0.17	-0.23	0.13	0.06	0.04	-0.12
Protective Service	-0.24	-0.84	-0.25	-0.35	-0.23	-0.10	-0.25	-0.29	-0.22
Low Paying	-1.78	-0.68	-1.95	-1.78	-3.01	-2.54	-3.47	-2.30	-2.01
Sales and Related	-1.06	-0.98	-1.34	-0.13	-1.26	-0.82	-2.09	-0.65	0.14
Office and Administrative Support	-2.01	-2.12	-2.59	-2.10	-2.12	-2.55	-2.08	-1.92	-1.68
Production	-0.46	-0.16	-0.30	-0.51	-0.38	-0.38	-0.37	-0.20	-0.95
Transportation and Material Moving	1.19	1.60	1.00	0.85	0.31	1.11	0.84	0.64	0.61
Military-only Occupations	-0.13	-0.09	-0.14	-0.16	-0.05	0.00	-0.22	-0.36	-0.46
Healthcare Support	0.47	0.38	1.30	0.09	0.42	-0.04	0.36	0.10	0.79
Building/Grounds Cleaning/Maintenance	-0.10	-0.08	-0.28	-0.18	-0.28	-0.07	0.07	-0.07	-0.40
Farming, Fishing, and Forestry	0.00	-0.06	0.01	-0.02	0.04	-0.01	-0.02	-0.03	-0.33
Personal Care and Service	-0.11	-0.10	-0.31	-0.17	-0.10	-0.13	-0.28	-0.07	-0.30
Food Preparation and Serving Related	0.44	0.93	0.68	0.55	0.39	0.35	0.31	0.25	0.56

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

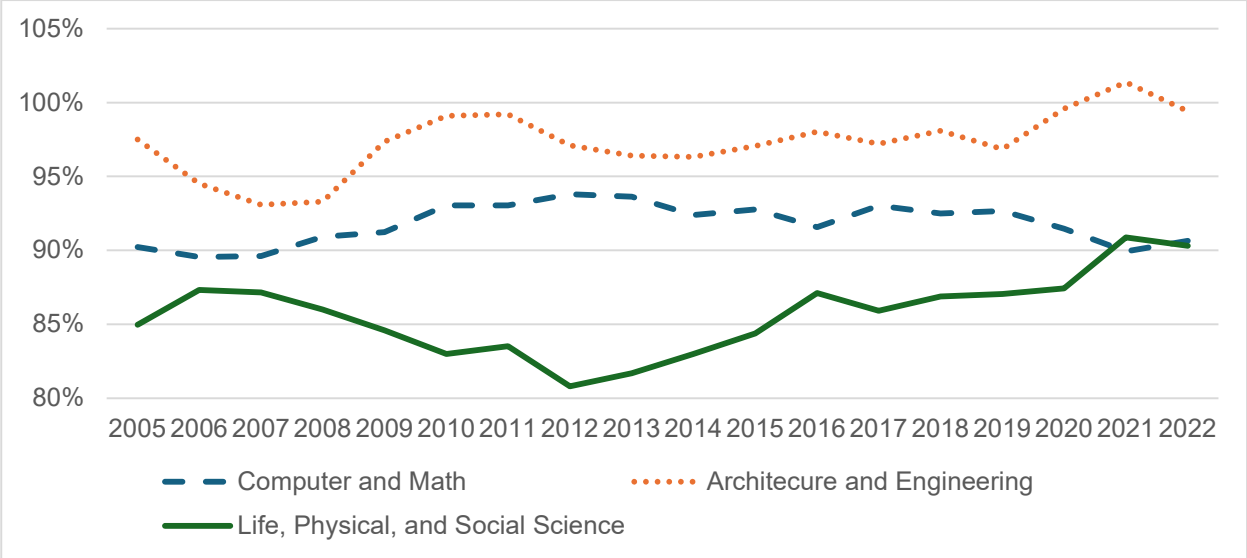
Charts 12 and 13 focus on the time series of the three occupational groups that account for the vast majority of STEM occupations. Chart 12 shows that earnings per worker in Arizona relative to the nation has improved over time in the architecture and engineering, and life, physical, and social science groups, with little change in the computer and math group.

Chart 13 displays the share in Arizona as a percentage of the nation in each of the three occupational groups, measured by employment and by aggregate earnings. Arizona's share in the architecture and engineering group declined considerably relative to the nation on both employment and aggregate earnings, though slight improvement has occurred in recent years. The share in Arizona rose relative to the nation in the computer and math group through 2015, though the relative employment share has been flat since then and the relative aggregate earnings share has declined. In the life, physical, and social science group, the relative share rose a little during the 2000s, but those gains have since been lost.

A summary of the high-paying category and each of its occupational groups follows for Arizona, with comparisons to the nation and ranks among the eight comparison states. The earnings per worker figures are adjusted for the cost of living.

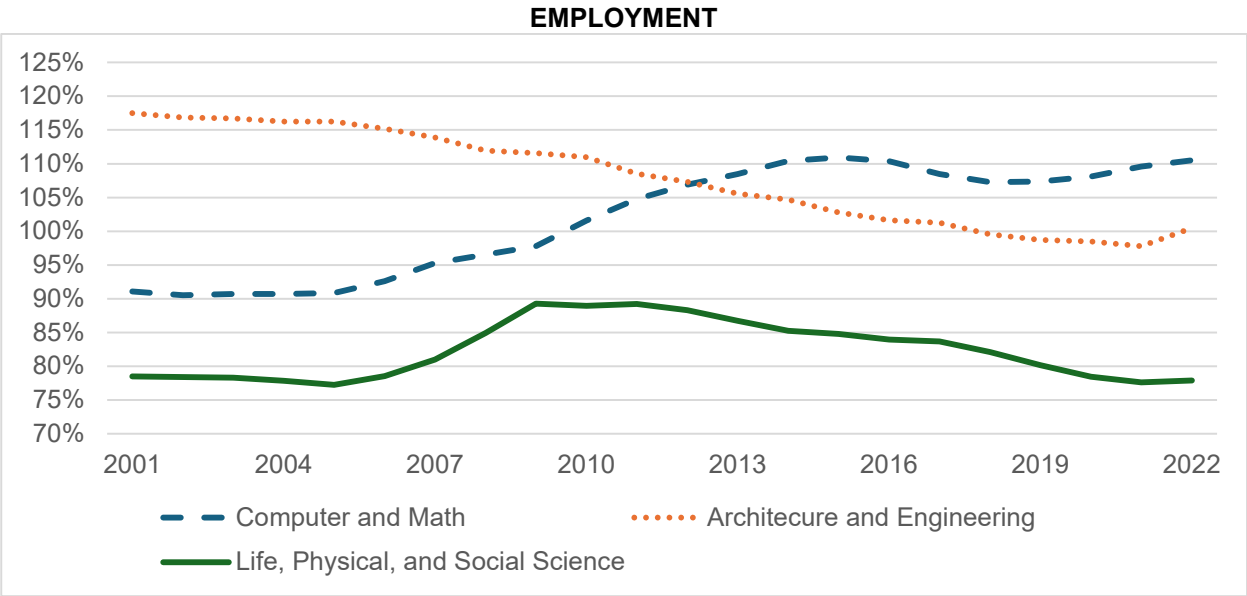
High-Paying Total. Arizona's share was close to the U.S. average in 2022, but Arizona compared poorly to the comparison states, ranking last on employment and sixth on aggregate earnings. Arizona also was last on median earnings per worker. Massachusetts and Virginia had the highest aggregate earnings shares; Maryland and Utah had shares lower than Arizona. The 2012-to-2022 change in share in Arizona exceeded the national average on employment, ranking fifth, but was equal to the U.S. average on aggregate earnings, ranking seventh. Utah and

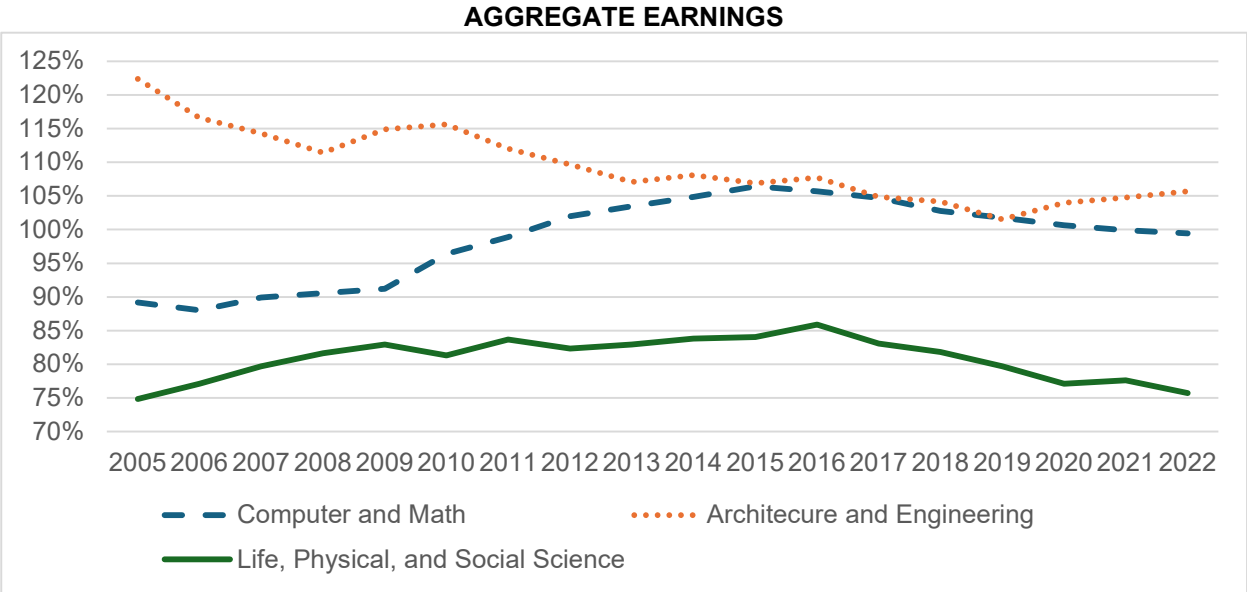
CHART 12
EARNINGS PER WORKER, ARIZONA AS A PERCENTAGE OF THE NATIONAL AVERAGE, SELECTED OCCUPATIONAL GROUPS



Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

CHART 13
SHARE OF TOTAL, ARIZONA AS A PERCENTAGE OF THE NATIONAL AVERAGE, SELECTED OCCUPATIONAL GROUPS





Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

Massachusetts had the greatest increases in share on aggregate earnings; only Washington had a lower figure than Arizona. On the change in median earnings per worker, Arizona was last.

A summary by high-paying occupational group follows:

- Subtotal of Three STEM Groups. Arizona's share was slightly higher than the national average in 2022, but Arizona compared poorly to the comparison states, ranking eighth on employment and seventh on aggregate earnings. Arizona also ranked seventh on median earnings per worker., Virginia and Washington had the highest aggregate earnings shares; Maryland's share was lower than Arizona. The 2012-to-2022 change in share in Arizona was slightly less than the national average and ranked seventh on both employment and aggregate earnings. Washington and Utah had the greatest increases in aggregate earnings share; only Massachusetts had a lower figure than Arizona. On the change in median earnings per worker, Arizona ranked seventh.
- Computer and Mathematical. Arizona's share was higher than the U.S. average in 2022, but Arizona ranked last on employment and seventh on aggregate earnings. Arizona also was last on median earnings per worker. Virginia and Washington had the highest aggregate earnings shares; only Maryland had a share lower than Arizona. The 2012-to-2022 change in share in Arizona somewhat exceeded the U.S. average, but ranked sixth on both employment and aggregate earnings. Washington and Utah had the greatest increases in aggregate earnings share; Massachusetts and Colorado had lower figures than Arizona. On the change in median earnings per worker, Arizona ranked seventh.
- Architecture and Engineering. Arizona's share was higher than the U.S. average in 2022, but Arizona ranked last on employment and fifth on aggregate earnings. Arizona was sixth on median earnings per worker. Colorado had the highest aggregate earnings share by far; only Maryland had a share lower than Arizona. The 2012-to-2022 change in share in Arizona was worse than the U.S. average, but ranked fifth on employment and fourth on aggregate earnings. The aggregate earnings share dropped in each state; Colorado had the least decline and Washington the most. Arizona ranked fifth on the change in median earnings per worker.
- Life, Physical, and Social Science. Arizona compares particularly poorly in this group, with employment and aggregate earnings shares considerably less than the U.S. average, ranking last in 2022. Arizona also was last on median earnings per worker. Massachusetts had the highest aggregate earnings share by far. Arizona's 2012-to-2022 change in employment share was less than the U.S. average, ranking eighth, but the change in the aggregate earnings share slightly exceeded the U.S. average and ranked fourth. Massachusetts was the only state with an increase in aggregate earnings share. Arizona had the greatest change in median earnings per worker.
- Healthcare Practitioners and Technical. Among the high-paying groups, Arizona compared most favorably in this group among the eight states, ranking third on employment (despite a share slightly less than the U.S. average) and second on aggregate earnings. Arizona's median earnings per worker was slightly higher than the U.S. average, but the state ranked seventh. Only Massachusetts had a higher aggregate earnings share. Arizona's 2012-to-2022 change in share also was strong, exceeding the U.S. average, ranking first on employment and second on aggregate earnings. California was the only state with a larger increase in aggregate earnings share. However, Arizona had the least change in median earnings per worker.

- Management. Arizona's employment share was higher than the U.S. average in 2022, but its aggregate earnings share was below average. Arizona ranked fifth on both measures; Arizona was last on median earnings per worker. Massachusetts had by far the highest aggregate earnings share, followed by California. Shares were lower than in Arizona in Colorado, Washington, and Maryland. Arizona's 2012-to-2022 change in employment share slightly exceeded the U.S. average and ranked fourth. However, the change in the aggregate earnings share was considerably below average, ranking sixth. Massachusetts and Utah had the greatest increases in aggregate earnings share; Virginia and Washington had lower figures than Arizona. On the change in median earnings per worker, Arizona ranked seventh.
- Business and Financial Operations. Arizona's employment share was higher than the U.S. average in 2022, ranking sixth. Its aggregate earnings share was slightly below average and ranked fifth. Arizona was last on median earnings per worker. Virginia and Colorado had the highest aggregate earnings shares; Utah, California, and Maryland had shares lower than Arizona. The 2012-to-2022 change in share in Arizona exceeded the U.S. average, ranking fifth on both employment and aggregate earnings. Virginia and Maryland had the greatest increases in aggregate earnings share; Utah, Massachusetts, and California had lower figures than Arizona. On the change in median earnings per worker, Arizona ranked fifth.
- Legal. Arizona's shares were substantially less than the U.S. average in 2022, but the state ranked sixth on employment and fifth on aggregate earnings. Arizona was seventh on median earnings per worker. Virginia and California had the highest aggregate earnings shares; Washington, Utah, and Maryland had shares lower than Arizona. The 2012-to-2022 change in share in Arizona was less than the U.S. average, ranking last on employment and seventh on aggregate earnings. Massachusetts was the only state with an increase in aggregate earnings share; only Utah had a lower figure than Arizona. On the change in median earnings per worker, Arizona ranked seventh.

Metropolitan Phoenix

Table 17 displays 2022 employment and aggregate earnings data by occupational group for Metro Phoenix. With Metro Phoenix in 2022 accounting for 72.2 percent of the state's employment, and 74.2 percent of the aggregate earnings, the occupational mix in Metro Phoenix was similar to that in Arizona. The primary differences were lesser shares in the Phoenix area in the military and the farming, fishing, and forestry groups.

As seen in Table 17, the occupational shares in Metro Phoenix in 2022 ranked near the bottom of the 12 large metropolitan areas used as a comparison group in six of the seven high-paying occupational groups, including each of the STEM groups, and last overall among the high-paying groups on both employment and aggregate earnings. In contrast, Metro Phoenix generally ranked among the top five metro areas in the share in the low-paying occupational groups; it had the highest overall share in the low-paying group on both employment and aggregate earnings.

In Table 18, the employment shares in 2022 are shown for the nation and for each of the 12 comparison areas. The shares of aggregate earnings are displayed in Table 19.

TABLE 17
EMPLOYMENT AND AGGREGATE EARNINGS, MAJOR OCCUPATIONAL GROUPS, METROPOLITAN PHOENIX, 2022

	Employment			Aggregate Earnings		
	Share of Total	Ratio to Nation	Rank*	Share of Total	Ratio to Nation	Rank*
High Paying	26.99%	1.05	12	43.04%	1.01	12
Legal	0.77	0.90	12	1.36	0.83	10
Management	7.38	1.03	10	12.97	0.97	9
Computer and Mathematical	3.78	1.19	11	6.44	1.11	10
Healthcare Practitioners and Technical	5.72	1.00	4	9.78	1.04	3
Architecture and Engineering	1.59	1.00	12	2.57	1.02	11
Life, Physical, and Social Science	0.56	0.62	12	0.75	0.59	12
Business and Financial Operations	7.19	1.12	10	9.18	1.04	9
Subtotal of Three STEM Groups	5.93	1.04	12	9.76	1.02	12
Mid Paying	18.55	0.94	9	16.97	0.90	6
Arts/Design/Entertainment/Sports/Media	1.57	0.85	12	1.43	0.76	12
Educational Instruction and Library	4.44	0.79	12	4.06	0.72	12
Installation, Maintenance, and Repair	3.92	1.00	1	3.64	0.98	1
Construction and Extraction	5.00	1.11	2	4.55	1.10	3
Community and Social Service	1.46	0.84	10	1.32	0.83	9
Protective Service	2.17	1.00	4	1.98	1.01	4
Low Paying	54.46	1.00	1	39.98	1.05	1
Sales and Related	9.08	1.03	5	7.45	1.08	4
Office and Administrative Support	13.81	1.16	1	10.69	1.17	1
Production	3.98	0.73	5	3.06	0.73	2
Transportation and Material Moving	8.68	1.00	1	6.77	1.02	1
Military-Only Occupations	0.35	0.58	5	0.23	0.56	5
Healthcare Support	4.30	0.96	6	2.79	1.00	3
Building/Grounds Cleaning/Maintenance	3.40	0.98	5	2.07	1.00	2
Farming, Fishing, and Forestry	0.32	0.45	3	0.19	0.46	3
Personal Care and Service	2.53	0.96	9	1.55	1.02	4
Food Preparation and Serving Related	8.02	1.04	3	5.18	1.23	1

* Among 12 large comparison metro areas

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

Table 20 depicts changes in employment and aggregate earnings shares in Metro Phoenix over the 10-year time period between 2012 and 2022. Relative to the state, Metro Phoenix had a greater increase in the healthcare practitioners and technical group.

The changes in employment shares between 2012 and 2022 are shown for the nation and for each of the comparison areas in Table 21. The change in shares of aggregate earnings are displayed in Table 22.

TABLE 18
EMPLOYMENT SHARE OF TOTAL, MAJOR OCCUPATIONAL GROUPS, METROPOLITAN PHOENIX AND SELECTED LARGE METROPOLITAN AREAS, 2022

	US	Aus	Bal	Bos	Den	Pho	Por	R-D	SD	SF	SJ	Sea	DC
High Paying	25.8%	31.1%	31.6%	34.1%	31.1%	27.0%	28.6%	32.3%	28.4%	34.1%	40.5%	31.6%	39.1%
Legal	0.9	1.0	1.1	1.1	1.2	0.8	0.9	0.8	1.0	1.3	0.8	0.8	2.2
Management	7.2	9.3	8.1	10.0	6.3	7.4	7.6	7.7	7.6	9.6	10.1	6.1	9.3
Computer/Mathematical	3.2	6.2	4.8	4.6	5.0	3.8	3.8	5.6	3.5	6.3	12.6	7.5	7.2
Healthcare Practice/Tech	5.7	4.1	6.4	6.7	5.0	5.7	5.1	7.0	5.1	4.8	4.4	4.8	4.8
Architecture/Engineering	1.6	2.1	1.8	2.0	2.5	1.6	2.9	2.0	2.5	2.1	3.9	2.3	1.8
Life/Physical/Social Sci	0.9	0.8	1.4	2.0	1.1	0.6	1.1	1.8	1.7	1.8	1.0	1.2	1.9
Business/Financial	6.4	7.3	8.0	7.7	9.9	7.2	7.2	7.5	7.0	8.3	7.6	8.9	11.8
Subtotal of Three STEM	5.7	9.2	7.9	8.6	8.7	5.9	7.7	9.4	7.7	10.2	17.6	10.9	11.0
Mid Paying	19.8	19.0	20.6	19.3	19.2	18.6	19.2	19.2	19.6	18.5	15.9	18.4	19.6
Arts/Des/Ent/Sports/Media	1.9	2.2	1.6	2.0	2.0	1.6	2.3	1.9	2.0	2.8	1.8	2.2	2.6
Educational and Library	5.6	5.1	6.2	6.4	5.0	4.4	5.0	6.3	5.5	5.3	5.2	4.5	5.7
Installation/Maint/Repair	3.9	3.7	3.7	2.8	3.5	3.9	3.4	3.4	3.4	2.6	2.5	3.4	3.1
Construction/Extraction	4.5	4.9	4.2	3.8	5.1	5.0	5.0	4.1	4.5	4.0	3.6	4.9	3.8
Community/Social Service	1.7	1.3	2.1	2.2	1.7	1.5	2.1	1.6	1.9	1.8	1.3	1.6	1.6
Protective Service	2.2	1.8	2.8	2.1	1.9	2.2	1.4	1.9	2.3	1.9	1.6	1.8	2.8
Low Paying	54.4	49.9	47.9	46.6	49.8	54.5	52.2	48.5	52.1	47.4	43.6	50.0	41.3
Sales and Related	8.8	9.3	8.2	7.7	10.6	9.1	8.3	9.4	8.0	7.7	7.6	9.1	7.1
Office/Admin Support	11.9	13.1	11.9	11.2	11.0	13.8	11.6	11.4	10.1	9.9	8.8	10.7	9.7
Production	5.5	3.4	2.5	3.7	3.0	4.0	5.7	3.6	4.1	3.5	4.9	4.0	1.5
Transport/Material Moving	8.7	6.4	8.5	5.7	7.6	8.7	8.4	7.4	6.3	6.5	4.8	7.5	5.5
Military-only Occupations	0.6	0.2	0.9	0.2	0.3	0.3	0.2	0.2	2.7	0.2	0.1	1.0	1.0
Healthcare Support	4.5	2.9	3.5	4.6	3.2	4.3	3.9	3.4	4.9	6.0	5.4	4.7	3.2
Build/Grounds Clean/Maint	3.5	3.4	3.1	3.4	3.0	3.4	3.1	3.2	4.0	3.6	3.4	2.9	3.6
Farming/Fishing/Forestry	0.7	0.1	0.2	0.2	0.3	0.3	0.9	0.3	0.5	0.2	0.3	0.2	0.1
Personal Care and Service	2.6	2.7	2.6	2.9	2.8	2.5	2.9	2.4	3.1	3.0	2.3	2.5	2.8
Food Preparation/Serving	7.7	8.3	6.6	7.0	7.9	8.0	7.2	7.2	8.5	6.9	6.0	7.4	6.8

Aus: Austin-Round Rock-San Marcos, Texas; Bal: Baltimore-Columbia-Towson, Maryland; Bos: Boston-Cambridge-Newton, Massachusetts; Den: Denver-Aurora-Centennial, Colorado; Pho: Phoenix-Mesa-Chandler, Arizona; Por: Portland-Vancouver-Hillsboro, Oregon-Washington; R-D: sum of Raleigh-Cary and Durham-Chapel Hill, North Carolina; SD: San Diego-Chula Vista-Carlsbad, California; SF: San Francisco-Oakland-Fremont, California; SJ: San Jose-Sunnyvale-Santa Clara, California; Sea: Seattle-Tacoma- Bellevue, Washington; DC: Washington-Arlington-Alexandria, District of Columbia-Virginia-Maryland-West Virginia

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

TABLE 19
AGGREGATE EARNINGS SHARE OF TOTAL, MAJOR OCCUPATIONAL GROUPS, METROPOLITAN PHOENIX AND SELECTED LARGE METROPOLITAN AREAS, 2022

	US	Aus	Bal	Bos	Den	Pho	Por	R-D	SD	SF	SJ	Sea	DC
High Paying	42.8%	49.6%	49.7%	52.9%	48.6%	43.0%	44.7%	51.4%	47.2%	55.2%	64.1%	48.9%	60.2%
Legal	1.6	1.8	1.8	1.9	2.4	1.4	1.5	1.4	2.0	2.5	1.5	1.3	4.4
Management	13.3	17.3	14.3	18.8	12.8	13.0	12.5	15.0	14.3	18.3	18.4	11.5	17.3
Computer/Mathematical	5.8	10.3	8.6	7.4	8.4	6.4	6.1	10.4	6.1	10.8	22.7	13.5	11.5
Healthcare Practice/Tech	9.4	6.6	9.8	9.9	7.3	9.8	9.7	9.6	9.5	8.1	6.5	7.2	6.7
Architecture/Engineering	2.5	3.3	2.7	2.7	3.6	2.6	4.4	2.9	4.1	3.0	5.5	3.1	2.5
Life/Physical/Social Sci	1.3	1.1	1.8	2.7	1.4	0.7	1.3	2.3	2.4	2.4	1.1	1.4	2.7
Business/Financial	8.8	9.2	10.7	9.4	12.6	9.2	9.0	9.8	8.8	10.1	8.5	10.8	15.0
Subtotal of Three STEM	9.6	14.7	13.1	12.8	13.5	9.8	11.9	15.6	12.6	16.3	29.3	18.0	16.8
Mid Paying	18.9	17.4	18.8	17.6	16.6	17.0	19.3	16.8	18.9	16.5	12.4	16.9	16.3
Arts/Des/Ent/Sports/Media	1.9	2.1	1.5	1.9	1.8	1.4	2.1	1.8	1.9	2.8	1.5	2.0	2.7
Educational and Library	5.7	5.2	6.1	6.3	4.2	4.1	5.5	5.9	5.8	5.0	4.2	4.3	4.9
Installation/Maint/Repair	3.7	3.1	3.3	2.4	3.2	3.6	3.2	3.0	3.2	2.2	1.8	3.0	2.4
Construction/Extraction	4.2	4.1	3.6	3.7	4.4	4.6	5.2	3.3	4.2	3.5	2.7	4.8	2.8
Community/Social Service	1.6	1.2	1.8	1.7	1.4	1.3	1.9	1.4	1.6	1.4	1.0	1.4	1.3
Protective Service	2.0	1.6	2.5	1.7	1.7	2.0	1.3	1.4	2.2	1.6	1.2	1.6	2.3
Low Paying	38.3	33.0	31.5	29.5	34.7	40.0	36.0	31.9	33.9	28.3	23.5	34.2	23.5
Sales and Related	6.9	7.2	5.8	5.7	9.0	7.5	6.3	7.5	5.9	5.5	5.8	7.5	4.6
Office/Admin Support	9.1	9.9	8.6	7.9	8.0	10.7	8.6	8.2	7.5	6.9	5.3	7.6	6.2
Production	4.2	2.4	1.8	2.4	2.1	3.1	4.2	2.6	2.9	2.2	2.6	2.9	1.0
Transport/Material Moving	6.6	4.4	6.3	3.6	5.9	6.8	6.0	4.7	4.4	4.0	2.4	5.8	3.4
Military-only Occupations	0.4	0.1	0.7	0.2	0.2	0.2	0.1	0.1	1.4	0.1	0.0	0.5	0.6
Healthcare Support	2.8	1.7	2.0	2.6	1.9	2.8	2.6	2.0	2.8	2.9	2.3	2.8	1.6
Build/Grounds Clean/Maint	2.1	1.9	1.7	1.9	1.7	2.1	1.9	1.8	2.3	1.8	1.5	1.6	1.7
Farming/Fishing/Forestry	0.4	0.1	0.1	0.1	0.1	0.2	0.5	0.2	0.2	0.1	0.1	0.1	0.1
Personal Care and Service	1.5	1.4	1.4	1.5	1.6	1.6	1.7	1.3	1.7	1.5	1.0	1.4	1.3
Food Preparation/Serving	4.2	4.0	3.3	3.6	4.2	5.2	4.0	3.4	4.6	3.3	2.4	4.0	3.1

Aus: Austin-Round Rock-San Marcos, Texas; Bal: Baltimore-Columbia-Towson, Maryland; Bos: Boston-Cambridge-Newton, Massachusetts; Den: Denver-Aurora-Centennial, Colorado; Pho: Phoenix-Mesa-Chandler, Arizona; Por: Portland-Vancouver-Hillsboro, Oregon-Washington; R-D: sum of Raleigh-Cary and Durham-Chapel Hill, North Carolina; SD: San Diego-Chula Vista-Carlsbad, California; SF: San Francisco-Oakland-Fremont, California; SJ: San Jose-Sunnyvale-Santa Clara, California; Sea: Seattle-Tacoma- Bellevue, Washington; DC: Washington-Arlington-Alexandria, District of Columbia-Virginia-Maryland-West Virginia

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

A summary of the high-paying category and each of its occupational groups for Metropolitan Phoenix, with comparisons to the nation and ranks among the 12 comparison areas, follows:

- High-Paying Total. Metro Phoenix's share was a little higher than the U.S. average in 2022, but Metro Phoenix ranked last among the comparison areas on both employment and aggregate earnings. San Jose and Washington, D.C. had the highest aggregate earnings shares; Portland had the lowest share other than Metro Phoenix. The 2012-to-2022 change in share in the Phoenix area exceeded the U.S. average on employment, but ranked ninth. The aggregate earnings change was slightly below the U.S. average; Metro Phoenix ranked 10th. San Francisco and Austin had the greatest increases in aggregate earnings share; Portland and Seattle had lower figures than Metro Phoenix.

TABLE 20
EMPLOYMENT AND AGGREGATE EARNINGS, MAJOR OCCUPATIONAL GROUPS, METROPOLITAN PHOENIX, 2012-TO-2022 CHANGE IN SHARE RELATIVE TO THE NATIONAL AVERAGE

	Employment		Aggregate Earnings	
	Share of Total	Rank*	Share of Total	Rank*
High Paying	0.68	9	-0.05	10
Legal	-0.08	10	-0.13	10
Management	-0.10	9	-0.75	10
Computer and Mathematical	0.09	10	-0.04	9
Healthcare Practitioners and Technical	0.64	2	0.83	3
Architecture and Engineering	-0.19	7	-0.22	7
Life, Physical, and Social Science	-0.11	9	0.00	6
Business and Financial Operations	0.41	5	0.26	6
Subtotal of Three STEM Groups	-0.20	11	-0.26	9
Mid Paying	-0.57	9	-0.78	10
Arts/Design/Entertainment/Sports/Media	-0.25	9	-0.20	9
Educational Instruction and Library	-0.36	9	-0.31	10
Installation, Maintenance, and Repair	0.22	2	0.00	2
Construction and Extraction	0.29	5	0.33	5
Community and Social Service	-0.19	11	-0.22	12
Protective Service	-0.29	12	-0.38	12
Low Paying	-0.11	1	0.83	1
Sales and Related	-0.95	12	-0.35	9
Office and Administrative Support	-0.13	3	-0.39	7
Production	0.18	6	0.22	5
Transportation and Material Moving	0.85	1	0.49	1
Military-Only Occupations	0.11	1	0.10	1
Healthcare Support	0.20	5	0.09	5
Building/Grounds Cleaning/Maintenance	-0.09	7	0.05	4
Farming, Fishing, and Forestry	0.03	7	0.01	3
Personal Care and Service	0.01	5	0.07	2
Food Preparation and Serving Related	-0.32	7	0.53	1

* Among 12 large comparison metro areas

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

- Subtotal of Three STEM Groups. Metro Phoenix's share was slightly higher than the U.S. average in 2022, but Metro Phoenix ranked last on both employment and aggregate earnings. San Jose and Seattle had the highest aggregate earnings shares; Portland had the lowest share other than Metro Phoenix. The 2012-to-2022 change in share in the Phoenix area was less than the U.S. average, ranking 11th on employment and ninth on aggregate earnings. San Jose and San Francisco had the greatest increases in aggregate earnings share; Washington, D.C., Austin, and Boston ranked below Metro Phoenix.
- Computer and Mathematical. Metro Phoenix's share was higher than the U.S. average in 2022, but Metro Phoenix ranked 11th on employment and 10th on aggregate earnings. San Jose and Seattle had the highest aggregate earnings shares; Portland and San Diego had shares lower than Metro Phoenix. The 2012-to-2022 change in share in the Phoenix area was similar to the U.S. average, but ranked 10th on employment and ninth on aggregate earnings. San Jose and San Francisco had the greatest increases in aggregate earnings share; Denver, San Diego, and Boston had lower figures than Metro Phoenix.
- Architecture and Engineering. Metro Phoenix's share was similar to the U.S. average in 2022, but Metro Phoenix ranked last on employment and 11th on aggregate earnings. San Jose and Portland had the highest aggregate earnings shares; only Washington, D.C. had a share lower than Metro Phoenix. The 2012-to-2022 change in share in the Phoenix area was worse than the U.S. average, but ranked seventh on both employment and aggregate earnings. Denver and Raleigh-Durham had the best change in aggregate earnings figures; Seattle and San Jose had the worst.
- Life, Physical, and Social Science. Metro Phoenix compares particularly poorly in this group, with employment and aggregate earnings shares far less than the U.S. average, ranking last in 2022. Boston and Washington, D.C. had the highest aggregate earnings shares. Metro Phoenix's 2012-to-2022 change in share was not much different from the U.S. average, ranking ninth on employment and sixth on aggregate earnings. Boston and San Diego had the greatest increases in aggregate earnings share; Washington, D.C. and Raleigh-Durham were lowest.
- Healthcare Practitioners and Technical. Among the high-paying groups, Metro Phoenix compared most favorably in this group among the 12 metro areas, ranking fourth on employment and third on aggregate earnings. Boston and Baltimore had barely higher aggregate earnings shares. Metro Phoenix's 2012-to-2022 change in share also was strong, considerably exceeding the U.S. average, ranking second on employment and third on aggregate earnings. San Diego and Raleigh-Durham were the only metro areas with a larger increase in aggregate earnings share.
- Management. Metro Phoenix's employment share was higher than the U.S. average in 2022, but its aggregate earnings share was below average. Metro Phoenix ranked 10th on employment and ninth on aggregate earnings. Boston and San Jose had the highest aggregate earnings shares. Portland, Denver, and Seattle had shares lower than Metro Phoenix. The 2012-to-2022 change in employment share in the Phoenix area was less than the U.S. average, ranking ninth on employment and 10th on aggregate earnings. Austin and Boston had the greatest increases in aggregate earnings share; Portland and Seattle had lower figures than Metro Phoenix.

TABLE 21
EMPLOYMENT SHARE OF TOTAL, MAJOR OCCUPATIONAL GROUPS, METROPOLITAN PHOENIX AND SELECTED LARGE METROPOLITAN AREAS, 2012-TO-2022 CHANGE

	US	Aus	Bal	Bos	Den	Pho	Por	R-D	SD	SF	SJ	Sea	DC
High Paying	3.90	6.26	4.22	4.60	5.01	4.58	4.76	5.37	4.28	6.37	5.67	4.36	4.78
Legal	0.02	-0.09	-0.04	0.03	0.02	-0.06	0.14	-0.02	0.03	0.07	-0.12	-0.03	-0.05
Management	1.63	4.19	2.33	2.84	1.35	1.54	1.43	2.24	1.62	2.83	2.39	0.50	1.83
Computer/Mathematical	0.52	1.31	0.84	0.17	0.68	0.61	0.77	0.62	0.45	1.62	3.32	1.42	0.76
Healthcare Practice/Tech	0.33	-0.17	-0.07	0.15	0.35	0.98	0.38	1.11	0.64	0.52	0.66	0.35	0.35
Architecture/Engineering	-0.08	-0.46	-0.29	-0.30	0.23	-0.27	0.00	-0.11	-0.04	-0.10	-0.93	-0.32	-0.21
Life/Physical/Social Sci	0.02	-0.13	0.07	0.34	0.06	-0.09	0.00	-0.18	0.17	0.09	-0.16	0.05	-0.07
Business/Financial	1.46	1.61	1.39	1.37	2.31	1.88	2.04	1.71	1.42	1.33	0.50	2.39	2.17
Subtotal of Three STEM	0.46	0.72	0.62	0.22	0.97	0.25	0.77	0.33	0.57	1.62	2.23	1.15	0.48
Mid Paying	-0.47	-0.84	-0.28	-0.82	-0.26	-1.04	0.01	-1.43	-0.01	-1.32	-1.58	-0.71	-0.62
Arts/Des/Ent/Sports/Media	0.05	-0.20	-0.04	-0.04	-0.21	-0.19	-0.03	0.03	0.03	-0.04	-0.24	-0.10	0.01
Educational and Library	-0.56	-1.37	0.00	-0.61	-0.45	-0.93	-0.70	-1.44	-0.39	-0.72	-0.96	-0.75	-0.47
Installation/Maint/Repair	0.03	0.41	-0.09	-0.13	-0.09	0.25	0.01	-0.11	-0.32	-0.23	-0.30	-0.38	-0.09
Construction/Extraction	0.10	0.57	-0.24	0.18	0.28	0.40	0.67	0.35	0.48	-0.20	0.23	0.70	-0.18
Community/Social Service	0.03	0.00	0.24	-0.14	0.41	-0.16	0.18	-0.02	0.27	-0.10	-0.20	-0.13	0.09
Protective Service	-0.12	-0.24	-0.16	-0.08	-0.19	-0.41	-0.12	-0.25	-0.08	-0.04	-0.11	-0.05	0.01
Low Paying	-3.43	-5.42	-3.94	-3.78	-4.75	-3.54	-4.77	-3.95	-4.26	-5.04	-4.09	-3.65	-4.16
Sales and Related	-1.38	-1.78	-1.26	-1.38	-0.82	-2.34	-1.69	-1.12	-1.92	-1.97	-1.91	-0.31	-1.05
Office/Admin Support	-1.96	-2.93	-2.19	-2.29	-2.26	-2.09	-1.59	-2.19	-2.71	-3.11	-2.82	-1.54	-2.52
Production	-0.52	-0.28	-0.55	-0.36	-0.53	-0.33	-0.46	-0.54	-0.31	-0.23	-0.03	-1.37	-0.19
Transport/Material Moving	1.12	1.77	1.34	0.09	0.88	1.96	1.27	1.79	0.65	0.05	0.15	0.19	0.47
Military-only Occupations	-0.14	-0.04	-0.10	-0.06	-0.04	-0.02	-0.08	-0.08	-0.89	-0.05	-0.04	-0.48	-0.06
Healthcare Support	0.63	0.14	0.01	0.74	-0.28	0.83	0.09	0.08	1.69	2.51	2.61	1.25	0.23
Build/Grounds Clean/Maint	-0.49	-0.55	-0.28	-0.32	-0.77	-0.58	-0.47	-0.62	-0.30	-1.03	-0.56	-0.69	-0.64
Farming/Fishing/Forestry	-0.06	-0.07	-0.02	0.07	0.03	-0.03	-0.07	0.00	-0.07	0.00	-0.13	-0.04	0.00
Personal Care and Service	-0.44	-0.36	-0.45	-0.16	-0.65	-0.42	-0.95	-0.47	-0.33	-0.63	-0.75	-0.72	-0.41
Food Preparation/Serving	-0.20	-1.33	-0.44	-0.09	-0.31	-0.51	-0.80	-0.80	-0.07	-0.59	-0.62	0.05	0.02

Aus: Austin-Round Rock-San Marcos, Texas; Bal: Baltimore-Columbia-Towson, Maryland; Bos: Boston-Cambridge-Newton, Massachusetts; Den: Denver-Aurora-Centennial, Colorado; Pho: Phoenix-Mesa-Chandler, Arizona; Por: Portland-Vancouver-Hillsboro, Oregon-Washington; R-D: sum of Raleigh-Cary and Durham-Chapel Hill, North Carolina; SD: San Diego-Chula Vista-Carlsbad, California; SF: San Francisco-Oakland-Fremont, California; SJ: San Jose-Sunnyvale-Santa Clara, California; Sea: Seattle-Tacoma- Bellevue, Washington; DC: Washington-Arlington-Alexandria, District of Columbia-Virginia-Maryland-West Virginia

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

TABLE 22
AGGREGATE EARNINGS SHARE OF TOTAL, MAJOR OCCUPATIONAL GROUPS, METROPOLITAN PHOENIX AND SELECTED LARGE METROPOLITAN AREAS, 2012-TO-2022 CHANGE

	US	Aus	Bal	Bos	Den	Pho	Por	R-D	SD	SF	SJ	Sea	DC
High Paying	3.61	6.84	3.96	5.02	3.95	3.56	3.47	6.00	4.13	7.58	6.07	3.15	3.57
Legal	-0.12	-0.08	-0.06	0.15	-0.01	-0.25	0.22	-0.07	0.00	-0.11	-0.36	-0.18	-0.49
Management	1.86	6.45	2.14	4.60	1.99	1.11	0.71	2.57	1.72	4.38	2.13	-0.10	1.80
Computer/Mathematical	1.02	1.41	1.67	0.12	0.83	0.98	1.10	1.75	0.78	3.25	7.50	2.95	1.10
Healthcare Practice/Tech	0.03	-0.49	-0.41	-0.45	-0.38	0.86	0.11	0.90	1.16	0.43	0.13	-0.18	0.29
Architecture/Engineering	-0.48	-1.07	-0.73	-0.79	-0.23	-0.70	-0.50	-0.43	-0.43	-0.55	-2.30	-1.13	-0.65
Life/Physical/Social Sci	-0.10	-0.25	-0.06	0.49	-0.10	-0.10	-0.17	-0.44	0.06	-0.03	-0.30	-0.02	-0.36
Business/Financial	1.40	0.87	1.42	0.90	1.84	1.66	2.00	1.72	0.84	0.20	-0.73	1.82	1.88
Subtotal of Three STEM	0.44	0.08	0.87	-0.18	0.50	0.18	0.44	0.89	0.41	2.67	4.90	1.80	0.09
Mid Paying	-1.82	-1.79	-1.77	-1.99	-1.99	-2.60	-0.16	-3.59	-1.54	-2.77	-2.59	-1.58	-1.70
Arts/Des/Ent/Sports/Media	0.00	-0.35	-0.14	-0.03	-0.21	-0.20	-0.01	0.05	-0.05	0.07	-0.23	-0.12	0.02
Educational and Library	-1.33	-1.67	-0.94	-1.34	-1.51	-1.64	-0.31	-3.35	-0.84	-0.94	-1.28	-0.87	-1.03
Installation/Maint/Repair	-0.16	0.08	-0.23	-0.34	-0.31	-0.16	-0.25	-0.22	-0.51	-0.49	-0.46	-0.65	-0.25
Construction/Extraction	-0.01	0.69	-0.36	0.16	0.13	0.32	0.64	0.39	0.17	-0.74	-0.16	0.47	-0.21
Community/Social Service	-0.09	-0.16	0.13	-0.22	0.21	-0.31	0.07	-0.20	0.12	-0.30	-0.23	-0.13	0.01
Protective Service	-0.24	-0.38	-0.24	-0.21	-0.29	-0.62	-0.30	-0.26	-0.42	-0.37	-0.25	-0.28	-0.23
Low Paying	-1.78	-5.05	-2.19	-3.03	-1.96	-0.96	-3.31	-2.40	-2.59	-4.81	-3.47	-1.57	-1.87
Sales and Related	-1.06	-2.16	-1.04	-1.30	-0.21	-1.42	-1.68	-0.60	-1.34	-1.62	-1.19	0.37	-0.45
Office/Admin Support	-2.01	-2.99	-2.32	-2.23	-2.46	-2.40	-1.86	-2.26	-2.59	-3.24	-2.75	-1.66	-2.27
Production	-0.46	-0.35	-0.41	-0.31	-0.54	-0.24	-0.54	-0.42	-0.17	-0.21	-0.20	-1.24	-0.08
Transport/Material Moving	1.19	1.26	1.48	0.23	1.19	1.68	0.94	1.28	0.61	-0.04	0.04	0.54	0.53
Military-only Occupations	-0.13	-0.03	-0.04	-0.05	-0.05	-0.03	-0.15	-0.07	-0.77	-0.04	-0.03	-0.49	-0.03
Healthcare Support	0.47	0.09	0.06	0.35	-0.08	0.56	0.23	0.11	0.86	0.94	0.92	0.72	0.12
Build/Grounds Clean/Maint	-0.10	-0.14	-0.03	-0.17	-0.14	-0.05	-0.01	-0.17	0.09	-0.56	-0.09	-0.27	-0.12
Farming/Fishing/Forestry	0.00	-0.03	-0.01	0.04	0.02	0.01	0.01	0.01	-0.01	0.01	-0.03	-0.03	0.00
Personal Care and Service	-0.11	-0.20	-0.12	0.01	-0.26	-0.04	-0.35	-0.08	-0.08	-0.27	-0.34	-0.17	-0.10
Food Preparation/Serving	0.44	-0.48	0.23	0.40	0.57	0.97	0.11	-0.21	0.82	0.22	0.20	0.65	0.52

Aus: Austin-Round Rock-San Marcos, Texas; Bal: Baltimore-Columbia-Towson, Maryland; Bos: Boston-Cambridge-Newton, Massachusetts; Den: Denver-Aurora-Centennial, Colorado; Pho: Phoenix-Mesa-Chandler, Arizona; Por: Portland-Vancouver-Hillsboro, Oregon-Washington; R-D: sum of Raleigh-Cary and Durham-Chapel Hill, North Carolina; SD: San Diego-Chula Vista-Carlsbad, California; SF: San Francisco-Oakland-Fremont, California; SJ: San Jose-Sunnyvale-Santa Clara, California; Sea: Seattle-Tacoma- Bellevue, Washington; DC: Washington-Arlington-Alexandria, District of Columbia-Virginia-Maryland-West Virginia

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

- Business and Financial Operations. Metro Phoenix's share was higher than the U.S. average in 2022, but ranked 10th on employment and ninth on aggregate earnings. Washington, D.C. and Denver had the highest aggregate earnings shares; Portland, San Diego, and San Jose had shares lower than Metro Phoenix. The 2012-to-2022 change in share in the Phoenix area exceeded the U.S. average, ranking fifth on employment and sixth on aggregate earnings. Portland and Washington, D.C. had the greatest increases in aggregate earnings share; San Francisco and San Jose ranked at the bottom.
- Legal. Metro Phoenix's shares were less than the U.S. average in 2022, ranking 12th on employment and 10th on aggregate earnings. Washington, D.C. and San Francisco had the highest aggregate earnings shares; Raleigh-Durham and Seattle had shares lower than Metro Phoenix. The 2012-to-2022 change in share in the Phoenix area was less than the U.S. average, ranking 10th on both measures. Portland and Boston had the largest increases in aggregate earnings share; San Jose and Washington, D.C. had lower figures than Metro Phoenix.

Metro Tucson

Table 23 displays 2022 employment and aggregate earnings data by occupational group for Metro Tucson. With Metro Tucson only accounting for 12.8 percent's of the state's employment and 12.2 percent of the state's aggregate earnings, its occupational mix is somewhat different from that of the state.

The share in the mid-paying category in 2022 was higher in Metro Tucson than in the state, with the differential focused in the educational instruction and library and community and social service occupational groups. In the high-paying category in 2022, the share was somewhat lower in Metro Tucson than in the state, with the differential mostly in the business and financial operations and computer and mathematical occupational groups. In contrast, the shares in Metro Tucson were higher than in the state in the architecture and engineering and the life, physical, and social science groups.

As seen in Table 23, the occupational shares in Metro Tucson in 2022 mostly ranked in the middle of the eight metropolitan areas serving as a comparison group in the high-paying category, based on both employment and aggregate earnings. In the mid-paying and low-paying categories, Metro Tucson's ranks ranged from high to low. In the high-paying category as a whole, Metro Tucson ranked sixth on employment and seventh on aggregate earnings. It ranked in the middle in each of the three STEM groups. In contrast, in the low-paying category, Metro Tucson ranked third based on employment and second based on aggregate earnings.

In Table 24, the employment shares in 2022 are shown for the nation and for each of the eight comparison areas. The shares of aggregate earnings are displayed in Table 25.

Table 26 depicts changes in employment and aggregate earnings shares in Metro Tucson over the 10-year time period between 2012 and 2022. These changes in Metro Tucson bear little resemblance to those in the state in most of the occupational groups. Relative to the state, Metro Tucson performed poorly in the high-paying category, particularly in the computer and mathematical; health practitioners and technical; and business and finance groups. This was offset by larger gains in the low-paying category.

TABLE 23
EMPLOYMENT AND AGGREGATE EARNINGS, MAJOR OCCUPATIONAL GROUPS, METROPOLITAN TUCSON, 2022

	Employment			Aggregate Earnings		
	Share of Total	Ratio to Nation	Rank*	Share of Total	Ratio to Nation	Rank*
High Paying	25.69%	1.00	6	41.75%	0.98	7
Legal	0.74	0.86	4	1.15	0.70	4
Management	7.21	1.01	3	12.42	0.93	4
Computer and Mathematical	3.10	0.97	5	5.25	0.91	5
Healthcare Practitioners and Technical	5.98	1.05	3	10.76	1.15	2
Architecture and Engineering	2.15	1.36	4	3.78	1.49	4
Life, Physical, and Social Science	1.18	1.29	3	1.45	1.15	4
Business and Financial Operations	5.34	0.83	7	6.93	0.78	7
Subtotal of Three STEM Groups	6.43	1.13	7	10.49	1.09	7
Mid Paying	21.25	1.08	4	20.19	1.07	4
Arts/Design/Entertainment/Sports/Media	1.52	0.82	7	1.46	0.78	7
Educational Instruction and Library	5.87	1.05	5	5.91	1.05	5
Installation, Maintenance, and Repair	4.42	1.13	2	4.13	1.11	2
Construction and Extraction	4.57	1.02	6	4.07	0.98	7
Community and Social Service	2.32	1.34	2	2.08	1.31	2
Protective Service	2.54	1.18	2	2.53	1.29	2
Low Paying	53.06	0.97	3	38.06	0.99	2
Sales and Related	7.93	0.90	8	5.97	0.86	8
Office and Administrative Support	12.78	1.08	4	9.86	1.08	5
Production	2.95	0.54	7	2.52	0.60	6
Transportation and Material Moving	7.49	0.86	3	5.87	0.89	3
Military-Only Occupations	1.05	1.74	3	0.72	1.79	3
Healthcare Support	4.99	1.11	3	3.24	1.17	2
Building/Grounds Cleaning/Maintenance	4.24	1.22	1	2.65	1.28	1
Farming, Fishing, and Forestry	0.23	0.33	6	0.14	0.34	6
Personal Care and Service	3.06	1.16	1	1.84	1.21	1
Food Preparation and Serving Related	8.35	1.09	3	5.25	1.24	1

* Among eight moderately large comparison metro areas

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

The changes in employment shares between 2012 and 2022 are shown for the nation and for each of the comparison areas in Table 27. The change in shares of aggregate earnings are displayed in Table 28.

A summary of the high-paying category and each of its occupational groups for Metropolitan Tucson, with comparisons to the nation and ranks among the eight comparison areas, follows:

- High-Paying Total. Metro Tucson's share was close to the U.S. average in 2022, but Metro Tucson ranked sixth on employment and seventh on aggregate earnings. Boulder and Salt Lake City had the highest aggregate earnings shares; only El Paso had a lower share than Metro Tucson. The 2012-to-2022 change in share in the Tucson area was

TABLE 24
EMPLOYMENT SHARE OF TOTAL, MAJOR OCCUPATIONAL GROUPS, METROPOLITAN TUCSON AND SELECTED SOUTHWESTERN METROPOLITAN AREAS, 2022

	US	Alb	Bou	CS	EP	FC	Pro	SLC	Tuc
High Paying	25.81%	26.26%	26.49%	28.63%	32.30%	31.97%	26.43%	29.91%	27.86%
Legal	0.86	0.74	0.91	0.94	1.00	0.98	0.69	0.96	0.73
Management	7.16	7.37	7.59	6.11	9.79	8.50	7.97	6.29	6.04
Computer and Mathematical	3.19	3.52	3.65	4.36	4.09	4.98	3.89	5.70	5.41
Healthcare Practitioners and Technical	5.70	5.65	4.93	5.10	6.66	5.85	4.47	5.36	4.92
Architecture and Engineering	1.58	1.59	1.74	2.33	1.78	1.90	1.81	1.68	2.02
Life, Physical, and Social Science	0.91	0.71	1.11	1.27	1.77	1.69	0.94	1.01	1.21
Business and Financial Operations	6.40	6.67	6.57	8.52	7.20	8.05	6.65	8.91	7.53
Subtotal of Three STEM Groups	5.68	5.83	6.49	7.96	7.64	8.58	6.65	8.38	8.64
Mid Paying	19.76	19.42	19.62	20.37	19.98	20.41	21.15	20.21	19.63
Arts/Design/Entertainment/Sports/Media	1.85	1.52	2.72	1.97	1.95	1.65	1.94	1.66	1.94
Educational Instruction and Library	5.60	4.73	5.50	5.39	6.63	6.13	6.08	5.84	5.04
Installation, Maintenance, and Repair	3.92	4.14	3.09	3.77	2.89	3.68	3.73	4.04	3.76
Construction and Extraction	4.50	5.06	4.24	5.32	4.05	4.41	6.20	4.40	5.25
Community and Social Service	1.73	1.57	1.89	1.93	2.39	1.97	1.73	1.81	1.79
Protective Service	2.16	2.40	2.17	2.00	2.08	2.57	1.46	2.47	1.85
Low Paying	54.43	54.32	53.89	50.99	47.72	47.63	52.43	49.88	52.51
Sales and Related	8.78	9.01	8.21	10.22	7.79	8.42	8.02	8.68	8.90
Office and Administrative Support	11.87	13.43	10.54	10.98	10.98	11.24	13.87	10.81	10.72
Production	5.48	3.80	4.31	3.45	3.89	2.46	5.99	4.07	4.38
Transportation and Material Moving	8.69	8.41	8.23	7.05	6.11	7.87	7.73	7.57	7.90
Military-only Occupations	0.60	0.54	0.52	0.96	0.24	0.88	0.49	1.45	0.92
Healthcare Support	4.50	4.25	6.28	3.37	5.10	3.39	3.06	3.60	5.01
Building/Grounds Cleaning/Maintenance	3.47	3.56	3.66	3.33	3.36	3.46	3.38	3.48	3.12
Farming, Fishing, and Forestry	0.70	0.54	1.63	0.57	0.32	0.28	0.29	0.33	1.49
Personal Care and Service	2.65	2.55	2.89	2.84	2.82	2.89	2.63	2.67	2.46
Food Preparation and Serving Related	7.69	8.22	7.62	8.23	7.11	6.73	6.97	7.24	7.61

Alb: Albuquerque, New Mexico; Bou: Boulder, Colorado; CS: Colorado Springs, Colorado; EP: El Paso, Texas;
FC: Fort Collins-Loveland, Colorado; Pro: Provo-Orem-Lehi, Utah; SLC: Salt Lake City-Murray, Utah; Tuc: Tucson, Arizona

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

TABLE 25
AGGREGATE EARNINGS SHARE OF TOTAL, MAJOR OCCUPATIONAL GROUPS, METROPOLITAN TUCSON AND SELECTED SOUTHWESTERN METROPOLITAN AREAS, 2022

	US	Alb	Bou	CS	EP	FC	Pro	SLC	Tuc
High Paying	42.79%	42.20%	45.12%	45.96%	50.87%	31.97%	41.34%	50.08%	44.54%
Legal	1.63	1.25	1.87	1.74	1.80	0.98	1.06	1.87	1.14
Management	13.34	12.76	14.44	12.00	18.61	8.50	13.78	12.82	11.01
Computer and Mathematical	5.80	6.08	7.15	7.70	6.59	4.98	6.58	10.82	10.30
Healthcare Practitioners and Technical	9.38	9.87	8.91	7.99	9.98	5.85	7.54	8.06	8.05
Architecture and Engineering	2.53	2.64	2.90	3.63	2.43	1.90	2.77	2.61	2.99
Life, Physical, and Social Science	1.26	0.93	1.57	1.66	2.51	1.69	1.19	1.41	1.50
Business and Financial Operations	8.85	8.66	8.28	11.23	8.96	8.05	8.41	12.50	9.56
Subtotal of Three STEM Groups	9.59	9.65	11.62	13.00	11.53	8.58	10.55	14.83	14.79
Mid Paying	18.95	17.90	19.75	18.31	18.56	20.41	20.37	17.70	18.89
Arts/Design/Entertainment/Sports/Media	1.87	1.42	2.99	1.83	1.84	1.65	1.75	1.60	1.86
Educational Instruction and Library	5.66	4.36	6.17	4.80	6.59	6.13	6.03	5.38	4.93
Installation, Maintenance, and Repair	3.71	3.85	2.79	3.48	2.50	3.68	3.65	3.62	3.45
Construction and Extraction	4.16	4.60	3.94	4.70	3.97	4.41	5.92	3.57	5.26
Community and Social Service	1.59	1.42	1.74	1.67	1.89	1.97	1.72	1.54	1.59
Protective Service	1.96	2.25	2.12	1.83	1.77	2.57	1.30	2.00	1.81
Low Paying	38.26	39.90	35.13	35.73	30.58	47.63	38.29	32.22	36.57
Sales and Related	6.91	7.35	6.26	8.56	5.79	8.42	6.47	6.34	7.30
Office and Administrative Support	9.13	10.46	7.89	8.16	7.93	11.24	10.53	7.57	7.92
Production	4.20	3.02	2.96	2.52	2.59	2.46	4.77	2.93	3.33
Transportation and Material Moving	6.62	6.57	5.63	5.42	3.89	7.87	6.39	5.44	6.03
Military-only Occupations	0.40	0.36	0.27	0.49	0.22	0.88	0.40	1.10	0.47
Healthcare Support	2.78	2.80	3.42	2.10	2.80	3.39	2.04	1.90	3.14
Building/Grounds Cleaning/Maintenance	2.07	2.20	2.13	1.99	1.95	3.46	2.10	1.84	1.82
Farming, Fishing, and Forestry	0.41	0.32	0.82	0.30	0.16	0.28	0.17	0.17	0.77
Personal Care and Service	1.52	1.58	1.63	1.67	1.55	2.89	1.49	1.38	1.48
Food Preparation and Serving Related	4.23	5.24	4.12	4.52	3.69	6.73	3.93	3.55	4.30

Alb: Albuquerque, New Mexico; Bou: Boulder, Colorado; CS: Colorado Springs, Colorado; EP: El Paso, Texas;
FC: Fort Collins-Loveland, Colorado; Pro: Provo-Orem-Lehi, Utah; SLC: Salt Lake City-Murray, Utah; Tuc: Tucson, Arizona

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

TABLE 26
EMPLOYMENT AND AGGREGATE EARNINGS, MAJOR OCCUPATIONAL GROUPS, METROPOLITAN TUCSON, 2012-TO-2022 CHANGE IN SHARE RELATIVE TO THE NATIONAL AVERAGE

	Employment		Aggregate Earnings	
	Share of Total	Rank*	Share of Total	Rank*
High Paying	-0.49	6	-1.25	7
Legal	-0.05	8	-0.03	6
Management	0.32	4	0.23	4
Computer and Mathematical	-0.11	4	-0.51	4
Healthcare Practitioners and Technical	-0.35	7	-0.60	7
Architecture and Engineering	0.16	4	-0.02	4
Life, Physical, and Social Science	0.00	4	0.10	3
Business and Financial Operations	-0.46	6	-0.41	6
Subtotal of Three STEM Groups	0.05	4	-0.44	6
Mid Paying	-0.15	4	-0.67	6
Arts/Design/Entertainment/Sports/Media	-0.35	8	-0.20	6
Educational Instruction and Library	-0.10	7	-0.17	5
Installation, Maintenance, and Repair	0.13	2	-0.12	4
Construction and Extraction	0.36	2	0.37	2
Community and Social Service	0.07	6	0.01	7
Protective Service	-0.26	7	-0.57	7
Low Paying	0.64	3	1.92	1
Sales and Related	-0.09	5	0.39	4
Office and Administrative Support	0.28	4	0.39	5
Production	0.46	1	0.48	1
Transportation and Material Moving	0.81	1	0.66	1
Military-Only Occupations	0.07	3	0.05	3
Healthcare Support	-0.74	8	-0.52	8
Building/Grounds Cleaning/Maintenance	-0.09	5	0.07	4
Farming, Fishing, and Forestry	0.10	3	0.03	2
Personal Care and Service	-0.16	6	-0.07	3
Food Preparation and Serving Related	-0.02	5	0.45	1

* Among eight moderately large comparison metro areas

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

considerably below the U.S. average, ranking sixth on employment and seventh on aggregate earnings. Provo and Salt Lake City had the greatest increases in aggregate earnings share; Albuquerque had a lower figure than Metro Tucson.

- Subtotal of Three STEM Groups. Metro Tucson's share was slightly higher than the U.S. average in 2022, but Metro Tucson ranked seventh on both employment and aggregate earnings. Boulder had the highest aggregate earnings share; El Paso had the lowest share. Metro Tucson's 2012-to-2022 change in share was near average on employment and ranked fourth, but was below the U.S. average on aggregate earnings, ranking sixth. Salt Lake City and Boulder had the greatest increases in aggregate earnings share; Colorado Springs and Fort Collins ranked below Metro Tucson.

TABLE 27
EMPLOYMENT SHARE OF TOTAL, MAJOR OCCUPATIONAL GROUPS, METROPOLITAN TUCSON AND SELECTED SOUTHWESTERN METROPOLITAN AREAS, 2012-TO-2022 CHANGE

	US	Alb	Bou	CS	EP	FC	Pro	SLC	Tuc
High Paying	3.90	1.74	5.83	3.41	4.02	4.41	5.92	6.66	3.41
Legal	0.02	0.07	0.09	0.10	0.03	0.02	0.04	0.02	-0.03
Management	1.63	0.46	1.37	0.36	2.29	0.77	3.31	2.98	1.95
Computer and Mathematical	0.52	0.38	1.31	0.29	0.14	-0.10	1.45	1.31	0.42
Healthcare Practitioners and Technical	0.33	0.10	0.04	0.94	0.44	1.21	-0.71	0.31	-0.01
Architecture and Engineering	-0.08	0.16	1.16	-0.10	0.15	-0.04	-0.36	-0.03	0.08
Life, Physical, and Social Science	0.02	-0.13	-0.09	0.01	0.10	0.34	-0.33	0.18	0.01
Business and Financial Operations	1.46	0.70	1.95	1.80	0.86	2.20	2.52	1.89	1.00
Subtotal of Three STEM Groups	0.46	0.42	2.37	0.20	0.40	0.21	0.75	1.46	0.51
Mid Paying	-0.47	-0.03	-1.04	-0.48	-0.96	-0.72	-3.47	-0.22	-0.62
Arts/Design/Entertainment/Sports/Media	0.05	-0.03	0.00	-0.11	-0.05	-0.08	-0.05	-0.05	-0.30
Educational Instruction and Library	-0.56	-0.42	-0.61	-0.62	-0.66	-0.39	-2.25	-0.47	-0.66
Installation, Maintenance, and Repair	0.03	0.30	-0.16	-0.03	-0.01	0.06	-0.12	-0.35	0.16
Construction and Extraction	0.10	0.41	-0.52	0.02	-0.05	-0.65	-0.58	0.80	0.46
Community and Social Service	0.03	-0.01	0.35	0.54	0.23	0.46	-0.36	0.17	0.10
Protective Service	-0.12	-0.29	-0.10	-0.28	-0.41	-0.13	-0.11	-0.31	-0.38
Low Paying	-3.43	-1.71	-4.79	-2.94	-3.06	-3.69	-2.45	-6.44	-2.79
Sales and Related	-1.38	-1.60	-0.45	-1.41	-1.37	-0.90	-2.46	-2.51	-1.47
Office and Administrative Support	-1.96	-0.96	-1.86	-1.99	-2.15	-1.44	-0.62	-3.15	-1.68
Production	-0.52	-0.06	-0.55	-0.39	-0.63	-0.79	-0.15	-0.48	-0.05
Transportation and Material Moving	1.12	0.99	-0.56	1.68	1.37	0.65	1.52	0.87	1.93
Military-only Occupations	-0.14	-0.13	-0.04	-1.04	-0.75	-0.03	-0.18	-0.13	-0.07
Healthcare Support	0.63	0.96	0.10	1.25	0.78	0.38	0.65	0.31	-0.10
Building/Grounds Cleaning/Maintenance	-0.49	-0.36	-0.80	-0.62	-0.30	-0.70	-0.24	-0.45	-0.57
Farming, Fishing, and Forestry	-0.06	0.13	0.07	0.00	-0.03	-0.02	-0.15	0.01	0.04
Personal Care and Service	-0.44	-0.69	-0.51	-0.16	-0.24	-0.48	-0.84	-0.58	-0.60
Food Preparation and Serving Related	-0.20	0.00	-0.20	-0.26	0.26	-0.35	0.04	-0.32	-0.21

Alb: Albuquerque, New Mexico; Bou: Boulder, Colorado; CS: Colorado Springs, Colorado; EP: El Paso, Texas;
FC: Fort Collins-Loveland, Colorado; Pro: Provo-Orem-Lehi, Utah; SLC: Salt Lake City-Murray, Utah; Tuc: Tucson, Arizona

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

TABLE 28
AGGREGATE EARNINGS SHARE OF TOTAL, MAJOR OCCUPATIONAL GROUPS, METROPOLITAN TUCSON AND SELECTED SOUTHWESTERN METROPOLITAN AREAS, 2012-TO-2022 CHANGE

	US	Alb	Bou	CS	EP	FC	Pro	SLC	Tuc
High Paying	3.61	1.87	4.32	2.97	3.25	3.42	6.80	6.15	2.36
Legal	-0.12	-0.17	-0.03	0.06	-0.14	-0.01	-0.02	-0.44	-0.15
Management	1.86	0.20	1.46	0.29	2.24	1.50	4.84	3.28	2.09
Computer and Mathematical	1.02	0.50	1.55	0.19	0.30	-0.75	2.50	2.27	0.51
Healthcare Practitioners and Technical	0.03	0.38	-0.21	1.51	0.18	1.37	-1.21	0.18	-0.56
Architecture and Engineering	-0.48	0.68	1.07	-0.65	-0.02	-1.00	-0.89	-0.54	-0.51
Life, Physical, and Social Science	-0.10	-0.40	-1.08	-0.11	0.07	-0.02	-0.52	0.13	0.00
Business and Financial Operations	1.40	0.68	1.56	1.69	0.62	2.33	2.11	1.27	0.99
Subtotal of Three STEM Groups	0.44	0.78	1.54	-0.58	0.35	-1.77	1.08	1.87	0.00
Mid Paying	-1.82	-0.70	-2.15	-2.50	-1.54	-1.87	-5.19	-1.41	-2.49
Arts/Design/Entertainment/Sports/Media	0.00	-0.17	-0.03	-0.25	-0.13	-0.01	0.02	-0.26	-0.20
Educational Instruction and Library	-1.33	-0.31	-1.61	-1.70	-1.04	-1.07	-3.17	-0.99	-1.50
Installation, Maintenance, and Repair	-0.16	-0.09	-0.27	-0.33	0.26	-0.29	-0.52	-0.67	-0.28
Construction and Extraction	-0.01	0.18	-0.35	-0.01	0.23	-0.65	-0.95	0.65	0.36
Community and Social Service	-0.09	0.02	0.29	0.24	0.07	0.27	-0.36	0.16	-0.08
Protective Service	-0.24	-0.32	-0.18	-0.45	-0.93	-0.12	-0.21	-0.31	-0.81
Low Paying	-1.78	-1.16	-2.18	-0.47	-1.70	-1.55	-1.61	-4.74	0.13
Sales and Related	-1.06	-1.17	-0.01	-0.38	-0.96	-0.13	-2.37	-2.44	-0.67
Office and Administrative Support	-2.01	-1.15	-1.69	-1.68	-1.62	-1.59	-0.46	-2.77	-1.62
Production	-0.46	-0.14	-0.60	-0.37	-0.24	-0.82	-0.19	-0.57	0.01
Transportation and Material Moving	1.19	0.93	-0.12	1.49	1.74	0.70	1.16	0.97	1.85
Military-only Occupations	-0.13	-0.27	-0.03	-0.90	-0.64	-0.04	-0.23	-0.15	-0.08
Healthcare Support	0.47	0.50	0.04	0.91	0.25	0.31	0.54	0.29	-0.06
Building/Grounds Cleaning/Maintenance	-0.10	-0.01	-0.27	-0.15	-0.10	-0.28	0.06	0.00	-0.03
Farming, Fishing, and Forestry	0.00	0.08	0.03	0.00	-0.01	-0.01	-0.09	0.01	0.03
Personal Care and Service	-0.11	-0.39	-0.21	0.05	-0.15	-0.20	-0.44	-0.30	-0.19
Food Preparation and Serving Related	0.44	0.45	0.69	0.56	0.02	0.52	0.41	0.22	0.89

Alb: Albuquerque, New Mexico; Bou: Boulder, Colorado; CS: Colorado Springs, Colorado; EP: El Paso, Texas;
FC: Fort Collins-Loveland, Colorado; Pro: Provo-Orem-Lehi, Utah; SLC: Salt Lake City-Murray, Utah; Tuc: Tucson, Arizona

Note: The occupational groups are listed in order of 2022 median earnings per worker in the nation.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

- Computer and Mathematical. Metro Tucson's share was less than the U.S. average in 2022, ranking fifth on both measures. Boulder had the highest aggregate earnings share. The Tucson area's 2012-to-2022 change in share was less than the U.S. average, but ranked fourth on each measure. Provo and Salt Lake City had the greatest increases in aggregate earnings share.
- Architecture and Engineering. Metro Tucson's share was considerably higher than the U.S. average in 2022, but ranked fourth on each measure. Boulder and Albuquerque had the highest aggregate earnings shares. The Tucson area's 2012-to-2022 change in share was similar to the U.S. average, ranking fourth on each measure. Boulder and Albuquerque had the greatest increases in aggregate earnings share.
- Life, Physical, and Social Science. Metro Tucson's employment and aggregate earnings shares were greater than the U.S. average in 2022, ranking third on employment and fourth on aggregate earnings. Boulder and Fort Collins had the highest aggregate earnings shares. Metro Tucson's 2012-to-2022 change in share was not much different from the U.S. average, ranking fourth on employment and third on aggregate earnings. None of the metro areas had much of an increase in aggregate earnings share.
- Healthcare Practitioners and Technical. Metro Tucson's share in 2022 was greater than the U.S. average, ranking third on employment and fourth on aggregate earnings. Only Albuquerque had a higher aggregate earnings share. Metro Tucson's 2012-to-2022 change in share was weak, considerably less than the U.S. average and ranking seventh on both measures. Only Provo ranked below Tucson on the change in the aggregate earnings share.
- Management. Metro Tucson's employment share was similar to the U.S. average in 2022, but its aggregate earnings share was below average. Metro Tucson ranked third on employment and fourth on aggregate earnings. Provo and Salt Lake City had the highest aggregate earnings shares. The Tucson area's 2012-to-2022 change in employment share was greater than the U.S. average, ranking fourth on both measures. Provo and Salt Lake City had the greatest increases in aggregate earnings share.
- Business and Financial Operations. Metro Tucson's share was considerably higher than the U.S. average in 2022, but ranked seventh on both employment and aggregate earnings. Boulder had the highest aggregate earnings share; El Paso had a share lower than Metro Tucson. The 2012-to-2022 change in share in the Tucson area was less than the U.S. average, ranking sixth on both measures. Albuquerque and El Paso performed more poorly than Tucson.
- Legal. Metro Tucson's shares were less than the U.S. average in 2022, but ranked fourth on both employment and aggregate earnings. Albuquerque had the highest aggregate earnings share. The Tucson area's 2012-to-2022 change in share was a bit less than the U.S. average, ranking eighth on employment and sixth on aggregate earnings. Albuquerque and Salt Lake City ranked below Metro Tucson on the change in aggregate earnings.

Industrial Comparison

To analyze the industrial structure of the regions, industrial clusters were used. Employment and earnings data for the 53 traded clusters and the 17 nontraded clusters were calculated from Lightcast data for 2001 through 2022, though this analysis is limited to the traded clusters. In addition to 2022, the analysis focuses on the change between 2012 and 2022.

Twelve traded clusters — six at least partially manufacturing and six wholly services — have been selected for particular analysis. Of the six at least partially manufacturing clusters, four entirely consist of manufacturing industries: aerospace vehicles and defense, automotive, biopharmaceutical, and medical devices. Twenty of the 21 information technology and analytical instruments industries are manufacturing.

The 12 highlighted traded clusters are high-tech and/or large clusters that have received attention in Arizona. Average earnings per worker in each was greater than the figure for the sum of the other 41 traded clusters. A few sizable traded clusters were not selected because the nature of their traded activities is specialized and/or their earnings per worker is quite low: federal government, hospitality and tourism, and transportation and logistics. Among the traded clusters not selected are a few that pay quite well, but whose employment share is quite small: electric power generation and transmission, metal mining, oil and gas production and transportation, and upstream chemical products. While the metal mining share in Arizona is much above the national average, it is still quite small at 0.33 percent of employment.

Of the 12 selected traded clusters, each industry in three — aerospace vehicles and defense, biopharmaceuticals, and information technology and analytical instruments — is defined as STEM. Most of the industries in the communications equipment and services cluster are STEM, and some industries in the business services and education and knowledge creation clusters are STEM.

United States

The 53 traded clusters are widely divergent is size, as measured by employment and aggregate earnings, and in average earnings per worker, as seen in Table 29. Most of the traded clusters accounted for less than 1 percent of the nation's aggregate earnings. The sum of the traded clusters accounted for less than one-third of total employment and less than 45 percent of total aggregate earnings in 2022 nationally.

Average earnings per worker was 68 percent higher in the sum of the traded clusters than in the sum of the nontraded clusters nationally in 2022. Earnings per worker in the sum of the 12 selected traded clusters was 53 percent higher than in the aggregate of the other 41 clusters.

The 2012-to-2022 changes in share and in average earnings per worker nationally are displayed in Table 30. The sum of the traded clusters share increased slightly based on employment, but slipped based on aggregate earnings. The sum of the 12 selected traded clusters experienced a substantial increase in share, but the gain occurred primarily in the business services cluster. In contrast, the share fell substantially in the aggregate of the other 41 traded clusters.

The inflation-adjusted increase over the 10 years in average earnings per worker was greater for the sum of the nontraded clusters (11.8 percent) than for the aggregate of the traded clusters (8.6 percent). The increase in the sum of the 12 selected clusters was 9.2 percent, but the change varied widely across the 12 clusters, from 33 percent to -7 percent.

TABLE 29
EARNINGS PER WORKER AND SHARES, TRADED CLUSTERS, UNITED STATES, 2022

	Share of Total Employment	Share of Total Aggregate Earnings	Average Earnings per Worker
Total Traded	32.56%	44.79%	$111,178
Total of 12 Selected Traded Clusters	18.34	29.72	130,961
At Least Partially Manufacturing Clusters	2.61	4.96	153,683
Information Technology/Analytical Instruments	0.92	2.21	195,254
Aerospace Vehicles and Defense	0.38	0.66	142,589
Communications Equipment and Services	0.32	0.71	180,134
Biopharmaceuticals	0.21	0.42	165,679
Medical Devices	0.17	0.26	120,525
Automotive	0.62	0.69	90,141
Wholly Services Clusters	15.73	24.76	127,193
Business Services	6.60	11.01	134,843
Marketing, Design, and Publishing	1.04	1.59	123,726
Education and Knowledge Creation	2.05	2.52	99,325
Distribution and Electronic Commerce	3.81	4.68	99,184
Financial Services	1.33	3.60	218,928
Insurance Services	0.91	1.37	121,689
Other 41 Traded Clusters	14.22	15.07	85,660
Agricultural Inputs and Services	0.32	0.20	50,724
Apparel	0.08	0.06	60,340
Coal Mining	0.03	0.04	121,558
Construction Products and Services	0.58	0.73	101,902
Downstream Chemical Products	0.17	0.22	107,106
Downstream Metal Products	0.29	0.29	81,703
Electric Power Generation and Transmission	0.10	0.24	192,126
Environmental Services	0.08	0.09	86,108
Fishing and Fishing Products	0.04	0.03	68,358
Food Processing and Manufacturing	0.76	0.71	76,078
Footwear	0.01	0.01	66,251
Forestry	0.06	0.05	68,432
Furniture	0.23	0.18	63,511
Hospitality and Tourism	1.83	1.31	57,832
Jewelry and Precious Metals	0.02	0.01	71,823
Leather and Related Products	0.02	0.02	59,068
Lighting and Electrical Equipment	0.17	0.23	107,769
Livestock Processing	0.33	0.26	64,543
Metal Mining	0.03	0.05	132,165
Metalworking Technology	0.27	0.27	81,540
Music and Sound Recording	0.02	0.03	97,614
Nonmetal Mining	0.06	0.07	95,476
Oil and Gas Production and Transportation	0.32	0.66	163,105
Paper and Packaging	0.22	0.25	92,276
Performing Arts	0.40	0.31	64,130
Plastics	0.41	0.42	82,541
Printing Services	0.24	0.20	67,561
Production Technology and Heavy Machinery	0.59	0.70	95,390

(continued)

TABLE 29 (continued)
EARNINGS PER WORKER AND SHARES, TRADED CLUSTERS, UNITED STATES, 2022

	Share of Total Employment	Share of Total Aggregate Earnings	Average Earnings per Worker
Recreational and Small Electric Goods	0.13%	0.13%	$85,399
Textile Manufacturing	0.11	0.10	71,292
Tobacco	0.01	0.01	110,733
Trailers, Motor Homes, and Appliances	0.11	0.11	82,523
Transportation and Logistics	1.34	1.56	94,107
Upstream Chemical Products	0.10	0.19	148,239
Upstream Metal Manufacturing	0.23	0.28	98,791
Video Production and Distribution	0.22	0.32	118,479
Vulcanized and Fired Materials	0.15	0.15	78,464
Water Transportation	0.19	0.25	105,766
Wood Products	0.25	0.22	69,852
Farming and Ranching	0.80	0.51	52,017
Federal Government	2.92	3.60	99,855
Total Nontraded	67.44	55.21	66,150

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

States: Average Earnings Per Worker

Overall industrial average earnings per worker adjusted for the cost of living was 8.0 percent less in Arizona than the national figure in 2022 and the lowest of the eight comparison states. Arizona's shortfall was 13.1 percent for the sum of the traded clusters and a substantial 20.1 percent for the sum of the 12 selected traded clusters. Adjusted earnings per worker in Arizona was less than the national figure in 11 of the 12 selected traded clusters, with a shortfall of more than 25 percent in six (see Chart 14). Arizona ranked last in five of the 12 clusters and second lowest in two others. It ranked higher than fifth only in the automotive cluster. The very low earnings per worker figures suggest that the industrial mix within these clusters is very different from the national average.

As seen in Table 31, Arizona also compared unfavorably on the change in cost-of-living-adjusted earnings per worker between 2012 and 2022. Arizona lost ground to the nation overall, in the sum of the traded clusters, and in the aggregate of the 12 selected clusters. Average earnings per worker in Arizona relative to the national average decreased over the 10 years in seven of the 12 clusters. In contrast, the 10-year change exceeded the U.S. average in the aggregate of the other 41 traded clusters.

States: Industrial Mix

The sum of the 53 traded clusters as a share in Arizona relative to the national average is shown in Chart 15 for the 2001-through-2022 period based on both employment and aggregate earnings. Arizona's traded cluster employment share improved relative to the U.S. average between 2006 and 2011, but then dropped back slightly. The traded cluster aggregate earnings share rose less relative to the nation from 2006 to 2011, then dropped back to a level lower than in 2001.

TABLE 30
EARNINGS PER WORKER AND SHARES, TRADED CLUSTERS, UNITED STATES, 2012-TO-2022 CHANGE

	Share of Total Employment	Share of Total Aggregate Earnings	Average Earnings per Worker*
Total Traded	0.41	-0.27	8.6%
Total of 12 Selected Traded Clusters	1.54	2.13	9.2
At Least Partially Manufacturing Clusters	0.11	0.27	12.0
Information Technology/Analytical Instruments	0.15	0.51	21.0
Aerospace Vehicles and Defense	-0.05	-0.17	-1.6
Communications Equipment and Services	-0.04	0.04	33.1
Biopharmaceuticals	0.03	-0.02	-6.7
Medical Devices	0.00	-0.03	1.2
Automotive	0.03	-0.06	-4.0
Wholly Services Clusters	1.43	1.86	8.8
Business Services	1.11	1.79	9.9
Marketing, Design, and Publishing	0.07	0.24	22.0
Education and Knowledge Creation	-0.04	0.19	21.8
Distribution and Electronic Commerce	0.43	-0.06	-3.1
Financial Services	-0.09	-0.11	14.3
Insurance Services	-0.06	-0.19	3.1
Other 41 Traded Clusters	-1.13	-2.40	3.0
Agricultural Inputs and Services	-0.02	0.01	24.3
Apparel	-0.04	-0.03	12.7
Coal Mining	-0.04	-0.06	0.9
Construction Products and Services	0.02	-0.01	4.9
Downstream Chemical Products	-0.01	-0.04	-0.9
Downstream Metal Products	0.01	-0.01	3.1
Electric Power Generation and Transmission	-0.02	-0.06	8.8
Environmental Services	0.01	0.00	-2.4
Fishing and Fishing Products	-0.01	-0.01	6.6
Food Processing and Manufacturing	0.10	-0.02	-5.9
Footwear	0.00	0.00	10.0
Forestry	-0.01	-0.01	17.0
Furniture	-0.01	-0.01	9.1
Hospitality and Tourism	-0.19	-0.03	19.4
Jewelry and Precious Metals	0.00	-0.01	-2.3
Leather and Related Products	0.00	0.00	10.9
Lighting and Electrical Equipment	-0.02	-0.06	-0.5
Livestock Processing	-0.01	0.02	24.9
Metal Mining	0.00	-0.01	1.9
Metalworking Technology	-0.05	-0.08	0.8
Music and Sound Recording	0.00	0.00	3.1
Nonmetal Mining	0.00	0.00	11.5
Oil and Gas Production and Transportation	-0.21	-0.54	-0.3
Paper and Packaging	-0.04	-0.08	-1.9
Performing Arts	0.02	0.01	6.5
Plastics	0.02	-0.01	3.6
Printing Services	-0.09	-0.11	-1.2
Production Technology and Heavy Machinery	-0.06	-0.17	-2.3

(continued)

TABLE 30 (continued)
EARNINGS PER WORKER AND SHARES, TRADED CLUSTERS, UNITED STATES, 2012-TO-2022 CHANGE

	Share of Total Employment	Share of Total Aggregate Earnings	Average Earnings per Worker*
Recreational and Small Electric Goods	0.00	-0.01	4.3%
Textile Manufacturing	-0.04	-0.04	8.1
Tobacco	0.00	-0.01	-22.3
Trailers, Motor Homes, and Appliances	0.02	0.02	4.2
Transportation and Logistics	0.04	0.05	11.0
Upstream Chemical Products	-0.01	-0.03	1.1
Upstream Metal Manufacturing	-0.04	-0.08	2.6
Video Production and Distribution	0.02	-0.01	-3.0
Vulcanized and Fired Materials	-0.02	-0.03	1.8
Water Transportation	-0.01	-0.03	2.2
Wood Products	0.02	0.03	19.4
Farming and Ranching	-0.08	-0.08	5.7
Federal Government	-0.39	-0.88	0.7
Total Nontraded	-0.41	0.27	11.8

* The inflation-adjusted percent change.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/ (employment and earnings) and U.S. Department of Commerce, Bureau of Economic Analysis (gross domestic product implicit price deflator). Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

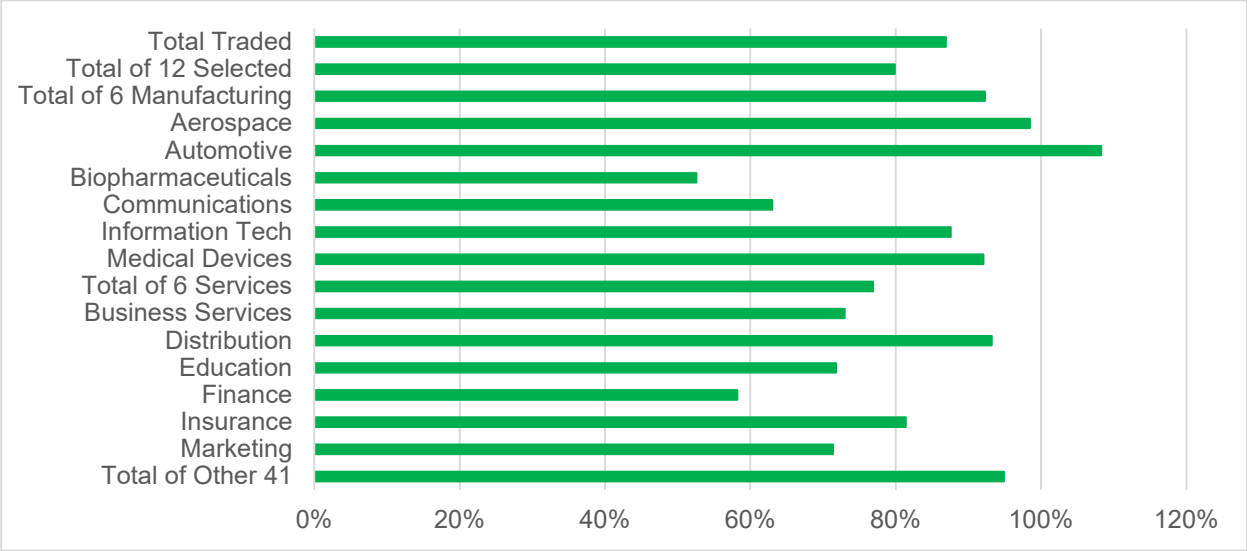
Arizona ranked last among the eight comparison states in its traded cluster share in every year from 2001 through 2022, based on both employment and aggregate earnings.

The sum of the 53 traded clusters in 2022 in Arizona accounted for 30.79 percent of total employment, lower than the national average of 32.56 percent. The change in share in Arizona between 2012 and 2022 of 0.03 percentage points was less than the U.S. average of 0.41. Among the comparison states, Arizona ranked last in 2022 and sixth on the 2012-to-2022 change.

The sum of the traded clusters in Arizona accounted for 40.01 percent of aggregate earnings in 2022, less than the national average of 44.79 percent. The share in Arizona fell 0.67 percentage points between 2012 and 2022, compared to a decrease of 0.27 percentage points nationally. Among the comparison states, Arizona ranked last in 2022 and next to last on the 2012-to-2022 change.

Arizona compared more unfavorably to the national average in 2022 in the sum of the traded clusters based on aggregate earnings (a share 10.7 percent less than the U.S. average) than on employment (a share 5.4 percent less than the U.S. average). This is a result of average earnings per worker being below average in Arizona. Even after adjusting for the cost of living, average earnings per worker in Arizona in 2022 in the sum of the traded clusters was 13.1 percent below the U.S. average. In contrast, the shortfall in the sum of the nontraded clusters was only 2.6 percent.

CHART 14
AVERAGE EARNINGS PER WORKER ADJUSTED FOR THE COST OF LIVING, SELECTED TRADED CLUSTERS, ARIZONA AS A PERCENTAGE OF THE NATIONAL AVERAGE, 2022



Source: Calculated from data from Lightcast, https://www.economicmodeling.com/ (employment and earnings) and U.S. Department of Commerce, Bureau of Economic Analysis (regional price parities). Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

Among the 53 traded clusters, Arizona's shares in 2022 in metal mining and in aerospace vehicles and defense were considerably above the national average based on both employment and aggregate earnings, with the state ranking first in the comparison group in metal mining and second in aerospace vehicles and defense (see Appendix Table E1). Arizona also ranked first in terms of employment in distribution and electronic commerce and in financial services. Arizona compared poorly in traded clusters such as production technology and heavy machinery, video production and distribution, footwear, apparel, and livestock processing, ranking last or next to last in both employment and aggregate earnings.

Table 32 summarizes traded clusters in Arizona in 2022. In most of the 12 selected clusters, the ratio to the national average was lower based on aggregate earnings than on employment, in several cases by a sizable amount. The large differential suggests that employment in these clusters in Arizona is disproportionately in industries with lower earnings per worker.

In 2022, Arizona's aggregate earnings share was last in the comparison group for the sum of the traded clusters and for the sum of the 12 selected traded clusters. Arizona ranked seventh in the sum of the other 41 traded clusters. It ranked fifth for the sum of the six at least partially manufacturing traded clusters, but was last for the sum of the six selected services traded clusters.

In Table 33, the employment shares in 2022 are shown for the nation and for each of the comparison states. The shares of aggregate earnings are displayed in Table 34.

TABLE 31
AVERAGE EARNINGS PER WORKER ADJUSTED FOR THE COST OF LIVING, SELECTED TRADED CLUSTERS, ARIZONA

	2022		2012-to-2022 Change	
	Percentage of Nation	Rank*	Percentage of Nation	Rank*
Total Traded	86.9%	8	-1.0	6
Total of 12 Selected Traded Clusters	79.9	8	-2.0	6
At Least Partially Manufacturing Clusters	92.3	6	-10.8	7
Information Tech/Analytical Instruments	87.6	5	-9.0	6
Aerospace Vehicles and Defense	98.5	6	-6.2	7
Communications Equipment & Services	63.0	7	-10.7	3
Biopharmaceuticals	52.6	8	1.1	5
Medical Devices	92.1	6	-1.2	8
Automotive	108.3	2	14.6	4
Wholly Services Clusters	76.9	8	0.2	6
Business Services	73.0	8	1.6	5
Marketing, Design, and Publishing	71.4	8	0.0	5
Education and Knowledge Creation	71.8	7	9.0	2
Distribution and Electronic Commerce	93.2	6	-14.1	8
Financial Services	58.2	8	0.3	8
Insurance Services	81.4	8	-2.6	6
Other 41 Traded Clusters	94.9	5	2.7	4

* Among eight comparison states

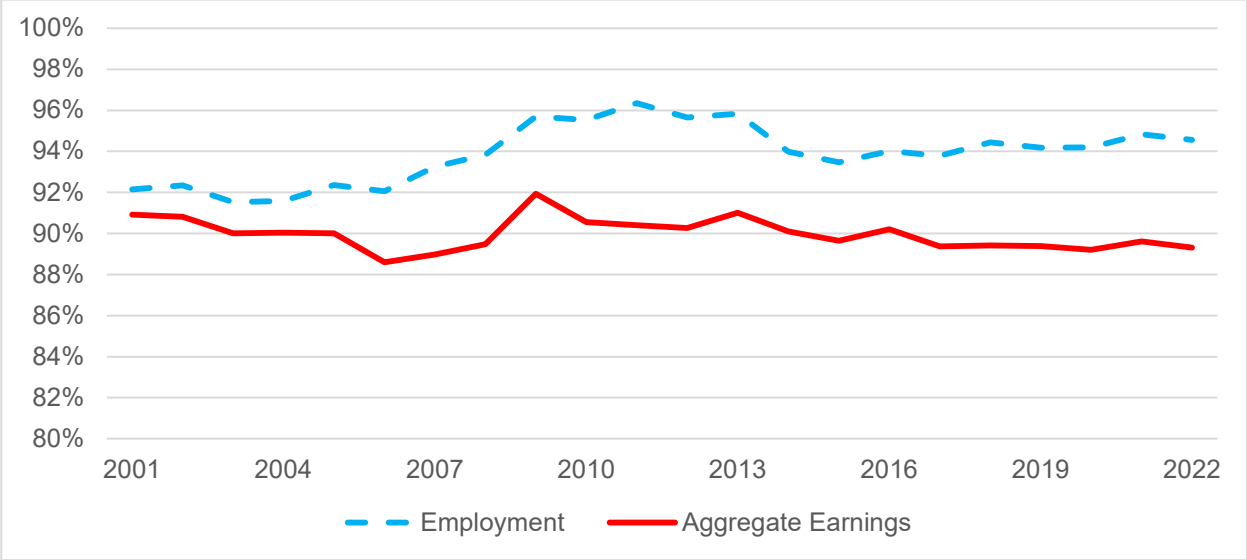
Source: Calculated from data from Lightcast, https://www.economicmodeling.com/ (employment and earnings) and the U.S. Department of Commerce, Bureau of Economic Analysis (regional price parities). Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

Focusing on the 10-year time period between 2012 and 2022, Table 35 depicts changes in employment and aggregate earnings shares in Arizona relative to the nation. Between 2012 and 2022, Arizona's change in share was less than the U.S. average in the sum of the 53 traded clusters and in the sum of the 12 selected clusters, based on both employment and aggregate earnings. The change in the aggregate earnings share exceeded the national average in the total of the other 41 traded clusters. Among the 12 selected clusters, Arizona outperformed the nation in six, though generally by small margins. In contrast, the state's performance was much inferior to the national average in the information technology and analytical instruments; aerospace vehicles and defense; business services; and education and knowledge creation clusters.

The changes in employment shares between 2012 and 2022 are shown for the nation and for each of the comparison states in Table 36. The change in shares of aggregate earnings are displayed in Table 37.

Chart 16 presents the time series of the share of aggregate earnings in each of the categories listed in Tables 32 through 37.A summary of each of the categories shown in Tables 32 through 37, with comparisons to the nation and ranks among the eight comparison states, follows. The earnings per worker figures are adjusted for the cost of living.

CHART 15
TOTAL TRADED CLUSTER SHARE,
ARIZONA AS A PERCENTAGE OF THE NATIONAL AVERAGE



Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

- Total of All Traded Clusters**.** Average earnings per worker in the sum of the traded clusters was 13 percent less in Arizona than the national average in 2022, lowest among the comparison states. As a result, the traded clusters' share of the total was further below the U.S. average based on aggregate earnings (11 percent) than on employment (5 percent). Arizona ranked last on each measure, with none of the other seven states below the national average on aggregate earnings. Virginia and Washington had the highest aggregate earnings share. The aggregate earnings share in Arizona dropped relative to the U.S. average between 2012 and 2022, ranking sixth on employment and seventh on aggregate earnings, ahead of only Virginia. Washington and Massachusetts had the greatest increases in aggregate earnings share. Earnings per worker in Arizona slipped relative to the nation between 2012 and 2022, ranking sixth.
- Total of 12 Selected Traded Clusters**.** In 2022, the employment share in Arizona of the sum of the 12 selected traded clusters was 10 percent above the U.S. average and ranked fifth. However, the aggregate earnings share was 5 percent below average and ranked last, with Massachusetts and Washington leading the eight states. Average earnings per worker in the sum of the 12 selected traded clusters was 20 percent less in Arizona than the national average in 2022, ranking last. Between 2012 and 2022, the employment share and especially the aggregate earnings share relative to the national average dropped, with Arizona ranking last on each measure. Washington and California had the greatest increases in the aggregate earnings share. Earnings per worker in Arizona relative to the nation slid between 2012 and 2022, ranking sixth.

TABLE 32
EMPLOYMENT AND AGGREGATE EARNINGS, SELECTED TRADED CLUSTERS, ARIZONA, 2022

	Employment			Aggregate Earnings		
	Share of Total	Ratio to Nation	Rank*	Share of Total	Ratio to Nation	Rank*
Total Traded	30.79%	0.95	8	40.01%	0.89	8
Total of 12 Selected Traded Clusters	20.16	1.10	5	28.38	0.95	8
At Least Partially Manufacturing Clusters	3.12	1.20	5	5.95	1.20	5
Information Tech/Analytical Instruments	1.21	1.33	5	2.80	1.26	5
Aerospace Vehicles and Defense	0.99	2.62	2	1.86	2.81	2
Communications Equipment and Services	0.30	0.94	5	0.46	0.64	7
Biopharmaceuticals	0.14	0.66	6	0.16	0.38	6
Medical Devices	0.23	1.34	4	0.35	1.34	4
Automotive	0.25	0.40	4	0.32	0.47	3
Wholly Services Clusters	17.04	1.08	5	22.43	0.91	8
Business Services	7.70	1.17	5	10.20	0.93	8
Marketing, Design, and Publishing	0.83	0.81	6	0.99	0.63	6
Education and Knowledge Creation	1.50	0.73	8	1.44	0.57	8
Distribution and Electronic Commerce	3.91	1.03	1	4.87	1.04	1
Financial Services	2.14	1.61	1	3.67	1.02	3
Insurance Services	0.95	1.05	2	1.27	0.93	2
Other 41 Traded Clusters	10.63	0.75	7	11.62	0.77	7

* Among eight comparison states

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

- Total of Six at Least Partially Manufacturing Clusters. Arizona performs moderately well in the sum of the six selected manufacturing clusters, ranking fifth in 2022 with a share 20 percent greater than the U.S. average on both employment and aggregate earnings. Washington and California had the highest aggregate earnings shares. Earnings per worker in Arizona in 2022 was 8 percent less than the U.S. average, ranking sixth. Between 2012 and 2022, Arizona's employment share and especially the aggregate earnings share dropped relative to the national average, with Arizona ranking fifth on employment and last on aggregate earnings. California had the largest change in aggregate earnings share. Earnings per worker in Arizona relative to the nation dropped 11 percentage points between 2012 and 2022, ranking seventh.
- Information Technology and Analytical Instruments. This is a very high-paying, high-technology cluster. It consists of eight subclusters: electronic components; computers and peripherals; semiconductors; software publishers; software reproducing; process and laboratory instruments; medical apparatus; and audio and video equipment. Average earnings per worker in 2022 in Arizona was 12 percent less than the U.S. average but ranked fifth. In Arizona in 2022, the cluster's share was above the U.S. average by 33 percent on employment and 26 percent on aggregate earnings; the rank on each measure was fifth. Washington and California had the highest aggregate earnings shares.

TABLE 33
EMPLOYMENT SHARE OF TOTAL, SELECTED TRADED CLUSTERS, UNITED STATES AND SELECTED STATES, 2022

	US	AZ	CA	CO	MA	MD	UT	VA	WA
Total Traded	32.56	30.79	32.88	33.05	33.77	33.42	34.87	36.37	35.22
Total of 12 Selected Traded Clusters	18.34	20.16	19.84	19.85	25.10	19.66	20.68	20.34	20.89
Total of at Least Partially Manufacturing Clusters	2.61	3.12	3.75	2.39	3.46	1.67	3.82	1.18	5.29
Information Technology and Analytical Instruments	0.92	1.21	1.89	1.16	2.24	0.42	1.62	0.36	2.54
Aerospace Vehicles and Defense	0.38	0.99	0.52	0.43	0.36	0.51	0.64	0.10	1.83
Communications Equipment and Services	0.32	0.30	0.58	0.39	0.29	0.27	0.18	0.31	0.60
Biopharmaceuticals	0.21	0.14	0.24	0.17	0.26	0.36	0.45	0.06	0.10
Medical Devices	0.17	0.23	0.25	0.17	0.27	0.07	0.64	0.06	0.06
Automotive	0.62	0.25	0.28	0.06	0.04	0.04	0.28	0.28	0.16
Total of Wholly Services Clusters	15.73	17.04	16.09	17.47	21.64	17.99	16.87	19.16	15.60
Business Services	6.60	7.70	6.85	8.72	7.61	8.59	6.98	11.37	8.05
Marketing, Design, and Publishing	1.04	0.83	1.43	1.14	1.24	0.81	1.15	0.77	1.14
Education and Knowledge Creation	2.05	1.50	2.28	1.61	6.89	3.27	3.04	2.15	1.60
Distribution and Electronic Commerce	3.81	3.91	3.84	3.45	2.80	3.44	3.09	2.70	3.39
Financial Services	1.33	2.14	1.12	1.64	1.84	1.24	2.03	1.41	0.87
Insurance Services	0.91	0.95	0.57	0.91	1.26	0.64	0.58	0.75	0.55
Total of Other 41 Traded Clusters	14.22	10.63	13.04	13.20	8.68	13.76	14.18	16.03	14.32

Note: Figures are percentages.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

TABLE 34
AGGREGATE EARNINGS SHARE OF TOTAL, SELECTED TRADED CLUSTERS, UNITED STATES AND SELECTED STATES, 2022

	US	AZ	CA	CO	MA	MD	UT	VA	WA
Total Traded	44.79	40.01	47.11	46.59	49.48	46.65	45.56	51.23	50.77
Total of 12 Selected Traded Clusters	29.72	28.38	34.85	32.91	41.48	28.54	30.52	32.56	38.25
Total of at Least Partially Manufacturing Clusters	4.96	5.95	9.15	4.61	6.41	3.19	6.60	1.88	13.33
Information Technology and Analytical Instruments	2.21	2.80	5.43	2.53	4.35	0.76	3.39	0.68	7.80
Aerospace Vehicles and Defense	0.66	1.86	0.84	0.92	0.59	0.96	1.12	0.20	3.00
Communications Equipment and Services	0.71	0.46	1.62	0.62	0.48	0.46	0.25	0.54	2.18
Biopharmaceuticals	0.42	0.16	0.50	0.22	0.57	0.87	0.56	0.10	0.13
Medical Devices	0.26	0.35	0.38	0.25	0.40	0.09	0.94	0.09	0.08
Automotive	0.69	0.32	0.38	0.07	0.04	0.04	0.34	0.27	0.15
Total of Wholly Services Clusters	24.76	22.43	25.70	28.30	35.06	25.35	23.91	30.67	24.91
Business Services	11.01	10.20	11.74	15.54	12.67	12.81	11.45	19.75	15.17
Marketing, Design, and Publishing	1.59	0.99	2.79	1.36	1.73	0.93	1.35	0.97	1.71
Education and Knowledge Creation	2.52	1.44	3.39	1.86	9.13	4.16	2.56	2.37	1.74
Distribution and Electronic Commerce	4.68	4.87	4.04	4.74	3.92	3.63	4.09	3.48	3.81
Financial Services	3.60	3.67	2.97	3.53	5.60	2.88	3.68	3.10	1.80
Insurance Services	1.37	1.27	0.77	1.26	2.01	0.93	0.78	1.00	0.68
Total of Other 41 Traded Clusters	15.07	11.62	12.26	13.67	8.00	18.11	15.04	18.67	12.53

Note: Figures are percentages.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

TABLE 35
EMPLOYMENT AND AGGREGATE EARNINGS, SELECTED TRADED CLUSTERS, ARIZONA, 2012-TO-2022 CHANGE IN SHARE RELATIVE TO THE NATIONAL AVERAGE

	Employment		Aggregate Earnings	
	Share of Total	Rank*	Share of Total	Rank*
Total Traded	-0.38	6	-0.40	7
Total of 12 Selected Traded Clusters	-0.28	8	-1.07	8
At Least Partially Manufacturing Clusters	-0.13	5	-0.83	8
Information Tech/Analytical Instruments	-0.11	7	-0.41	6
Aerospace Vehicles and Defense	-0.22	7	-0.76	7
Communications Equipment and Services	0.03	4	-0.04	4
Biopharmaceuticals	0.05	3	0.09	2
Medical Devices	0.07	2	0.10	2
Automotive	0.06	2	0.19	2
Wholly Services Clusters	-0.16	6	-0.24	6
Business Services	-0.32	7	-0.49	6
Marketing, Design, and Publishing	0.01	3	-0.06	3
Education and Knowledge Creation	-0.64	8	-0.39	8
Distribution and Electronic Commerce	0.48	1	0.07	3
Financial Services	0.13	2	0.36	3
Insurance Services	0.20	1	0.28	1
Other 41 Traded Clusters	-0.09	3	0.67	3

* Among eight comparison states

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

Between 2012 and 2022, Arizona's employment share and especially the aggregate earnings share decreased relative to the national average, with Arizona ranking seventh on employment and sixth on aggregate earnings. Washington and California had the greatest change in aggregate earnings share. More generally, Arizona's aggregate earnings share dropped considerably between 2001 and 2021. Earnings per worker in Arizona relative to the nation fell 9 percentage points between 2012 and 2022, ranking sixth. In Arizona, this cluster largely consists of the semiconductors industry. In 2022, it accounted for 58 percent of the cluster's aggregate earnings, compared to only a 15 percent share nationally. In the last couple of years, numerous announcements have been made of new semiconductor manufacturing facilities (and of facilities to supply the semiconductor manufacturers), but these facilities remain under construction and have not yet boosted employment in this cluster.

- Aerospace Vehicles and Defense. This high-paying, high-technology cluster consists of three subclusters: aircraft, missiles and space vehicles, and search and navigation equipment. Average earnings per worker in Arizona in 2022 was close to the U.S. average but ranked sixth. The cluster's share was far higher in Arizona than the national average in 2022 at 2.62 times the U.S. average on employment and 2.81 times the average on aggregate earnings. Arizona ranked second to Washington.

TABLE 36
EMPLOYMENT SHARE OF TOTAL, SELECTED TRADED CLUSTERS, UNITED STATES AND SELECTED STATES, 2012-TO-2022 CHANGE

	US	AZ	CA	CO	MA	MD	UT	VA	WA
Total Traded	0.41	0.03	-0.12	0.44	1.08	1.80	-0.22	0.69	0.96
Total of 12 Selected Traded Clusters	1.54	1.26	1.35	1.83	1.66	1.97	1.41	1.91	2.96
Total of at Least Partially Manufacturing Clusters	0.11	-0.01	0.31	-0.11	-0.02	0.10	0.37	0.10	-0.54
Information Technology and Analytical Instruments	0.15	0.04	0.34	-0.05	0.12	0.10	0.18	0.09	0.48
Aerospace Vehicles and Defense	-0.05	-0.27	-0.08	0.07	-0.11	-0.03	0.14	-0.01	-1.01
Communications Equipment and Services	-0.04	-0.02	-0.05	-0.15	0.00	-0.10	-0.05	-0.01	0.00
Biopharmaceuticals	0.03	0.07	-0.02	0.06	0.01	0.11	0.09	-0.02	0.02
Medical Devices	0.00	0.07	-0.02	-0.04	-0.04	0.02	0.09	0.02	-0.02
Automotive	0.03	0.10	0.12	0.00	-0.01	0.00	-0.08	0.03	-0.03
Total of Wholly Services Clusters	1.43	1.27	1.04	1.94	1.68	1.87	1.05	1.81	3.51
Business Services	1.11	0.79	0.82	1.66	0.96	1.50	0.78	1.40	3.19
Marketing, Design, and Publishing	0.07	0.08	0.21	0.04	0.00	0.00	0.00	-0.02	0.26
Education and Knowledge Creation	-0.04	-0.68	0.06	-0.03	1.03	0.12	0.28	0.04	-0.01
Distribution and Electronic Commerce	0.43	0.91	0.28	0.45	-0.10	0.68	-0.13	0.28	0.23
Financial Services	-0.09	0.04	-0.19	-0.09	-0.15	-0.27	0.12	0.02	0.00
Insurance Services	-0.06	0.14	-0.13	-0.08	-0.07	-0.15	0.00	0.09	-0.17
Total of Other 41 Traded Clusters	-1.13	-1.22	-1.47	-1.40	-0.58	-0.17	-1.63	-1.22	-2.01

Note: Figures are the change in percentages.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

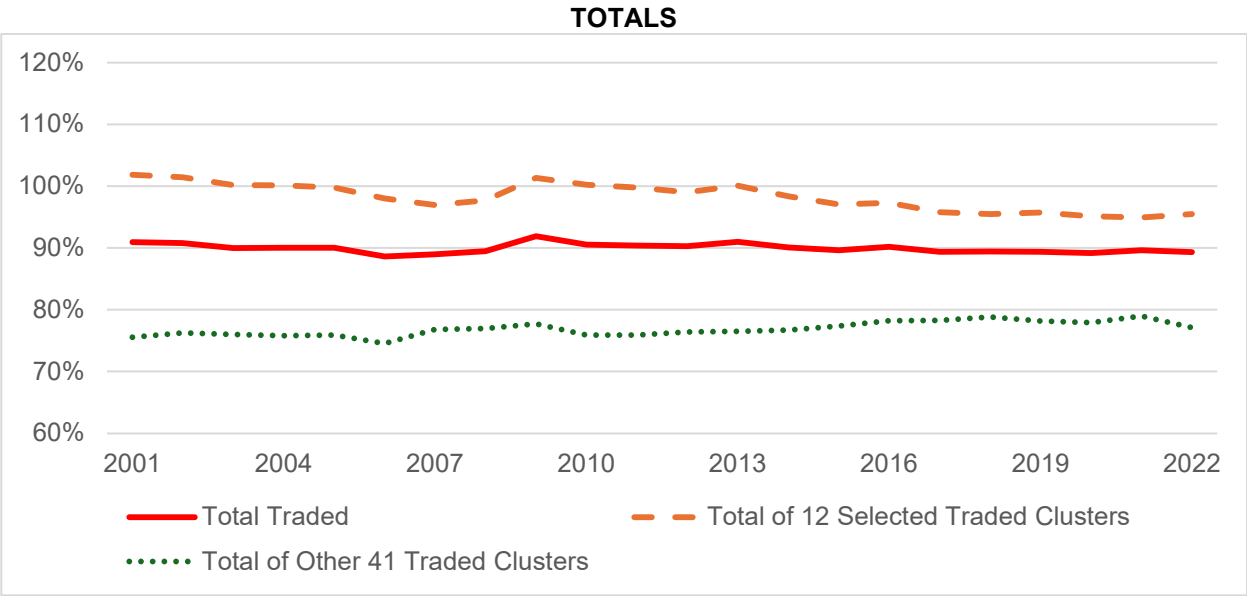
TABLE 37
AGGREGATE EARNINGS SHARE OF TOTAL, SELECTED TRADED CLUSTERS, UNITED STATES AND SELECTED STATES, 2012-TO-2022 CHANGE

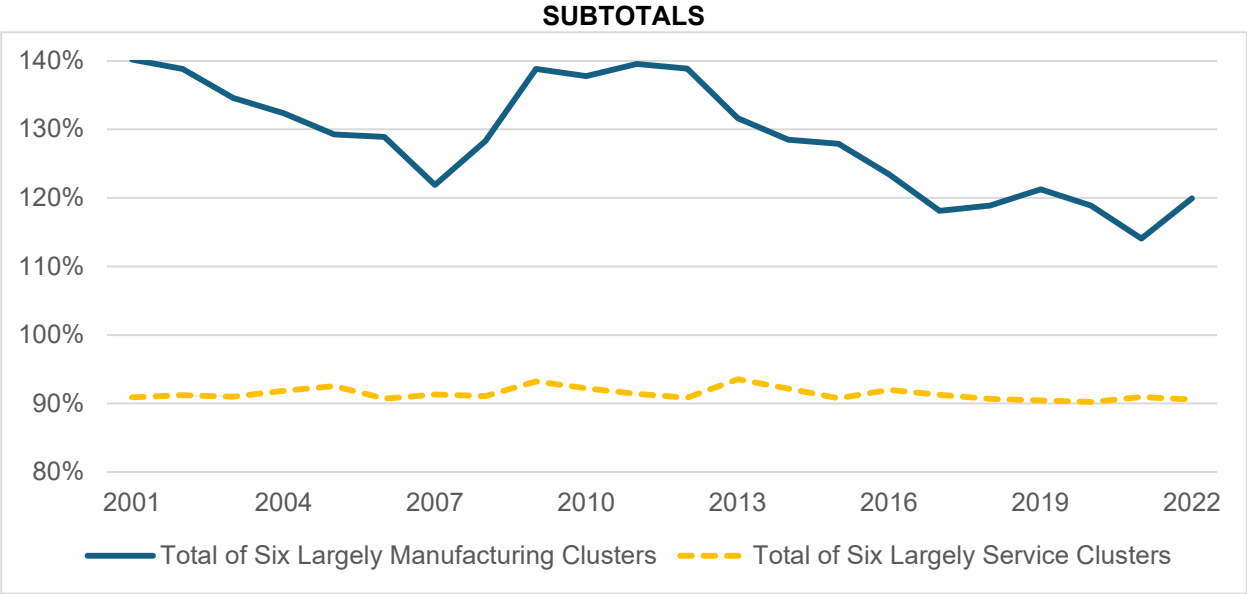
	US	AZ	CA	CO	MA	MD	UT	VA	WA
Total Traded	-0.27	-0.67	1.24	-0.40	1.75	0.44	-0.15	-0.95	3.36
Total of 12 Selected Traded Clusters	2.13	1.06	3.69	2.26	3.08	1.08	3.14	1.62	7.02
Total of at Least Partially Manufacturing Clusters	0.27	-0.56	1.56	-0.42	-0.52	0.16	0.59	0.11	-0.22
Information Technology and Analytical Instruments	0.51	0.10	1.52	0.05	-0.10	0.16	0.62	0.20	1.63
Aerospace Vehicles and Defense	-0.17	-0.94	-0.32	0.04	-0.37	-0.11	0.09	-0.01	-2.71
Communications Equipment and Services	0.04	0.00	0.39	-0.42	0.01	-0.23	-0.13	-0.08	0.88
Biopharmaceuticals	-0.02	0.07	-0.17	-0.02	0.03	0.32	-0.01	-0.03	0.05
Medical Devices	-0.03	0.07	-0.07	-0.07	-0.08	0.03	0.13	0.02	-0.01
Automotive	-0.06	0.13	0.22	0.00	-0.01	-0.02	-0.10	0.00	-0.05
Total of Wholly Services Clusters	1.86	1.62	2.13	2.68	3.60	0.92	2.55	1.51	7.24
Business Services	1.79	1.30	1.51	2.70	1.12	1.33	2.30	1.09	7.31
Marketing, Design, and Publishing	0.24	0.18	0.88	0.13	0.13	-0.02	0.05	-0.04	0.67
Education and Knowledge Creation	0.19	-0.20	0.55	-0.15	2.66	0.34	0.37	-0.14	0.01
Distribution and Electronic Commerce	-0.06	0.01	-0.39	0.11	-0.16	-0.11	-0.47	0.20	-0.47
Financial Services	-0.11	0.25	-0.14	0.09	-0.10	-0.27	0.36	0.33	0.12
Insurance Services	-0.19	0.08	-0.28	-0.19	-0.05	-0.34	-0.05	0.07	-0.39
Total of Other 41 Traded Clusters	-2.40	-1.73	-2.45	-2.66	-1.33	-0.64	-3.30	-2.57	-3.66

Note: Figures are the change in percentages.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

CHART 16
TRADED CLUSTER SHARE BASED ON AGGREGATE EARNINGS, ARIZONA AS A PERCENTAGE OF THE NATIONAL AVERAGE

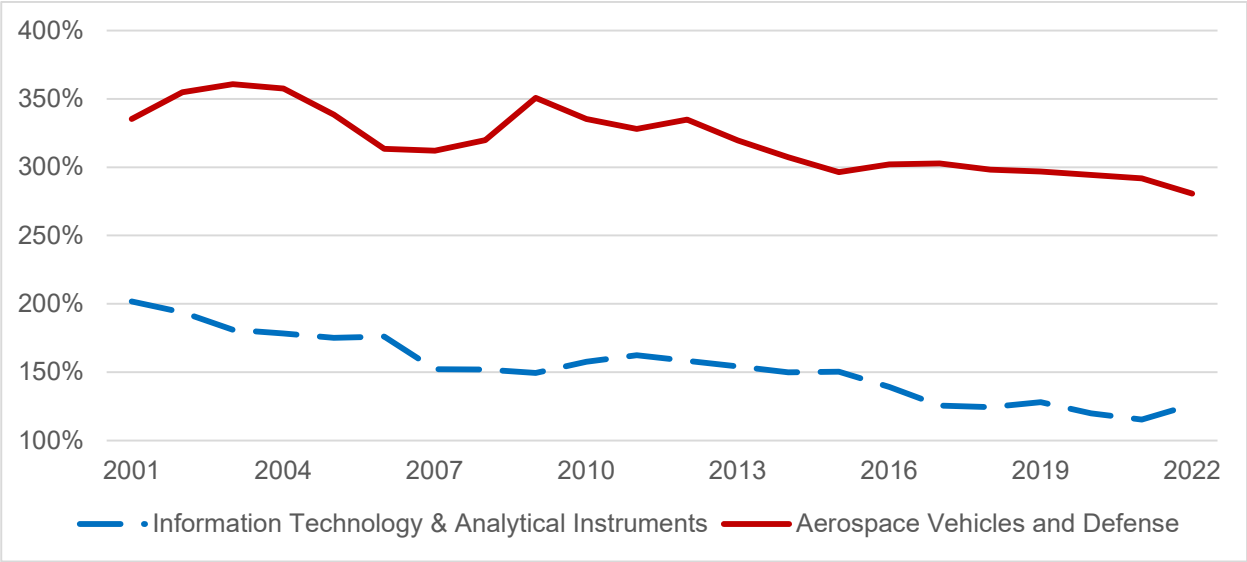


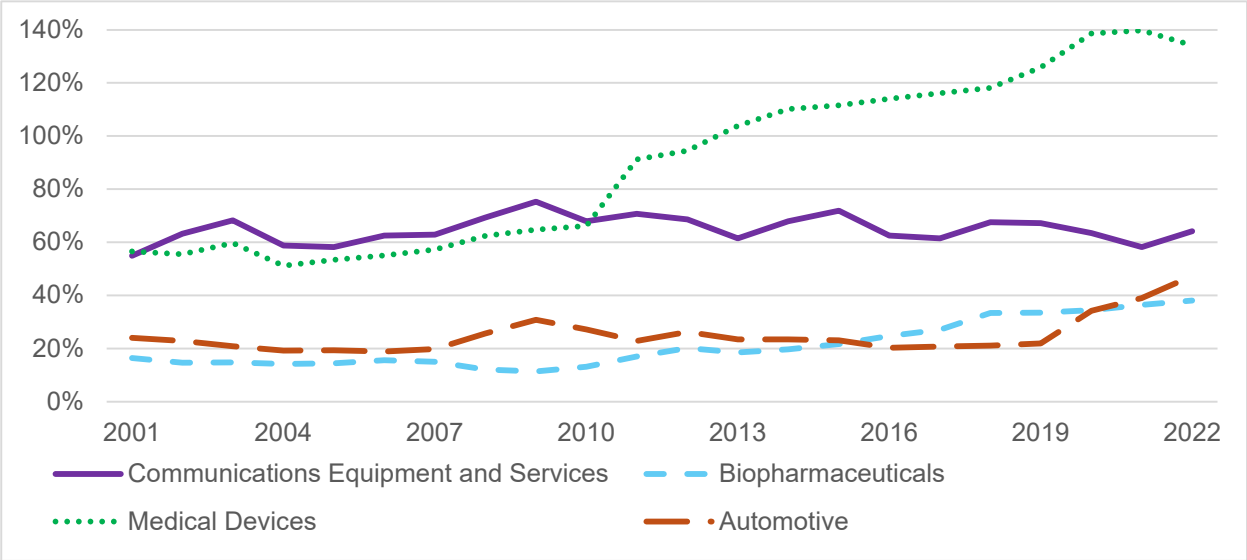


(continued)

CHART 16 (continued)
TRADED CLUSTER SHARE BASED ON AGGREGATE EARNINGS, ARIZONA AS A PERCENTAGE OF THE NATIONAL AVERAGE

SELECTED INDIVIDUAL TRADED CLUSTERS

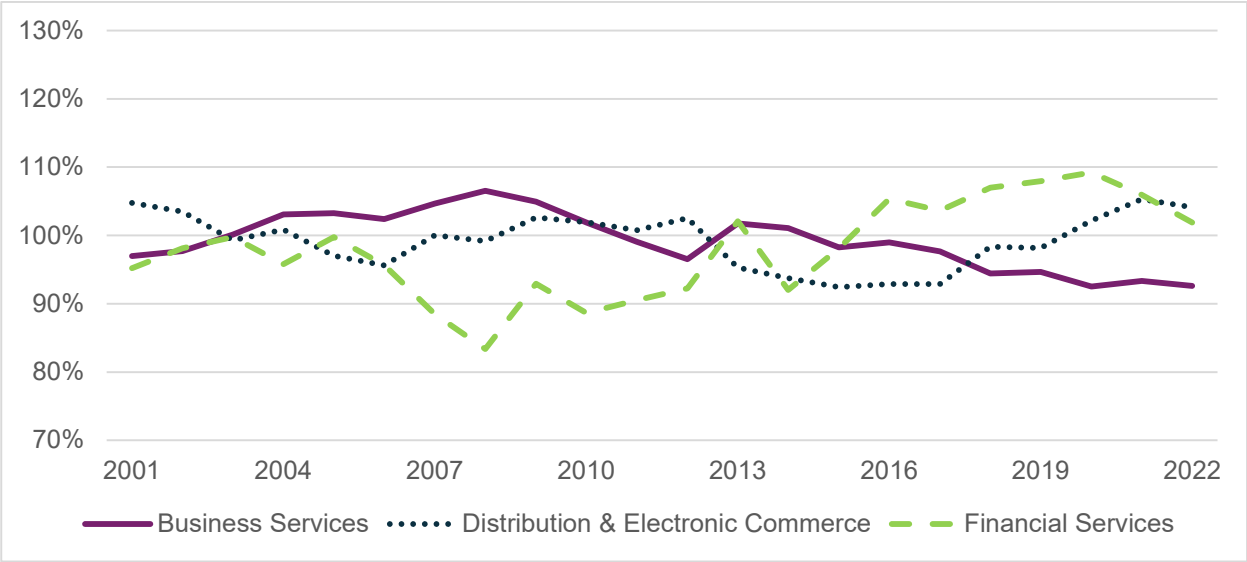


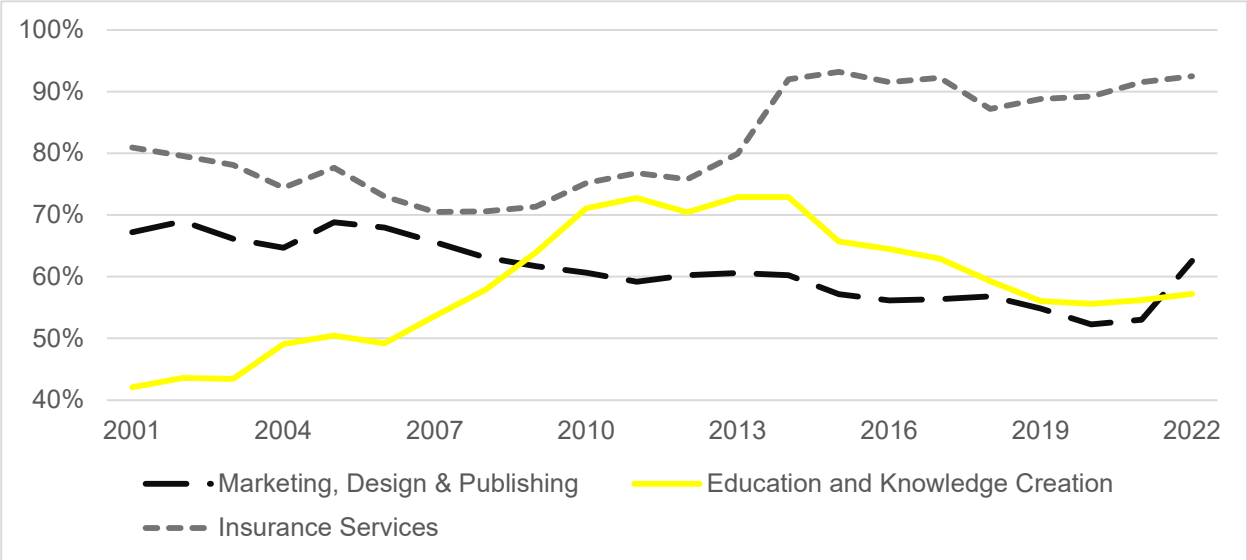


(continued)

CHART 16 (continued)
TRADED CLUSTER SHARE BASED ON AGGREGATE EARNINGS, ARIZONA AS A PERCENTAGE OF THE NATIONAL AVERAGE

SELECTED INDIVIDUAL TRADED CLUSTERS





Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

Between 2012 and 2022, Arizona's employment share and especially the aggregate earnings share dropped relative to the national average, with Arizona ranking seventh on both measures, ahead of only Washington on aggregate earnings. More generally, Arizona's aggregate earnings share decreased considerably between 2009 and 2022. Earnings per worker in Arizona relative to the nation declined 6 percentage points between 2012 and 2022, ranking seventh.

- Communications Equipment and Services. Most of the industries within this cluster are defined as high technology; it is a high-paying cluster nationally. Its three subclusters are communications services, communications equipment, and communications equipment components. Average earnings per worker in 2022 in Arizona was 37 percent less than the U.S. average, ranking seventh. The cluster's share of employment was only 6 percent less than the U.S. average in Arizona in 2022, ranking fifth. However, the aggregate earnings share in Arizona was 36 percent below the U.S. average in 2022, ranking seventh, ahead of only Utah. Washington and California had the highest aggregate earnings shares. Between 2012 and 2022, there was little change in the employment share and the aggregate earnings share in Arizona relative to the U.S. average, with Arizona ranking fourth on both measures. Washington and California had the greatest changes in aggregate earnings share. More generally, Arizona's aggregate earnings share increased from 2001 to 2009, but then lost part of its gains. Earnings per worker in Arizona relative to the nation dropped 11 percentage points between 2012 and 2022, but this ranked third.
- Biopharmaceuticals. Nationally, this is a high-paying, high-technology cluster; its three subclusters are biopharmaceutical products, biological products, and diagnostic substances. Average earnings per worker in Arizona in 2022 was 47 percent less than the U.S. average, the lowest in the comparison group. The cluster's share of employment was 34 percent less than the U.S. average in Arizona in 2022, ranking sixth. The aggregate earnings share in Arizona was 62 percent below the U.S. average in 2022, ranking sixth, ahead of Washington and Virginia. Maryland and Massachusetts had the highest aggregate earnings shares. Between 2012 and 2022, a small increase in the employment share and in the aggregate earnings share was realized in Arizona relative to the U.S. average, with Arizona ranking third on employment and second on aggregate earnings, behind only Maryland. More generally, Arizona's aggregate earnings share increased between 2004 and 2021. Earnings per worker in Arizona relative to the nation increased 1 percentage point between 2012 and 2022, ranking fifth.
- Medical Devices. The cluster's two subclusters are optical instruments and ophthalmic goods; and surgical and dental instruments and supplies. Average earnings per worker in 2022 in Arizona was 8 percent less than the U.S. average, ranking sixth. Arizona's share of both employment and aggregate earnings was 34 percent above the U.S. average in 2022, ranking fourth. Utah had the highest aggregate earnings share. The cluster's share increased somewhat in Arizona between 2012 and 2022, ranking second behind Utah. More generally, Arizona's aggregate earnings share increased between 2004 and 2021. Earnings per worker in Arizona relative to the nation decreased 1 percentage point between 2012 and 2022, worst in the comparison group.
- Automotive. Though this cluster nationally is neither particularly large nor high paying, it was selected for analysis because of the current "buzz" in Arizona relating to the location of electric vehicle manufacturing facilities in the state. This cluster consists of several subclusters, including motor vehicles, small vehicles, military vehicles and tanks,

automotive parts, and metal mills and foundries. Average earnings per worker in 2022 was 8 percent higher in Arizona than the U.S. average, likely due to the disproportionately high share of electric vehicle manufacturing in Arizona in the cluster. The state ranked second. In 2022, Arizona's employment share was 60 percent less than the U.S. average, but ranked fourth. Arizona's share of aggregate earnings was 53 percent below the U.S. average, but ranked third. All of the comparison states were well below the U.S. average in aggregate earnings share. Between 2012 and 2022, an increase in the employment share and the aggregate earnings share was realized in Arizona relative to the U.S. average, with Arizona ranking second, behind only California. More generally, Arizona's aggregate earnings share doubled between 2019 and 2022. Earnings per worker in Arizona relative to the nation jumped 15 percentage points between 2012 and 2022, but this only ranked fourth.

- Total of Six Wholly Services Clusters. In 2022, the employment share in Arizona of the sum of the six selected traded services clusters was 8 percent above the U.S. average and ranked fifth among the comparison states, but the aggregate earnings share was 9 percent below average and ranked last. Massachusetts and Virginia had the highest aggregate earnings shares. Average earnings per worker in the sum of the six selected clusters was a substantial 23 percent less in Arizona than the U.S. average in 2022, lowest in the comparison group. Between 2012 and 2022, a decrease in the employment share and in the aggregate earnings share occurred in Arizona relative to the U.S. average, with Arizona ranking sixth on each measure, ahead of Virginia and Maryland. Washington had the highest aggregate earnings share by a wide margin. Earnings per worker in Arizona relative to the nation was unchanged between 2012 and 2022, ranking sixth.
- Business Services. This large cluster consists of eight subclusters, including corporate headquarters, consulting services, business support services, employment placement services, computer services, engineering services, and architectural services. Eight of the cluster's 33 industries are defined as STEM. Average earnings per worker in Arizona in 2022 was 27 percent less than the U.S. average, lowest in the comparison group. The employment share in Arizona in 2022 was 17 percent above average and ranked fifth, but the share of aggregate earnings was 7 percent below average, lowest in the comparison group. Virginia and Colorado had the highest aggregate earnings shares. Between 2012 and 2022, the share in Arizona fell moderately versus the nation, ranking seventh on employment and sixth on aggregate earnings, ahead of Massachusetts and Virginia. Washington had the greatest gain in aggregate earnings share by a wide margin. More generally, Arizona's aggregate earnings share decreased between 2008 and 2020. Earnings per worker in Arizona relative to the nation increased 2 percentage points between 2012 and 2022, ranking fifth.
- Marketing, Design, and Publishing. The cluster's four subclusters are advertising-related services, other marketing-related services, design services, and publishing. Included is the high-tech industry of Web search portals. Average earnings per worker in Arizona in 2022 was 29 percent less than the U.S. average, lowest in the comparison group. The state's share in 2022 ranked sixth, 19 percent below average on employment and 37 percent below average on aggregate earnings, ahead of Virginia and Maryland. California had the highest aggregate earnings share. Between 2012 and 2022, the share in Arizona fell somewhat versus the nation on aggregate earnings; the state ranked third on employment and aggregate earnings, behind California and Washington. More generally,

Arizona's aggregate earnings share decreased between 2005 and 2020, but subsequently rebounded. Earnings per worker in Arizona relative to the nation was unchanged between 2012 and 2022, ranking fifth.

- Education and Knowledge Creation. This cluster consists of five subclusters: training programs; colleges, universities, and professional schools; educational support services; research organizations; and professional organizations. The three research and development industries are defined as STEM. Average earnings per worker in Arizona in 2022 was 28 percent less than the U.S. average, ranking seventh. Arizona's share in 2022 was 27 percent less than the U.S. average on employment and 43 percent below average on aggregate earnings, lowest among the comparison states on both measures. Massachusetts had the highest aggregate earnings share. Between 2012 and 2022, the share in Arizona fell versus the nation on both employment and aggregate earnings; the state was last in the comparison group on each measure. Massachusetts had the greatest change in aggregate earnings share. More generally, the cluster's share of total aggregate earnings in Arizona relative to the nation rose considerably from 2003 to 2011, but part of the gain was lost from 2014 to 2019. Earnings per worker in Arizona relative to the nation rose 9 percent between 2012 and 2022, ranking second.
- Distribution and Electronic Commerce. This cluster consists of numerous subclusters, most of which consist of wholesale trade industries. Average earnings per worker in Arizona in 2022 was 7 percent less than the U.S. average, ranking sixth. The cluster's share of both employment and aggregate earnings was slightly higher than the U.S. average in Arizona in 2022, highest among the comparison states. Between 2012 and 2022, the share in Arizona rose substantially versus the nation based on employment, the most in the comparison group. The increase was much smaller on aggregate earnings, ranking third behind Virginia and Colorado. More generally, the cluster's share of total aggregate earnings in Arizona relative to the nation dropped somewhat from 2001 to 2015, but the loss was recovered by 2021. Earnings per worker in Arizona relative to the nation decreased 14 percent between 2012 and 2022, the worst in the comparison group.
- Financial Services. This cluster is very high-paying nationally. It consists of five subclusters: financial investment activities; credit intermediation; credit bureaus; monetary authorities; and security brokers, dealers, and exchanges. Average earnings per worker in Arizona in 2022 was a very substantial 42 percent less than the U.S. average, lowest in the comparison group. The cluster's share of employment in Arizona was 61 percent above the U.S. average in 2022, highest in the comparison group. However, the aggregate earnings share was only 2 percent higher than the U.S. average, ranking third. Massachusetts had the highest aggregate earnings share. Between 2012 and 2022, the share in Arizona rose versus the nation based on both measures, ranking second on employment and third on aggregate earnings, behind Utah and Virginia. The increase was much smaller on aggregate earnings, ranking third behind Virginia and Colorado. More generally, the cluster's share of aggregate earnings in Arizona relative to the nation climbed between 2007 and 2020. Earnings per worker in Arizona relative to the nation was unchanged between 2012 and 2022, the worst in the comparison group.
- Insurance Services. The cluster's three subclusters are insurance-related services, insurance carriers, and reinsurance carriers. Average earnings per worker in Arizona in 2022 was 19 percent less than the U.S. average, the lowest in the comparison group. Arizona's share of employment in 2022 was 5 percent above the U.S. average but the

aggregate earnings share was 7 percent below average in 2022. Arizona ranked second on each measure, behind Massachusetts. Between 2012 and 2022, the share in Arizona rose versus the nation, ranking first on both measures. More generally, the cluster's share of aggregate earnings in Arizona relative to the nation climbed between 2009 and 2015. Earnings per worker in Arizona relative to the nation slipped 3 percentage points between 2012 and 2022, the third worst in the comparison group.

- Total of the Other 41 Traded Clusters**.** Arizona compares poorly on the sum of the other 41 traded clusters, with an employment share 25 percent, and an aggregate earnings share 23 percent, less than the U.S. average in 2022, ranking second to last among the comparison states on each measure, ahead of Massachusetts. Average earnings per worker in 2022 was only 5 percent below average, ranking fifth. Between 2012 and 2022, the employment share in Arizona slipped versus the nation but ranked third. The share increased on aggregate earnings, ranking third behind Maryland and Massachusetts. Earnings per worker in Arizona relative to the nation rose 3 percentage points between 2012 and 2022, ranking fourth.

Metropolitan Phoenix

The sum of the 53 traded clusters in 2022 in Metro Phoenix accounted for 30.88 percent of total employment, lower than the national average of 32.56 percent. The sum of the traded clusters in Metro Phoenix accounted for 39.71 percent of total aggregate earnings in 2022, less than the national average of 44.79 percent.

Metro Phoenix ranked last among 12 large metro areas in its traded cluster share in 2022 based on both employment and aggregate earnings. In terms of employment, it ranked between ninth and 12th from 2001 to 2022. Based on aggregate earnings, Metro Phoenix ranked last in each year from 2002 through 2022.

The change in the traded cluster employment share in Metro Phoenix between 2012 and 2022 of -0.72 percentage points compared poorly to the national average gain of 0.41 percentage points. The traded cluster aggregate earnings share in Metro Phoenix decreased by 1.39 percentage points during the same time period, also comparing unfavorably to the national average decrease of 0.27 percentage points. Metro Phoenix ranked 11th on the 2012-to-2022 change in share based on employment, and ninth on the change based on aggregate earnings.

Metro Phoenix compared favorably in several traded clusters in 2022, such as metal mining and financial services, in which it ranked first in terms of employment among the 12 comparison metros. In terms of aggregate earnings in 2022, Metro Phoenix ranked first in metal mining, but fourth in financial services.

Table 38 summarizes traded clusters in Metro Phoenix in 2022. In most of the 12 selected clusters, the ratio to the national average was lower based on aggregate earnings than on employment, in several cases by a sizable amount. The large differential suggests that employment in these clusters in Metro Phoenix is disproportionately in industries with lower earnings per worker.

TABLE 38
EMPLOYMENT AND AGGREGATE EARNINGS, SELECTED TRADED CLUSTERS, METROPOLITAN PHOENIX, 2022

	Employment			Aggregate Earnings		
	Share of Total	Ratio to Nation	Rank*	Share of Total	Ratio to Nation	Rank*
Total Traded	30.88%	0.95	12	39.71%	0.89	12
Total of 12 Selected Traded Clusters	22.00	1.20	9	30.24	1.02	11
At Least Partially Manufacturing Clusters	3.23	1.24	9	5.95	1.20	9
Information Tech/Analytical Instruments	1.41	1.54	9	3.20	1.44	8
Aerospace Vehicles and Defense	0.77	2.05	4	1.32	1.99	4
Communications Equipment and Services	0.34	1.08	9	0.51	0.72	10
Biopharmaceuticals	0.18	0.89	7	0.20	0.48	9
Medical Devices	0.21	1.23	7	0.33	1.26	5
Automotive	0.30	0.49	3	0.39	0.57	3
Wholly Services Clusters	18.77	1.19	9	24.29	0.98	10
Business Services	8.31	1.26	9	10.85	0.99	11
Marketing, Design, and Publishing	0.94	0.91	11	1.08	0.68	11
Education and Knowledge Creation	1.71	0.83	10	1.52	0.60	10
Distribution and Electronic Commerce	4.29	1.13	2	5.30	1.13	3
Financial Services	2.57	1.94	1	4.27	1.19	4
Insurance Services	0.95	1.04	3	1.27	0.93	3
Other 41 Traded Clusters	8.89	0.62	7	9.48	0.63	6

* Among 12 comparison metro areas

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

In 2022, Metro Phoenix's aggregate earnings share was the lowest of the 12 large metro areas for the sum of the 53 traded clusters and 11th for the sum of the 12 selected traded clusters. Metro Phoenix ranked sixth on the sum of the other 41 traded clusters. It ranked ninth for the sum of the six at least partially manufacturing traded clusters, and was 10th for the sum of the six selected services traded clusters.

In Table 39, the employment shares in 2022 are shown for the nation and for each of the comparison areas. The shares of aggregate earnings are displayed in Table 40.

Focusing on the 10-year time period between 2012 and 2022, Table 41 depicts changes in employment and aggregate earnings shares in Metro Phoenix relative to the nation. Between 2012 and 2022, Metro Phoenix's change in share was considerably less than the U.S. average in the sum of the 53 traded clusters and in the sum of the 12 selected clusters, on both employment and aggregate earnings. The change in the aggregate earnings share considerably exceeded the national average in the total of the other 41 traded clusters. Among the 12 selected clusters, Metro Phoenix outperformed the nation in four, though by small margins. In contrast, the metro area's performance was much inferior to the national average in the information technology and analytical instruments; aerospace vehicles and defense; and business services clusters.

TABLE 39
EMPLOYMENT SHARE OF TOTAL, SELECTED TRADED CLUSTERS, UNITED STATES AND SELECTED LARGE METROPOLITAN AREAS, 2022

	US	Aus	Bal	Bos	Den	Pho	Por	R-D	SD	SF	SJ	Sea	DC
Total Traded	32.56	33.06	33.54	36.19	34.31	30.88	33.59	32.30	35.00	35.99	45.95	38.45	39.84
Total of 12 Selected Traded Clusters	18.34	25.50	20.32	28.27	23.64	22.00	21.97	24.54	19.54	28.36	40.48	27.59	22.59
Total of at Least Partially Manufacturing Clusters	2.61	3.88	1.84	4.13	2.25	3.23	5.21	4.28	3.92	6.32	14.84	7.88	1.28
Information Technology and Analytical Instruments	0.92	2.99	0.39	2.71	0.96	1.41	4.03	2.82	1.43	2.66	13.27	3.65	0.41
Aerospace Vehicles and Defense	0.38	0.07	0.97	0.46	0.55	0.77	0.25	0.03	0.96	0.05	0.36	3.02	0.10
Communications Equipment and Services	0.32	0.45	0.19	0.31	0.39	0.34	0.20	0.38	0.59	1.84	0.55	0.93	0.50
Biopharmaceuticals	0.21	0.18	0.20	0.31	0.10	0.18	0.10	0.80	0.51	0.56	0.17	0.09	0.21
Medical Devices	0.17	0.12	0.05	0.28	0.22	0.21	0.27	0.17	0.35	0.29	0.29	0.05	0.03
Automotive	0.62	0.08	0.04	0.06	0.03	0.30	0.37	0.09	0.07	0.93	0.19	0.13	0.04
Total of Wholly Services Clusters	15.73	21.62	18.48	24.14	21.39	18.77	16.76	20.26	15.62	22.04	25.64	19.71	21.31
Business Services	6.60	11.70	7.33	8.78	10.69	8.31	8.29	8.51	6.80	11.36	12.47	11.02	13.13
Marketing, Design, and Publishing	1.04	1.92	0.77	1.38	1.31	0.94	1.20	1.30	1.07	1.85	4.40	1.56	1.20
Education and Knowledge Creation	2.05	1.44	3.90	7.96	1.72	1.71	1.63	4.77	3.68	3.86	5.61	1.76	3.80
Distribution and Electronic Commerce	3.81	4.01	4.31	2.54	4.22	4.29	3.80	3.72	2.39	2.36	2.02	3.78	1.44
Financial Services	1.33	2.03	1.49	2.15	2.30	2.57	1.07	1.33	1.16	2.04	1.01	0.97	1.29
Insurance Services	0.91	0.52	0.68	1.33	1.15	0.95	0.77	0.63	0.52	0.56	0.14	0.61	0.45
Total of Other 41 Clusters	14.22	7.56	13.22	7.92	10.67	8.89	11.62	7.75	15.46	7.63	5.47	10.86	17.25

Aus: Austin-Round Rock-San Marcos, Texas; Bal: Baltimore-Columbia-Towson, Maryland; Bos: Boston-Cambridge-Newton, Massachusetts; Den: Denver-Aurora-Centennial, Colorado; Pho: Phoenix-Mesa-Chandler, Arizona; Por: Portland-Vancouver-Hillsboro, Oregon-Washington; R-D: sum of Raleigh-Cary and Durham-Chapel Hill, North Carolina; SD: San Diego-Chula Vista-Carlsbad, California; SF: San Francisco-Oakland-Fremont, California; SJ: San Jose-Sunnyvale-Santa Clara, California; Sea: Seattle-Tacoma- Bellevue, Washington; DC: Washington-Arlington-Alexandria, District of Columbia-Virginia-Maryland-West Virginia

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

TABLE 40
AGGREGATE EARNINGS SHARE OF TOTAL, SELECTED TRADED CLUSTERS, UNITED STATES AND SELECTED LARGE METROPOLITAN AREAS, 2022

	US	Aus	Bal	Bos	Den	Pho	Por	R-D	SD	SF	SJ	Sea	DC
Total Traded	44.79	49.42	44.65	52.85	48.37	39.71	44.42	46.17	45.95	56.43	72.09	56.94	56.00
Total of 12 Selected Traded Clusters	29.72	42.68	28.49	45.67	36.48	30.24	33.56	38.85	30.97	49.75	68.86	47.62	32.53
Total of at Least Partially Manufacturing Clusters	4.96	7.99	3.38	7.30	4.04	5.95	9.84	8.78	6.99	13.11	29.67	17.80	2.29
Information Technology and Analytical Instruments	2.21	6.53	0.75	5.01	1.91	3.20	8.35	5.92	2.80	4.85	27.73	10.14	0.70
Aerospace Vehicles and Defense	0.66	0.07	1.89	0.71	1.14	1.32	0.35	0.06	1.50	0.06	0.42	4.26	0.16
Communications Equipment and Services	0.71	0.91	0.29	0.52	0.57	0.51	0.32	0.66	1.05	5.47	0.77	3.08	0.88
Biopharmaceuticals	0.42	0.23	0.33	0.65	0.10	0.20	0.11	1.79	0.98	1.37	0.21	0.12	0.48
Medical Devices	0.26	0.15	0.07	0.37	0.30	0.33	0.30	0.27	0.61	0.41	0.33	0.07	0.04
Automotive	0.69	0.10	0.05	0.05	0.02	0.39	0.41	0.08	0.07	0.96	0.21	0.12	0.03
Total of Wholly Services Clusters	24.76	34.69	25.10	38.37	32.44	24.29	23.72	30.06	23.97	36.64	39.20	29.82	30.25
Business Services	11.01	20.36	11.13	14.02	17.82	10.85	13.43	13.44	9.73	18.85	19.49	19.25	19.40
Marketing, Design, and Publishing	1.59	2.63	0.87	1.88	1.49	1.08	1.30	1.68	1.24	2.90	10.03	2.20	1.67
Education and Knowledge Creation	2.52	1.45	4.71	10.45	1.60	1.52	1.38	6.67	7.14	5.81	5.67	1.85	4.02
Distribution and Electronic Commerce	4.68	5.58	3.89	3.45	5.38	5.30	4.57	4.66	3.11	2.28	2.26	3.90	1.86
Financial Services	3.60	4.00	3.52	6.56	4.58	4.27	2.00	2.57	2.08	6.10	1.65	1.92	2.76
Insurance Services	1.37	0.68	0.98	2.01	1.56	1.27	1.04	1.04	0.67	0.70	0.10	0.70	0.53
Total of Other 41 Clusters	15.07	6.74	16.17	7.19	11.88	9.48	10.86	7.32	14.98	6.68	3.23	9.32	23.47

Aus: Austin-Round Rock-San Marcos, Texas; Bal: Baltimore-Columbia-Towson, Maryland; Bos: Boston-Cambridge-Newton, Massachusetts; Den: Denver-Aurora-Centennial, Colorado; Pho: Phoenix-Mesa-Chandler, Arizona; Por: Portland-Vancouver-Hillsboro, Oregon-Washington; R-D: sum of Raleigh-Cary and Durham-Chapel Hill, North Carolina; SD: San Diego-Chula Vista-Carlsbad, California; SF: San Francisco-Oakland-Fremont, California; SJ: San Jose-Sunnyvale-Santa Clara, California; Sea: Seattle-Tacoma- Bellevue, Washington; DC: Washington-Arlington-Alexandria, District of Columbia-Virginia-Maryland-West Virginia

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

TABLE 41
EMPLOYMENT AND AGGREGATE EARNINGS, SELECTED TRADED CLUSTERS, METROPOLITAN PHOENIX, 2012-TO-2022 CHANGE IN SHARE RELATIVE TO THE NATIONAL AVERAGE

	Employment		Aggregate Earnings	
	Share of Total	Rank*	Share of Total	Rank*
Total Traded	-1.13	11	-1.13	9
Total of 12 Selected Traded Clusters	-1.45	12	-2.54	12
At Least Partially Manufacturing Clusters	-0.22	9	-1.02	8
Information Tech/Analytical Instruments	-0.21	10	-0.62	9
Aerospace Vehicles and Defense	-0.36	10	-0.94	11
Communications Equipment and Services	0.04	4	-0.04	4
Biopharmaceuticals	0.07	2	0.10	2
Medical Devices	0.14	1	0.23	1
Automotive	0.10	2	0.24	2
Wholly Services Clusters	-1.23	12	-1.52	11
Business Services	-0.56	12	-0.89	9
Marketing, Design, and Publishing	-0.03	7	-0.13	7
Education and Knowledge Creation	-0.89	12	-0.37	10
Distribution and Electronic Commerce	0.38	2	-0.21	5
Financial Services	-0.07	9	0.09	5
Insurance Services	-0.05	3	-0.01	5
Other 41 Traded Clusters	0.32	6	1.41	1

* Among 12 comparison metro areas

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

The changes in employment shares between 2012 and 2022 are shown for the nation and for each of the comparison areas in Table 42. The change in shares of aggregate earnings are displayed in Table 43.

A summary of employment and aggregate earnings shares in each of the categories shown in Tables 38 through 43, with comparisons to the nation and ranks among the 12 large comparison metropolitan areas, follows:

- Total of All Traded Clusters. The share of the total accounted for by the sum of the 53 traded clusters was further below the U.S. average based on aggregate earnings (11 percent) than on employment (5 percent). Metro Phoenix was last among the comparison areas on each measure. San Jose and Seattle had the highest aggregate earnings shares. The employment and aggregate earnings shares in Metro Phoenix dropped considerably relative to the national average between 2012 and 2022, ranking 11th on employment and ninth on aggregate earnings. Austin and San Francisco had the greatest changes in share.
- Total of 12 Selected Traded Clusters. In 2022, the employment share in Metro Phoenix of the 12 selected traded clusters as a whole was 20 percent above the U.S. average but ranked ninth. The aggregate earnings share was only 2 percent above average and ranked 11th, ahead of only Baltimore. San Jose and San Francisco had the highest aggregate earnings shares. Between 2012 and 2022, the employment share and especially the

TABLE 42
EMPLOYMENT SHARE OF TOTAL, SELECTED TRADED CLUSTERS, UNITED STATES AND SELECTED LARGE METROPOLITAN AREAS, 2012-TO-2022 CHANGE

	US	Aus	Bal	Bos	Den	Pho	Por	R-D	SD	SF	SJ	Sea	DC
Total Traded	0.41	4.54	2.14	1.38	1.70	-0.72	-0.07	1.19	-0.96	3.26	2.48	2.13	-0.51
Total of 12 Selected Traded Clusters	1.54	4.71	2.49	1.86	2.36	0.09	1.07	1.59	1.14	5.13	3.73	4.05	0.53
Total of at Least Partially Manufacturing Clusters	0.11	-0.19	0.20	-0.08	0.02	-0.11	0.01	-0.84	0.35	2.70	0.67	-1.23	0.09
Information Technology and Analytical Instruments	0.15	-0.24	0.14	0.09	0.24	-0.06	0.34	-0.21	0.18	0.78	2.09	0.43	0.06
Aerospace Vehicles and Defense	-0.05	-0.03	0.10	-0.14	0.01	-0.40	-0.02	-0.03	0.20	0.00	-0.44	-1.74	-0.01
Communications Equipment and Services	-0.04	0.03	-0.04	-0.01	-0.19	0.00	-0.04	-0.11	-0.16	1.02	-1.00	0.07	-0.07
Biopharmaceuticals	0.03	-0.01	0.02	-0.02	0.02	0.09	-0.04	-0.29	0.14	0.04	0.03	0.05	0.07
Medical Devices	0.00	0.03	0.01	0.00	-0.05	0.13	0.03	-0.10	-0.02	0.09	-0.13	-0.02	0.01
Automotive	0.03	0.02	-0.03	-0.01	-0.02	0.13	-0.25	-0.10	0.01	0.77	0.11	-0.02	0.02
Total of Wholly Services Clusters	1.43	4.89	2.29	1.95	2.34	0.20	1.06	2.43	0.79	2.43	3.05	5.28	0.44
Business Services	1.11	4.89	1.19	1.17	2.14	0.54	2.02	1.09	0.90	1.92	2.45	4.91	0.86
Marketing, Design, and Publishing	0.07	0.50	-0.03	-0.05	0.12	0.03	-0.03	0.42	-0.05	0.12	1.75	0.41	-0.05
Education and Knowledge Creation	-0.04	-0.18	0.02	1.30	-0.11	-0.93	-0.38	0.27	0.45	0.86	0.12	0.10	-0.15
Distribution and Electronic Commerce	0.43	-0.43	1.34	-0.18	0.47	0.81	-0.09	0.57	-0.11	-0.31	-1.10	0.27	-0.02
Financial Services	-0.09	0.44	0.01	-0.18	-0.15	-0.16	-0.07	0.42	-0.27	-0.05	-0.09	-0.10	-0.22
Insurance Services	-0.06	-0.33	-0.25	-0.11	-0.12	-0.10	-0.38	-0.33	-0.14	-0.12	-0.08	-0.30	0.02
Total of Other 41 Clusters	-1.13	-0.17	-0.35	-0.49	-0.66	-0.81	-1.14	-0.40	-2.10	-1.87	-1.24	-1.92	-1.05

Aus: Austin-Round Rock-San Marcos, Texas; Bal: Baltimore-Columbia-Towson, Maryland; Bos: Boston-Cambridge-Newton, Massachusetts; Den: Denver-Aurora-Centennial, Colorado; Pho: Phoenix-Mesa-Chandler, Arizona; Por: Portland-Vancouver-Hillsboro, Oregon-Washington; R-D: sum of Raleigh-Cary and Durham-Chapel Hill, North Carolina; SD: San Diego-Chula Vista-Carlsbad, California; SF: San Francisco-Oakland-Fremont, California; SJ: San Jose-Sunnyvale-Santa Clara, California; Sea: Seattle-Tacoma- Bellevue, Washington; DC: Washington-Arlington-Alexandria, District of Columbia-Virginia-Maryland-West Virginia

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

TABLE 43
AGGREGATE EARNINGS SHARE OF TOTAL, SELECTED TRADED CLUSTERS, UNITED STATES AND SELECTED LARGE METROPOLITAN AREAS, 2012-TO-2022 CHANGE

	US	Aus	Bal	Bos	Den	Pho	Por	R-D	SD	SF	SJ	Sea	DC
Total Traded	-0.27	6.44	0.39	2.30	0.24	-1.39	-1.73	-0.19	-2.34	6.33	5.39	4.86	-1.62
Total of 12 Selected Traded Clusters	2.13	7.86	1.64	3.38	1.81	-0.41	0.30	1.05	1.03	8.94	6.85	8.25	0.21
Total of at Least Partially Manufacturing Clusters	0.27	-1.25	0.34	-0.59	-0.05	-0.75	-0.90	-3.02	0.06	6.48	0.98	-1.59	0.15
Information Technology and Analytical Instruments	0.51	-1.38	0.32	-0.07	0.50	-0.11	-0.21	-1.18	0.41	1.41	4.29	1.22	0.11
Aerospace Vehicles and Defense	-0.17	-0.06	0.08	-0.46	-0.03	-1.11	-0.15	-0.07	-0.02	0.00	-0.87	-4.19	-0.02
Communications Equipment and Services	0.04	0.19	-0.02	-0.01	-0.37	0.00	-0.03	-0.36	-0.25	4.12	-2.21	1.34	-0.17
Biopharmaceuticals	-0.02	-0.04	0.00	0.00	-0.04	0.09	-0.01	-1.11	-0.03	0.04	-0.13	0.07	0.20
Medical Devices	-0.03	0.00	0.01	-0.04	-0.09	0.20	-0.02	-0.17	-0.05	0.10	-0.24	-0.01	0.02
Automotive	-0.06	0.04	-0.04	-0.01	-0.02	0.18	-0.47	-0.13	0.01	0.81	0.13	-0.03	0.00
Total of Wholly Services Clusters	1.86	9.11	1.29	3.98	1.86	0.34	1.20	4.07	0.96	2.45	5.87	9.84	0.06
Business Services	1.79	9.99	1.34	1.15	2.21	0.90	4.04	2.71	0.61	-0.36	4.90	9.93	0.53
Marketing, Design, and Publishing	0.24	1.01	-0.03	0.06	0.22	0.12	-0.02	0.65	0.11	1.01	3.52	0.87	-0.07
Education and Knowledge Creation	0.19	-0.13	0.39	3.25	-0.08	-0.18	-0.22	0.73	1.16	2.22	-0.30	0.24	-0.08
Distribution and Electronic Commerce	-0.06	-2.12	0.05	-0.23	-0.13	-0.27	-1.84	-0.44	-0.27	-0.71	-1.78	-0.54	-0.11
Financial Services	-0.11	0.86	0.00	-0.15	-0.08	-0.02	-0.11	0.79	-0.38	0.50	-0.37	-0.08	-0.12
Insurance Services	-0.19	-0.51	-0.45	-0.11	-0.28	-0.21	-0.65	-0.39	-0.27	-0.20	-0.10	-0.59	-0.09
Total of Other 41 Clusters	-2.40	-1.42	-1.25	-1.09	-1.57	-0.98	-2.03	-1.24	-3.37	-2.61	-1.46	-3.39	-1.83

Aus: Austin-Round Rock-San Marcos, Texas; Bal: Baltimore-Columbia-Towson, Maryland; Bos: Boston-Cambridge-Newton, Massachusetts; Den: Denver-Aurora-Centennial, Colorado; Pho: Phoenix-Mesa-Chandler, Arizona; Por: Portland-Vancouver-Hillsboro, Oregon-Washington; R-D: sum of Raleigh-Cary and Durham-Chapel Hill, North Carolina; SD: San Diego-Chula Vista-Carlsbad, California; SF: San Francisco-Oakland-Fremont, California; SJ: San Jose-Sunnyvale-Santa Clara, California; Sea: Seattle-Tacoma- Bellevue, Washington; DC: Washington-Arlington-Alexandria, District of Columbia-Virginia-Maryland-West Virginia

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

aggregate earnings share in Metro Phoenix dropped substantially relative to the national average, with Metro Phoenix ranking last on each measure. San Francisco and Seattle had the greatest changes in aggregate earnings share.

- Total of Six at Least Partially Manufacturing Clusters. Metro Phoenix's share was 24 percent higher than the U.S. average on employment and 20 percent above average on aggregate earnings, but only ranked ninth in 2022. San Jose and Seattle had the highest aggregate earnings shares. Between 2012 and 2022, the employment share and especially the aggregate earnings share in Metro Phoenix dropped relative to the U.S. average, with Metro Phoenix ranking ninth aggregate earnings share.
- Information Technology and Analytical Instruments. In Metro Phoenix in 2022, the cluster's share was above the U.S. average by 54 percent on employment and 44 percent on aggregate earnings, but the rank was only ninth on employment and eighth on aggregate earnings. San Jose and Seattle had the highest aggregate earnings shares. Between 2012 and 2022, the employment share and especially the aggregate earnings share in Metro Phoenix dropped relative to the U.S. average, with Metro Phoenix ranking 10th on employment and ninth on aggregate earnings. San Jose had the greatest change in aggregate earnings share.
- Aerospace Vehicles and Defense. The cluster's share was considerably higher in Metro Phoenix than the U.S. average in 2022, at 2.05 times the U.S. average on employment and 1.99 times the average on aggregate earnings. Metro Phoenix ranked fourth on each measure. Seattle had the highest aggregate earning share. Between 2012 and 2022, the employment share and especially the aggregate earnings share in Metro Phoenix dropped relative to the U.S. average, with Metro Phoenix ranking 10th on employment and 11th on aggregate earnings, ahead of only Seattle.
- Communications Equipment and Services. The cluster's share of employment was 8 percent more than the U.S. average in Metro Phoenix in 2022, ranking ninth. However, the aggregate earnings share in Metro Phoenix was 28 percent below the U.S. average, ranking 10th, ahead of only Portland and Baltimore. San Francisco and Seattle had the highest aggregate earnings shares. Between 2012 and 2022, there was little change in the employment share and the aggregate earnings share in Metro Phoenix relative to the U.S. average, with Metro Phoenix ranking fourth on both measures. San Francisco had the greatest change in aggregate earnings share.
- Biopharmaceuticals. The cluster's share of employment was 11 percent less than the U.S. average in Metro Phoenix in 2022, ranking seventh. However, the aggregate earnings share in Metro Phoenix was 52 percent below the U.S. average in 2022, ranking ninth. Raleigh-Durham and San Francisco had the highest aggregate earnings shares. Between 2012 and 2022, a small increase in the employment share and in the aggregate earnings share was realized in Metro Phoenix relative to the U.S. average, with Metro Phoenix ranking second on both measures, behind only Washington, D.C.
- Medical Devices. The cluster's share of employment was 23 percent higher than the U.S. average in Metro Phoenix in 2022, but only ranked seventh. The aggregate earnings share was 26 percent above the U.S. average in 2022, ranking fifth. San Diego and San Francisco had the highest aggregate earnings shares. In Metro Phoenix, the cluster's share increased somewhat versus the U. S. average between 2012 and 2022, ranking first on both measures.

- Automotive. In 2022, Metro Phoenix's employment share was 51 percent less, and the share of aggregate earnings was 43 percent below, the U.S. average, but Metro Phoenix ranked third on each measure. All of the comparison areas except San Francisco were well below the U.S. average. Between 2012 and 2022, an increase in the employment share and in the aggregate earnings share was realized in Metro Phoenix relative to the U.S. average, with Metro Phoenix ranking second on each measure, behind only San Francisco.
- Total of Six Wholly Services Clusters. In 2022 in Metro Phoenix, the employment share of the sum of the six selected traded services clusters was 19 percent above the U.S. average but only ranked ninth. The aggregate earnings share was 2 percent below average and ranked 10th. San Jose and Boston had the highest aggregate earnings shares. Between 2012 and 2022, a large decrease in the employment share and in the aggregate earnings share occurred in Metro Phoenix relative to the U.S. average, with Metro Phoenix ranking last on employment and 11th on aggregate earnings, ahead of Washington, D.C. The greatest changes in share were in Seattle and Austin.
- Business Services. The employment share in Metro Phoenix in 2022 was 26 percent above average but only ranked ninth. The share of aggregate earnings was 1 percent below average, ranking 11th. Austin and San Jose had the highest aggregate earnings shares. Between 2012 and 2022, the share in Metro Phoenix fell considerably versus the nation, ranking last on employment and ninth on aggregate earnings. Austin and Seattle had the greatest changes in share.
- Marketing, Design, and Publishing. The share in Metro Phoenix in 2022 was 9 percent below average on employment but 32 percent below average on aggregate earnings, ranking 11th on each measure, ahead of only Baltimore. San Jose had the highest aggregate earnings share. Between 2012 and 2022, the share in Metro Phoenix fell somewhat versus the nation, ranking seventh on each measure. San Jose had the greatest change in aggregate earnings share.
- Education and Knowledge Creation. Metro Phoenix's share in 2022 was 17 percent less than the U.S. average based on employment and 40 percent below average on aggregate earnings, ranking 10th on both measures. Boston and San Diego had the highest aggregate earnings shares. Between 2012 and 2022, the share in Metro Phoenix fell considerably versus the nation on both employment and aggregate earnings, ranking last on employment and 10th on aggregate earnings. Boston and San Francisco had the greatest changes in aggregate earnings share.
- Distribution and Electronic Commerce. The cluster's share of both employment and aggregate earnings was higher than the U.S. average in Metro Phoenix in 2022, ranking second on employment and third on aggregate earnings. Austin and Denver had slightly higher aggregate earnings shares. Between 2012 and 2022, the share in Metro Phoenix rose versus the nation based on employment, ranking second, but fell on aggregate earnings, ranking fifth. Only Baltimore had a change in aggregate earnings share greater than the national average.
- Financial Services. The cluster's share of employment in Metro Phoenix was 94 percent above the U.S. average in 2022, highest in the comparison group. However, the aggregate earnings share was only 19 percent higher than the U.S. average, ranking fourth. Boston and San Francisco had the highest aggregate earnings shares. Between 2012 and 2022 versus the nation, the share in Metro Phoenix fell slightly based on employment, ranking

ninth, but rose a little on aggregate earnings, ranking fifth. Austin and Raleigh-Durham had the greatest changes in aggregate earnings share.

- Insurance Services. Metro Phoenix's share of employment in 2022 was 4 percent above the U.S. average but the aggregate earnings was 9 percent below average. Metro Phoenix ranked third on each measure, behind Boston and Denver. Between 2012 and 2022, the share in Metro Phoenix dropped marginally versus the nation, ranking third on employment and fifth on aggregate earnings.
- Total of the Other 41 Traded Clusters. Metro Phoenix compares poorly to the nation on the sum of the other 41 traded clusters, with an employment share 38 percent, and an aggregate earnings share 37 percent, less than the U.S. average in 2022. However, Metro Phoenix ranked in the middle of the comparison areas. Washington, D.C. had the highest aggregate earnings share. Between 2012 and 2022, the share in Metro Phoenix increased relative to the national average, especially on aggregate earnings. Metro Phoenix ranked sixth on employment and first on aggregate earnings. Boston had the greatest change in aggregate earnings share.

Metro Tucson

The sum of the 53 traded clusters in 2022 in Metro Tucson accounted for 28.84 percent of total employment, lower than the national average of 32.56 percent. The sum of the traded clusters in Metro Tucson accounted for 39.19 percent of total aggregate earnings in 2022, less than the national average of 44.79 percent.

Metro Tucson ranked sixth among the eight moderately large comparison metro areas in its traded cluster employment share in 2022. Metro Tucson's rankings have improved slightly from ranks of eighth between 2001 and 2006. In terms of the traded cluster aggregate earnings share, Metro Tucson also ranked sixth in 2002, up from eighth in some years between 2006 and 2012.

The change in the traded cluster employment share in Metro Tucson between 2012 and 2022 of 2.02 percentage points compared favorably to the national average gain of 0.41 percentage points. The traded cluster aggregate earnings share in Metro Tucson increased 0.88 percentage points during the same time period, also comparing favorably to the national average decrease of 0.27 percentage points. Metro Tucson ranked second on the 2012-to-2022 change in share based on employment, and fourth on the change based on aggregate earnings.

Metro Tucson compared well in several traded clusters in 2022, such as metal mining, aerospace vehicles and defense, and electric power generation and transmission, where it ranked first based on the share of both employment and aggregate earnings shares.

Table 44 summarizes traded clusters in Metro Tucson in 2022. In most of the 12 selected clusters, the ratio to the national average was lower based on aggregate earnings than on employment. This differential suggests that employment in these clusters in Metro Tucson is disproportionately in industries with lower earnings per worker.

In 2022, Metro Tucson's aggregate earnings share was sixth of the eight moderately large metro areas for the sum of the 53 traded clusters and for the sum of the 12 selected traded clusters. Metro Tucson ranked third on the sum of the other 41 traded clusters. It ranked second for the

TABLE 44
EMPLOYMENT AND AGGREGATE EARNINGS, SELECTED TRADED CLUSTERS, METROPOLITAN TUCSON, 2022

	Employment			Aggregate Earnings		
	Share of Total	Ratio to Nation	Rank*	Share of Total	Ratio to Nation	Rank*
Total Traded	28.84%	0.89	6	39.19%	0.88	6
Total of 12 Selected Traded Clusters	17.45	0.95	4	24.73	0.83	6
At Least Partially Manufacturing Clusters	4.54	1.74	2	10.07	2.03	2
Information Tech/Analytical Instruments	1.06	1.16	7	2.40	1.09	5
Aerospace Vehicles and Defense	3.15	8.38	1	7.27	10.96	1
Communications Equipment and Services	0.14	0.44	6	0.18	0.25	7
Biopharmaceuticals	0.00	0.02	8	0.02	0.04	7
Medical Devices	0.14	0.81	4	0.16	0.62	6
Automotive	0.04	0.07	7	0.05	0.07	7
Wholly Services Clusters	12.92	0.82	6	14.65	0.59	7
Business Services	6.22	0.94	5	7.35	0.67	7
Marketing, Design, and Publishing	0.49	0.47	6	0.58	0.37	6
Education and Knowledge Creation	0.99	0.48	7	1.21	0.48	7
Distribution and Electronic Commerce	3.49	0.91	2	2.87	0.61	6
Financial Services	0.84	0.63	5	1.52	0.42	6
Insurance Services	0.89	0.98	4	1.11	0.81	4
Other 41 Traded Clusters	11.39	0.80	4	14.47	0.96	3

* Among eight comparison metro areas

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

sum of the six at least partially manufacturing traded clusters, but only seventh for the sum of the six selected services traded clusters.

In Table 45, the employment shares in 2022 are shown for the nation and for each of the comparison areas. The shares of aggregate earnings are displayed in Table 46.

Focusing on the 10-year time period between 2012 and 2022, Table 47 depicts changes in employment and aggregate earnings shares in Metro Tucson relative to the nation. Between 2012 and 2022, Metro Tucson's change in share was stronger than the U.S. average in the sum of the 53 traded clusters on both employment and aggregate earnings. On the sum of the 12 selected clusters, the employment share had a sizable gain, but the change in aggregate earnings was less than the U.S. average. The change in the aggregate earnings share considerably exceeded the national average in the total of the other 41 traded clusters; the employment share also rose relative to the nation. Among the 12 selected clusters, Metro Tucson outperformed the nation in six.

The changes in employment shares between 2012 and 2022 are shown for the nation and for each of the comparison areas in Table 46. The change in shares of aggregate earnings are displayed in Table 47.

TABLE 45
EMPLOYMENT SHARE OF TOTAL, SELECTED TRADED CLUSTERS, UNITED STATES AND SELECTED SOUTHWESTERN METROPOLITAN AREAS, 2022

	US	Alb	Bou	CS	EP	FC	Pro	SLC	Tuc
Total Traded	32.56	27.67	39.52	35.52	30.64	25.64	36.95	36.22	28.84
Total of 12 Selected Traded Clusters	18.34	16.79	31.00	16.44	10.43	15.03	27.18	24.31	17.45
Total of at Least Partially Manufacturing Clusters	2.61	2.09	8.20	1.81	0.97	3.47	4.30	3.83	4.54
Information Technology and Analytical Instruments	0.92	1.14	4.74	1.19	0.17	2.24	2.92	1.85	1.06
Aerospace Vehicles and Defense	0.38	0.13	1.56	0.04	0.16	0.17	0.16	0.39	3.15
Communications Equipment and Services	0.32	0.47	0.74	0.12	0.16	0.28	0.33	0.13	0.14
Biopharmaceuticals	0.21	0.25	0.96	0.08	0.02	0.46	0.63	0.32	0.00
Medical Devices	0.17	0.11	0.09	0.26	0.18	0.10	0.04	1.08	0.14
Automotive	0.62	0.00	0.11	0.11	0.28	0.20	0.21	0.06	0.04
Total of Wholly Services Clusters	15.73	14.70	22.80	14.63	9.46	11.56	22.89	20.48	12.92
Business Services	6.60	5.99	12.13	8.03	5.04	5.67	8.88	8.49	6.22
Marketing, Design, and Publishing	1.04	0.41	2.02	0.64	0.35	0.97	1.72	1.19	0.49
Education and Knowledge Creation	2.05	3.99	4.19	1.59	0.30	1.24	8.17	2.76	0.99
Distribution and Electronic Commerce	3.81	2.52	3.09	2.17	2.82	2.63	2.51	3.86	3.49
Financial Services	1.33	0.62	1.25	1.08	0.59	0.83	1.36	3.24	0.84
Insurance Services	0.91	1.18	0.12	1.11	0.35	0.22	0.24	0.94	0.89
Total of Other 41 Traded Clusters	14.22	10.88	8.52	19.08	20.21	10.61	9.77	11.91	11.39

Alb: Albuquerque, New Mexico
Bou: Boulder, Colorado
CS: Colorado Springs, Colorado
EP: El Paso, Texas
FC: Fort Collins-Loveland, Colorado
Pro: Provo-Orem-Lehi, Utah
SLC: Salt Lake City-Murray, Utah
Tuc: Tucson, Arizona

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

TABLE 46
AGGREGATE EARNINGS SHARE OF TOTAL, SELECTED TRADED CLUSTERS, UNITED STATES AND SELECTED SOUTHWESTERN METROPOLITAN AREAS, 2022

	US	Alb	Bou	CS	EP	FC	Pro	SLC	Tuc
Total Traded	44.79	37.55	58.92	46.41	38.44	39.62	47.36	47.11	39.19
Total of 12 Selected Traded Clusters	29.72	24.29	51.60	26.13	11.68	28.00	38.13	35.03	24.73
Total of at Least Partially Manufacturing Clusters	4.96	3.22	15.28	2.98	1.13	7.85	9.22	6.15	10.07
Information Technology and Analytical Instruments	2.21	2.01	10.13	2.11	0.21	5.85	7.49	3.41	2.40
Aerospace Vehicles and Defense	0.66	0.22	2.30	0.10	0.18	0.42	0.26	0.57	7.27
Communications Equipment and Services	0.71	0.58	1.26	0.16	0.19	0.33	0.51	0.19	0.18
Biopharmaceuticals	0.42	0.29	1.32	0.06	0.01	0.76	0.64	0.46	0.02
Medical Devices	0.26	0.12	0.18	0.37	0.25	0.22	0.05	1.46	0.16
Automotive	0.69	0.00	0.10	0.18	0.29	0.28	0.27	0.06	0.05
Total of Wholly Services Clusters	24.76	21.06	36.32	23.15	10.55	20.15	28.92	28.88	14.65
Business Services	11.01	8.18	19.85	14.90	5.24	10.97	15.58	13.30	7.35
Marketing, Design, and Publishing	1.59	0.36	2.38	0.75	0.33	1.05	2.01	1.42	0.58
Education and Knowledge Creation	2.52	7.25	6.32	1.74	0.21	1.71	4.83	2.81	1.21
Distribution and Electronic Commerce	4.68	2.60	4.84	2.23	3.30	4.49	3.75	4.88	2.87
Financial Services	3.60	1.14	2.75	2.02	0.98	1.64	2.43	5.33	1.52
Insurance Services	1.37	1.54	0.19	1.52	0.51	0.29	0.32	1.15	1.11
Total of Other 41 Traded Clusters	15.07	13.26	7.32	20.27	26.76	11.62	9.23	12.08	14.47

Alb: Albuquerque, New Mexico
Bou: Boulder, Colorado
CS: Colorado Springs, Colorado
EP: El Paso, Texas
FC: Fort Collins-Loveland, Colorado
Pro: Provo-Orem-Lehi, Utah
SLC: Salt Lake City-Murray, Utah
Tuc: Tucson, Arizona

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

TABLE 47
EMPLOYMENT AND AGGREGATE EARNINGS, SELECTED TRADED CLUSTERS, METROPOLITAN TUCSON, 2012-TO-2022 CHANGE IN SHARE RELATIVE TO THE NATIONAL AVERAGE

	Employment		Aggregate Earnings	
	Share of Total	Rank*	Share of Total	Rank*
Total Traded	1.61	2	1.15	4
Total of 12 Selected Traded Clusters	1.09	2	-0.47	6
At Least Partially Manufacturing Clusters	0.42	1	0.15	1
Information Tech/Analytical Instruments	0.01	3	-0.03	3
Aerospace Vehicles and Defense	0.40	2	0.14	4
Communications Equipment and Services	0.04	2	-0.04	2
Biopharmaceuticals	-0.03	8	0.01	4
Medical Devices	0.05	3	0.09	4
Automotive	-0.04	4	-0.02	7
Wholly Services Clusters	0.67	2	-0.62	8
Business Services	-1.31	8	-1.86	8
Marketing, Design, and Publishing	-0.10	4	-0.13	2
Education and Knowledge Creation	-0.30	6	-0.78	5
Distribution and Electronic Commerce	1.54	1	0.88	2
Financial Services	0.08	4	0.29	4
Insurance Services	0.76	1	0.98	1
Other 41 Traded Clusters	0.53	4	1.62	1

* Among eight comparison metro areas

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

A summary of employment and aggregate earnings shares in each of the categories shown in Tables 42 through 47, with comparisons to the nation and ranks among the eight moderately large comparison metropolitan areas, follows:

- Total of All Traded Clusters. The share of the total in Metro Tucson was 11 percent below the U.S. average based on employment and 12 percent lower based on aggregate earnings in 2022. Metro Tucson ranked sixth on each measure. Boulder and Provo had the highest aggregate earnings shares. The employment and aggregate earnings shares in Metro Tucson increased considerably relative to the national average between 2012 and 2022, ranking second on employment and fourth on aggregate earnings. Boulder had the greatest change in the aggregate earnings share.
- Total of 12 Selected Traded Clusters. In 2022, the employment share in Metro Tucson of the sum of the 12 selected traded clusters was 5 percent below the U.S. average and ranked fourth. The aggregate earnings share was 17 percent below average and ranked sixth. Boulder and Provo had the highest aggregate earnings shares. Between 2012 and 2022, the employment share relative to the national average increased substantially in Metro Tucson, ranking second. However, the aggregate earnings share dropped, with Metro Tucson ranking sixth. Boulder and Salt Lake City had the greatest changes in the aggregate earnings share.

TABLE 48
EMPLOYMENT SHARE OF TOTAL, SELECTED TRADED CLUSTERS, UNITED STATES AND SELECTED SOUTHWESTERN METROPOLITAN AREAS, 2012-TO-2022 CHANGE

	US	Alb	Bou	CS	EP	FC	Pro	SLC	Tuc
Total Traded	0.41	-0.22	3.47	-2.81	0.51	-0.65	-0.79	0.69	2.02
Total of 12 Selected Traded Clusters	1.54	0.38	3.46	0.32	1.80	0.06	-0.28	2.26	2.62
Total of at Least Partially Manufacturing Clusters	0.11	-1.08	-0.04	-1.07	0.00	0.30	0.13	0.39	0.53
Information Technology and Analytical Instruments	0.15	-0.39	-1.06	-0.79	-0.04	-0.17	0.21	0.20	0.15
Aerospace Vehicles and Defense	-0.05	-0.33	0.77	-0.05	-0.04	0.12	0.03	-0.02	0.35
Communications Equipment and Services	-0.04	-0.48	0.08	-0.20	-0.20	-0.07	-0.20	-0.07	0.00
Biopharmaceuticals	0.03	0.12	0.25	0.02	0.01	0.26	0.17	0.04	-0.01
Medical Devices	0.00	0.02	-0.10	-0.05	0.16	0.04	0.02	0.25	0.05
Automotive	0.03	-0.03	0.03	-0.01	0.11	0.12	-0.10	-0.01	-0.01
Total of Wholly Services Clusters	1.43	1.47	3.50	1.39	1.80	-0.24	-0.40	1.87	2.10
Business Services	1.11	0.34	3.23	1.16	1.58	0.15	1.95	0.66	-0.20
Marketing, Design, and Publishing	0.07	-0.03	-0.20	-0.13	0.00	-0.25	-0.23	0.11	-0.03
Education and Knowledge Creation	-0.04	0.65	0.49	-0.20	-0.12	-0.47	-2.73	1.10	-0.34
Distribution and Electronic Commerce	0.43	0.36	0.32	0.95	0.43	0.45	0.06	-0.20	1.97
Financial Services	-0.09	-0.06	-0.31	-0.04	0.02	-0.09	0.50	0.19	-0.01
Insurance Services	-0.06	0.21	-0.03	-0.35	-0.10	-0.02	0.05	0.00	0.70
Total of Other 41 Traded Clusters	-1.13	-0.60	0.02	-3.13	-1.29	-0.71	-0.51	-1.56	-0.60

Alb: Albuquerque, New Mexico
Bou: Boulder, Colorado
CS: Colorado Springs, Colorado
EP: El Paso, Texas
FC: Fort Collins-Loveland, Colorado
Pro: Provo-Orem-Lehi, Utah
SLC: Salt Lake City-Murray, Utah
Tuc: Tucson, Arizona

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

TABLE 49
AGGREGATE EARNINGS SHARE OF TOTAL, SELECTED TRADED CLUSTERS, UNITED STATES AND SELECTED SOUTHWESTERN METROPOLITAN AREAS, 2012-TO-2022 CHANGE

	US	Alb	Bou	CS	EP	FC	Pro	SLC	Tuc
Total Traded	-0.27	-1.18	2.65	-4.28	-2.30	0.35	0.93	0.99	0.88
Total of 12 Selected Traded Clusters	2.13	0.00	3.97	1.25	2.03	2.40	2.59	3.55	1.66
Total of at Least Partially Manufacturing Clusters	0.27	-2.37	-0.75	-2.40	-0.12	-0.14	0.02	0.38	0.42
Information Technology and Analytical Instruments	0.51	-1.35	-0.85	-1.84	-0.01	-0.60	0.79	0.57	0.48
Aerospace Vehicles and Defense	-0.17	-0.64	0.37	-0.09	-0.11	0.25	0.04	-0.31	-0.03
Communications Equipment and Services	0.04	-0.50	0.26	-0.36	-0.31	-0.46	-0.65	-0.11	0.00
Biopharmaceuticals	-0.02	0.13	-0.37	-0.01	0.00	0.37	-0.06	-0.09	-0.01
Medical Devices	-0.03	0.03	-0.19	-0.09	0.23	0.11	0.02	0.32	0.06
Automotive	-0.06	-0.03	0.03	-0.01	0.08	0.19	-0.11	-0.01	-0.08
Total of Wholly Services Clusters	1.86	2.37	4.72	3.64	2.15	2.55	2.57	3.17	1.24
Business Services	1.79	1.14	5.49	3.55	1.74	2.82	5.56	1.96	-0.07
Marketing, Design, and Publishing	0.24	-0.06	-0.49	-0.09	-0.03	-0.23	-0.68	0.25	0.11
Education and Knowledge Creation	0.19	1.25	-0.68	-0.34	-0.12	-1.40	-2.36	1.09	-0.59
Distribution and Electronic Commerce	-0.06	-0.17	0.55	0.53	0.44	1.37	-0.29	-0.56	0.82
Financial Services	-0.11	0.11	-0.09	0.26	0.15	-0.01	0.30	0.55	0.18
Insurance Services	-0.19	0.11	-0.06	-0.26	-0.03	0.00	0.06	-0.11	0.79
Total of Other 41 Traded Clusters	-2.40	-1.18	-1.32	-5.53	-4.33	-2.05	-1.67	-2.56	-0.77

Alb: Albuquerque, New Mexico
Bou: Boulder, Colorado
CS: Colorado Springs, Colorado
EP: El Paso, Texas
FC: Fort Collins-Loveland, Colorado
Pro: Provo-Orem-Lehi, Utah
SLC: Salt Lake City-Murray, Utah
Tuc: Tucson, Arizona

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

- Total of Six at Least Partially Manufacturing Clusters. Metro Tucson's share was 74 percent higher than the U.S. average on employment and 103 percent above average on aggregate earnings, ranking second in 2022. Boulder had the highest aggregate earnings share. Between 2012 and 2022, the employment and aggregate earnings shares in Metro Tucson rose relative to the U.S. average, with Metro Tucson ranking first on each measure.
- Information Technology and Analytical Instruments. In Metro Tucson in 2022, the cluster's share was above the U.S. average by 16 percent based on employment and 9 percent on aggregate earnings, but the rank was only seventh on employment and fifth on aggregate earnings. Boulder and Provo had the highest aggregate earnings shares. Between 2012 and 2022, the shares in Metro Tucson were unchanged relative to the U.S. average, with Metro Tucson ranking third on both measures. Provo and Salt Lake City had the greatest changes in the aggregate earnings share.
- Aerospace Vehicles and Defense. Metro Tucson's strong performance on the total of the six at least partially manufacturing clusters was almost entirely due to the aerospace cluster. The cluster's employment share in Metro Tucson was 8.38 times higher than the U.S. average in 2022 and 10.96 times the average on aggregate earnings. Metro Tucson ranked first on each measure by a wide margin. Between 2012 and 2022, the shares in Metro Tucson increased relative to the U.S. average, with Metro Tucson ranking second on employment and fourth on aggregate earnings. Boulder and Fort Collins had the greatest changes in the aggregate earnings share.
- Communications Equipment and Services. The cluster's share of employment was 56 percent less than the U.S. average in Metro Tucson in 2022, ranking sixth. The aggregate earnings share in Metro Tucson was 75 percent below the U.S. average in 2022, ranking seventh, ahead of only Colorado Springs. Boulder had the highest aggregate earnings share. Between 2012 and 2022, there was little change in the employment share and in the aggregate earnings share in Metro Tucson relative to the U.S. average, with Metro Tucson ranking second on both measures. Boulder had the greatest change in the aggregate earnings share.
- Biopharmaceuticals. The cluster is hardly present in Metro Tucson, with shares more than 95 percent less than the U.S. average in 2022, ranking last on employment and seventh on aggregate earnings. Boulder had the highest aggregate earnings share. Between 2012 and 2022, little change in the employment share and in the aggregate earnings share occurred in Metro Tucson relative to the U.S. average, with Metro Tucson ranking last on employment and fourth on aggregate earnings. Fort Collins had the greatest change in the aggregate earnings share.
- Medical Devices. The share of employment in Metro Tucson was 19 percent less than the U.S. average in 2022 but ranked fourth. The aggregate earnings share was 38 percent below the U.S. average, ranking sixth. Salt Lake City had the highest aggregate earnings shares The cluster's share increased somewhat in Metro Tucson relative to the nation between 2012 and 2022, ranking third on employment and fourth on aggregate earnings. Salt Lake City had the greatest change in the aggregate earnings share.
- Automotive. In 2022, Metro Tucson's share was 93 percent less than the U.S. average and ranked seventh on both measures. All of the comparison areas were well below the U.S. average. Between 2012 and 2022, a small decrease in the employment share and in the aggregate earnings share occurred in Metro Tucson relative to the U.S. average, with

Metro Tucson ranking fourth on employment and seventh on aggregate earnings. El Paso had the greatest change in the aggregate earnings share.

- Total of Six Wholly Services Clusters. In 2022, the employment share in Metro Tucson of the sum of the six selected traded services clusters was 18 percent below the U.S. average, ranking sixth. The aggregate earnings share was 41 percent below average and ranked seventh. Boulder and Provo had the highest aggregate earnings shares. Between 2012 and 2022, a large increase in the employment share in Metro Tucson relative to the U.S. average ranked second, but a sizable decrease in the relative aggregate earnings share ranked last. Boulder and Colorado Springs had the greatest changes in the aggregate earnings share.
- Business Services. The employment share in Metro Tucson in 2022 was 6 percent below average and ranked fifth, but the share of aggregate earnings was 33 percent below average, ranking seventh. Boulder and Provo had the highest aggregate earnings shares. Between 2012 and 2022, the share in Metro Tucson fell considerably versus the nation, ranking last on both measures. Provo and Boulder had the greatest changes in the aggregate earnings share.
- Marketing, Design, and Publishing. The share in Metro Tucson in 2022 was 53 percent below average on employment and 63 percent below average on aggregate earnings, ranking sixth on each measure. Boulder and Provo had the highest aggregate earnings shares. Between 2012 and 2022, the share in Metro Tucson fell somewhat versus the nation, but ranked fourth on employment and second on aggregate earnings. None of the comparison areas had a change greater than the U.S. average.
- Education and Knowledge Creation. Metro Tucson's share in 2022 was 52 percent less than the U.S. average and ranked seventh on both measures. Albuquerque and Boulder had the highest aggregate earnings shares. Between 2012 and 2022, the share in Metro Tucson fell versus the nation on both employment and aggregate earnings, ranking sixth on employment and fifth on aggregate earnings. Albuquerque and Salt Lake City had the greatest changes in the aggregate earnings share.
- Distribution and Electronic Commerce. The cluster's share of employment in Metro Tucson in 2022 was 9 percent below average and ranked second, but the aggregate earnings share was 39 percent below the U.S. average and ranked sixth. Salt Lake City and Boulder had the highest aggregate earnings shares. Between 2012 and 2022, the share in Metro Tucson rose substantially versus the nation, ranking first on employment and second on aggregate earnings.
- Financial Services. The cluster's share of employment in Metro Tucson was 37 percent below the U.S. average in 2022, ranking fifth. The aggregate earnings share was 58 percent less than average, ranking sixth. Salt Lake City had the highest aggregate earnings share. Between 2012 and 2022, the share in Metro Tucson rose versus the nation, ranking fourth on both measures. Salt Lake City had the greatest change in the aggregate earnings share.
- Insurance Services. Metro Tucson's share of employment in 2022 was only 2 percent less than the U.S. average but the aggregate earnings share was 19 percent below average. Metro Tucson ranked fourth on each measure. Albuquerque and Colorado Springs had the highest aggregate earnings shares. Between 2012 and 2022, the share in Metro Tucson increased considerably versus the nation, ranking first on both measures.

- Total of the Other 41 Traded Clusters. Metro Tucson's employment share was 20 percent less than the U.S. average in 2022, ranking fourth. The aggregate earnings share was only 4 percent below average, ranking third. El Paso and Colorado Springs had the highest aggregate earnings shares. Between 2012 and 2022, the share in Metro Tucson rose relative to the national average. Metro Tucson ranked fourth on employment and first on aggregate earnings.

HIGH-TECHNOLOGY INDICATORS FOR ARIZONA

Most of the indicators examined in this section are not available by metropolitan area. Arizona is compared to the national average and is ranked among all states and among the eight comparison states. Historical data are provided in order to see how Arizona's position has changed over time. Categorical results from the Milken Institute's *State Technology and Science Index* and from the Information Technology and Innovation Foundation's *State New Economy Index* are examined first.

The indicators in the Milken and ITIF reports are a mixture of input variables and output variables. Research and development spending is an example of an input variable; the percentage of the workforce working in high-technology occupations is an example of an output variable. A few indicators, such as patents granted, might be considered to be either an input or output measure.

A number of specific indicators are examined in this section; some are output indicators, but most are input variables. For those indicators measured in dollars, it is possible to make a cost-of-living adjustment for 2008 through 2022, using the regional price parity estimates produced by the U.S. Department of Commerce, Bureau of Economic Analysis. Relative to the national average, Arizona's cost of living shifted from 3 percent above average in 2008 and 2009 to 3 percent below average in 2021; the 2022 figure was nearly identical to the national average. With Arizona's cost of living not much different from the national average, a cost-of-living adjustment does not have much effect on Arizona's percentage of the national average, but a more noticeable effect may be seen in the state's ranks since the adjustment has more of an effect in high-cost and low-cost states. Though Arizona's cost of living has been less than the U.S. average since 2011, adjusting for the cost of living may worsen the state's ranking.

Milken Institute

Every two years, the Milken Institute updates its *State Technology and Science Index*. The last report, for 2022, was released at the end of November 2022. The earliest data available online are for 2010.

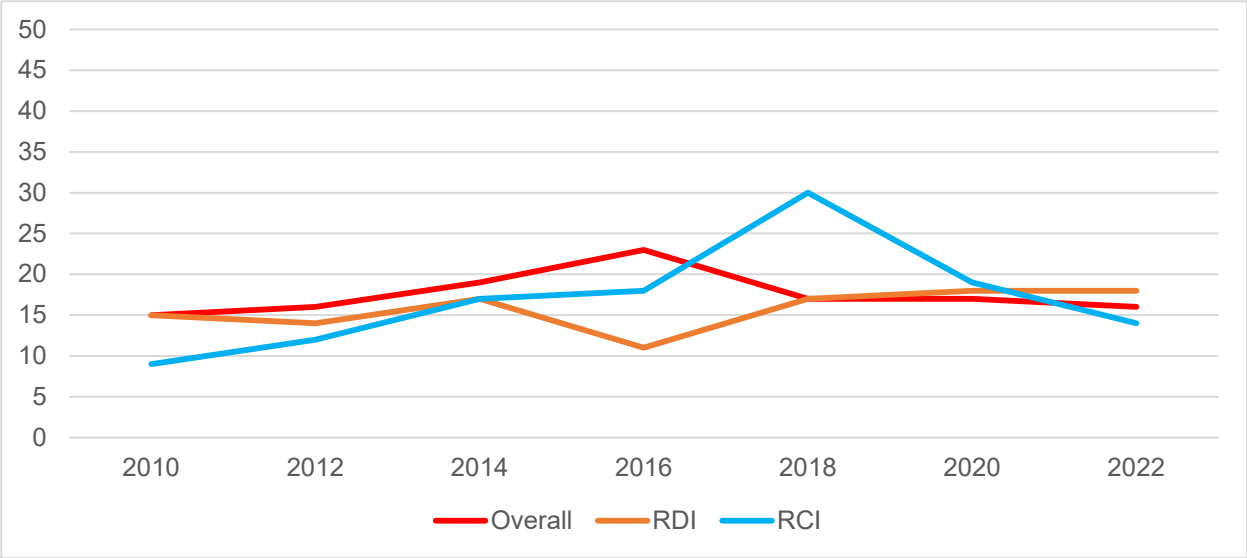
The report ranks the 50 states on an overall index and on each of five subindices:

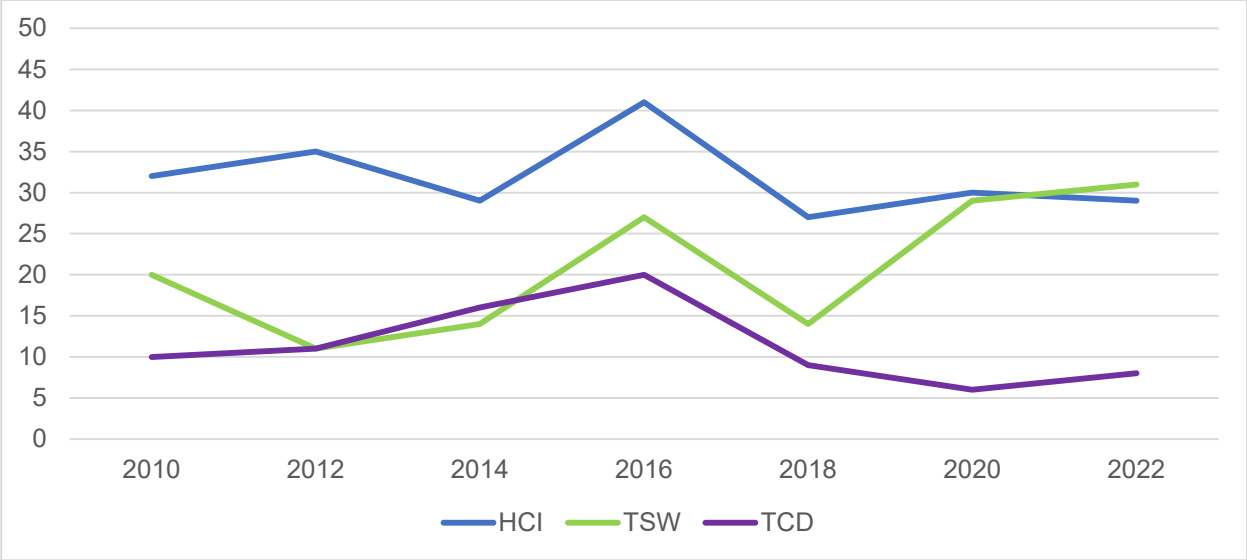
- Research and Development Inputs
- Risk Capital and Entrepreneurial Infrastructure
- Human Capital Investment
- Technology and Science Workforce
- Technology Concentration and Dynamism

Each of the five subindexes consist of several-to-numerous indicators. Changes have occurred over time in the list of indicators included, meaning that year-to-year comparisons could reflect changes in methodology as well as changes in science and technology conditions in a given state.

On the overall index, Arizona's ranks from 2010 to 2022 generally ranged between 15th and 19th. No trend is apparent (see Chart 17). In each year, Arizona ranked last among the eight comparison states.

CHART 17
ARIZONA'S RANKS IN THE MILKEN INSTITUTE'S STATE TECHNOLOGY AND SCIENCE INDEX





Notes:

The rank is among the 50 states; a rank of 1 is best
RDI: Research and Development Inputs
RCI: Risk Capital and Entrepreneurial Infrastructure
HCI: Human Capital Investment
TSW: Technology and Science Workforce
TCD: Technology Concentration and Dynamism

Source: Milken Institute, *State Technology and Science Index*, various years.

Not much trend is seen in Arizona's ranks in the subindices. Slight improvement occurred in the Technology Concentration and Dynamism subindex, but Arizona's position worsened in the Technology and Science Workforce subindex. In most years, Arizona compared least favorably in the Human Capital Investment subindex, with national ranks mostly between 27th and 35th; Arizona ranked last among the eight comparison states. In recent years, Arizona's national rank in the Technology and Science Workforce subindex has been similar to that of the Human Capital Investment subindex, both nationally and among the comparison states.

Arizona's strongest performance nationally in recent years has been in the Technology Concentration and Dynamism subindex, though the state ranked last among the comparison states in 2022. The strongest performance relative to the comparison states has been in the Risk Capital and Entrepreneurial Infrastructure subindex, with ranks ranging from fifth to eighth.

Information Technology and Innovation Foundation

Periodically, the ITIF updates its *State New Economy Index*. The last report was released in 2020. The earliest data are for 1999.

The report ranks the 50 states on an overall index and on each of five subindices:

- Knowledge Jobs
- Innovation Capacity
- Economic Dynamism
- Digital Economy
- Globalization

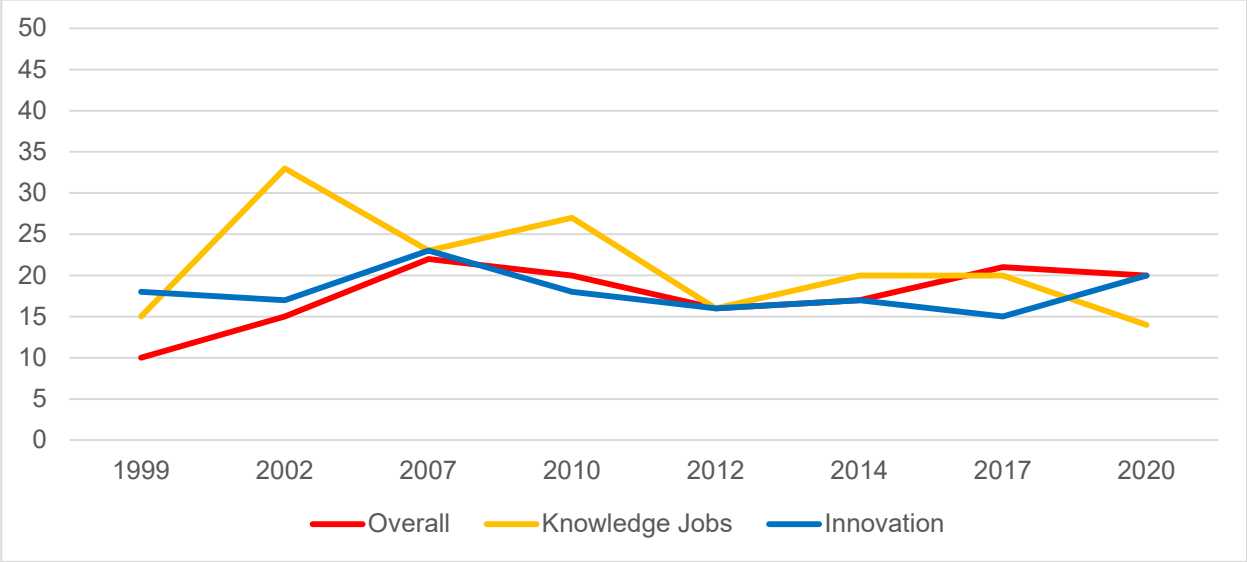
There are 25 indicators spread across the five subindices. With fewer indicators than the Milken Institute's report, the ITIF's results are more variable from year to year.

The ITIF's report is broader in nature than the Milken Institute's report, bringing in indicators, such as those related to globalization, not included in Milken's report. For the purposes of this paper, two of the ITIF's subindices are of particular importance: Knowledge Jobs and Innovation Capacity. The time series of Arizona's ranks in these subindices, as well as the overall index, are shown in Chart 18.

Since 2010, Arizona's overall ranking from the ITIF has been similar to that from Milken, with ranks between 16th and 21st. There has been no apparent trend. Arizona's national ranks in the ITIF's knowledge jobs subindex have been superior to those in Milken's Technology and Science Workforce subindex, but Arizona generally has ranked last among the eight comparison states even on the ITIF's measure. In the ITIF's Innovation Capacity subindex, Arizona's national rank generally has been between 15th and 20th, with Arizona ranking seventh or eighth among the eight comparison states.

Thus, the Milken Institute and the ITIF suggest that Arizona is a second-tier technology state, ranking above most states, but comparing poorly to the leading states. The state's high-tech share of employment in 2022 ranks similarly: 14th based on industrial data and 17th based on occupational data . However, the state's high-tech shares of employment and aggregate earnings are only about equal to the U.S. average.

CHART 18
ARIZONA'S RANKS IN THE ITIF'S
STATE NEW ECONOMY INDEX



Note: A rank of 1 is best

Source: Information Technology and Innovation Foundation, *State New Economy Index*, various years.

STEM Share of Employment and Aggregate Earnings

The STEM/high-tech shares of employment and aggregate earnings are perhaps the best measures of high-tech output. The STEM shares are analyzed both occupationally and industrially, overall and by category. The occupational categories, their national share of total high-tech occupational aggregate earnings in 2022, and median earnings per worker nationally in 2022 follow. The overall occupational median earnings per worker figure was $55,281; the overall STEM figure was 73 percent higher at $95,685.

- Computer, 61 percent, $101,828.
- Engineering, 21 percent, $98,858.
- Science, 6 percent, $81,434.
- Mathematics, 5 percent, $118,680.
- Engineering Technicians, 4 percent, $51,607.
- Science Technicians, 3 percent, $73,120.

Thus, computer-related occupations accounted for more than 60 percent of the overall occupational high-tech aggregate earnings. The computer category has the second-highest earnings per worker, behind mathematics. In contrast, earnings per worker are lowest in the two technician categories, with the median in the engineering technician category less than the figure for the overall economy.

For this analysis, the industrial categories differ from, and are more detailed than, those categories discussed earlier in this report — those category definitions were limited by the amount of industry detail available from the historical County Business Patterns reports. The industrial categories, their national share of total high-tech industrial aggregate earnings in 2022,

and average earnings per worker nationally in 2022 follow. The overall earnings per worker figure was $80,830; the overall STEM figure was twice as high at $161,502.

- Computer Services, 49 percent, $176,628.
- Engineering Services, 12 percent, $120,394.
- Research and Development, 11 percent, $187,714.
- Computer and Electronics Manufacturing, 8 percent, $199,784.
- Aerospace Manufacturing, 5 percent, $140,624.
- Instruments Manufacturing, 4 percent, $140,189.
- Biopharmaceutical Manufacturing, 4 percent, $165,679.
- Scientific and Technical Consulting, 3 percent, $112,002.
- Other High-Technology Manufacturing, 2 percent, $139,878.
- Telecommunications, 2 percent, $138,972.

Thus, computer services industries account for nearly half of high-tech industrial aggregate earnings. While each of the high-tech industrial categories pay well — at least 38 percent more than the economywide average — computer and electronics manufacturing, research and development, and computer services have the highest figures.

The following analysis looks at the entire time series of data from Lightcast: 2001 through 2022 except for 2005 through 2022 for occupational aggregate earnings. In addition, the change in high-tech share between 2012 and 2022 is highlighted.

States

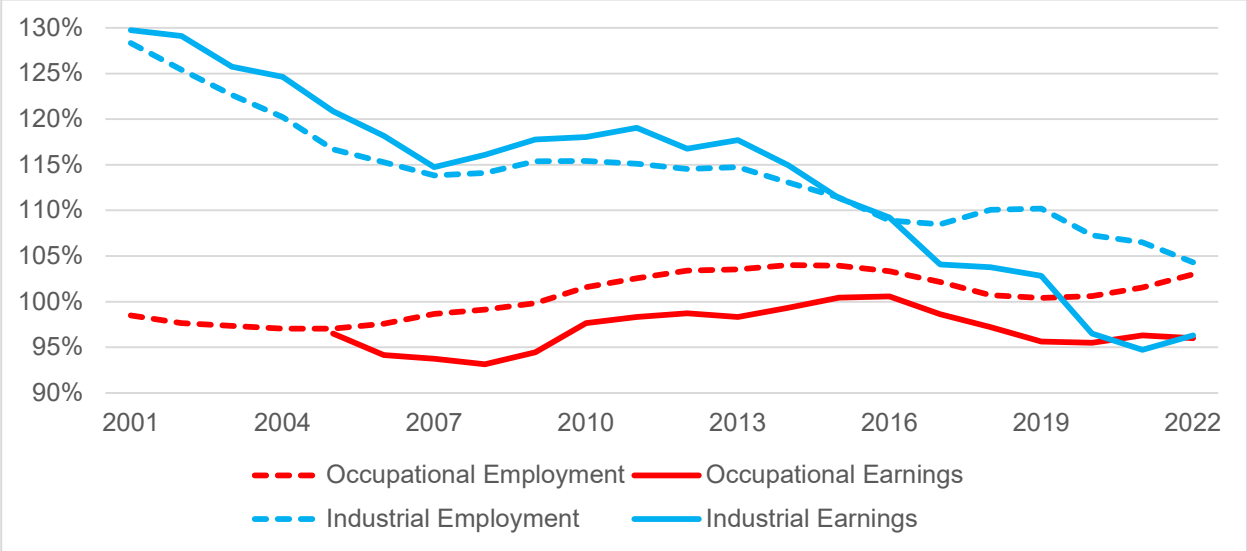
Arizona's overall high-tech share relative to the national average is shown in Chart 19 for the 2001-through-2022 period based on both employment and aggregate earnings and using both occupational and industrial data. Based on occupational employment, Arizona's high-tech share improved modestly relative to the U.S. average between 2005 and 2014, but then then dropped back slightly. Arizona's occupational aggregate earnings improved from 2008 through 2016, but most of the improvement was lost after that. In contrast, significant decreases relative to the nation have occurred in the high-tech shares based on the industrial data, especially based on aggregate earnings.

Occupation. In 2022, Arizona's high-tech share of occupational employment was 5.91 percent, slightly higher than the national average of 5.74 percent. The change in share in Arizona between 2012 and 2022 of 0.52 percentage points was nearly identical to the U.S. average. Among all states, Arizona ranked 17th in 2022 and 19th on the 2012-to-2022 change.

Arizona's high-tech share of occupational aggregate earnings in 2022 was 9.54 percent, a little less than the national average of 9.94 percent. The change in share in Arizona between 2012 and 2022 of 0.51 percentage points was less than the U.S. average of 0.79 percentage points. Among all states, Arizona ranked 19th in 2022 and 26th on the 2012-to-2022 change. Thus, Arizona compares less favorably based on aggregate earnings than employment, indicating that occupational high-tech job quality (as defined by median earnings) is a little below average in Arizona.

Arizona ranked last among the eight comparison states in its high-tech occupational share of the total economy in every year from 2001 through 2022, based on both employment and aggregate

CHART 19
TOTAL HIGH-TECHNOLOGY SHARE IN ARIZONA
AS A PERCENTAGE OF THE NATIONAL AVERAGE



Source: Calculated from data from Lightcast, https://www.economicmodeling.com/ (employment and earnings). High-technology categories defined by authors.

earnings. On the 2012-to-2022 change in share, Arizona ranked sixth based on employment, ahead of Massachusetts and Virginia, and seventh based on aggregate earnings, ahead of Massachusetts. However, Arizona's share in 2022 still was far less than the shares in these two states. Arizona lost ground to most of the leading high-tech states over the last decade.

Arizona's share in 2022 in the large computer category exceeded the national average based on employment, but not based on aggregate earnings. Arizona was last among the comparison states on each measure. In the moderately sized engineering category, Arizona's employment share in 2022 equaled the national average but ranked last among the comparison states, while its aggregate earnings share was a little above the U.S. average and ranked fifth among the comparison states. In the science category, Arizona's share in 2022 was far below the national average, ranking last based on employment and 50th based on aggregate earnings. Arizona's share in 2022 was less than the national average in the math and science technicians categories, ranking last among the comparison states. In the engineering technicians category, Arizona's share was a little above average in 2022 and ranked fourth among the comparison states. Table 50 summarizes the high-tech occupational data for Arizona.

As seen in Table 50, the gain in the occupational high-tech share of employment and aggregate earnings nationally occurred largely in the computer category, with the math category also recording an increase. In contrast, the engineering and engineering technicians categories experienced declines.

Between 2012 and 2022, the change in share in Arizona exceeded the national average in the computer category based on employment. Otherwise, the change in Arizona was similar to, or a

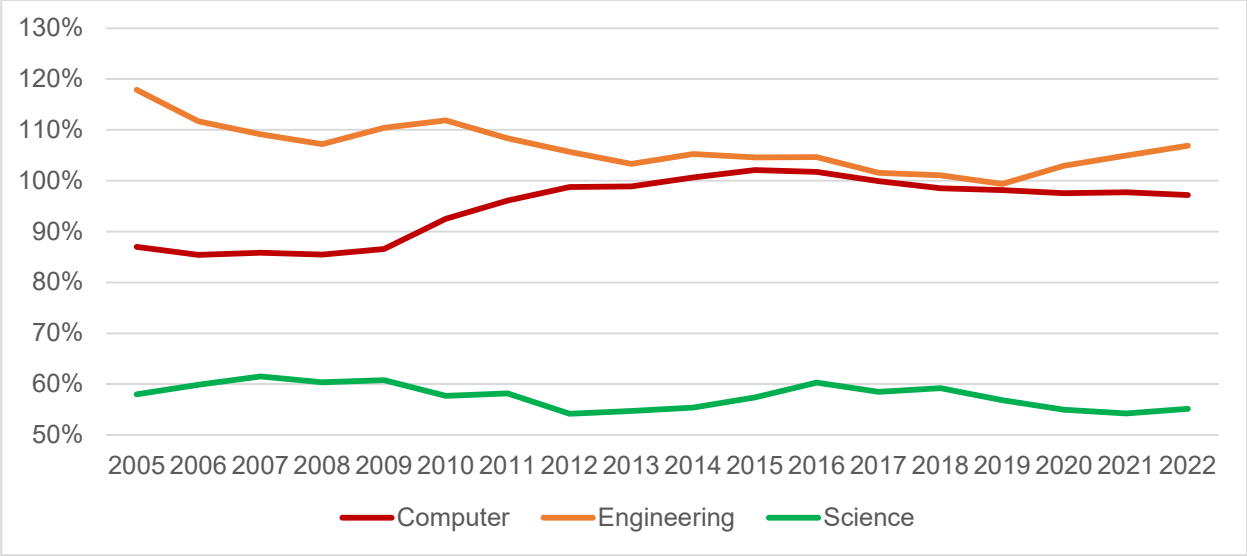
TABLE 50
SUMMARY OF OCCUPATIONAL HIGH TECHNOLOGY IN ARIZONA

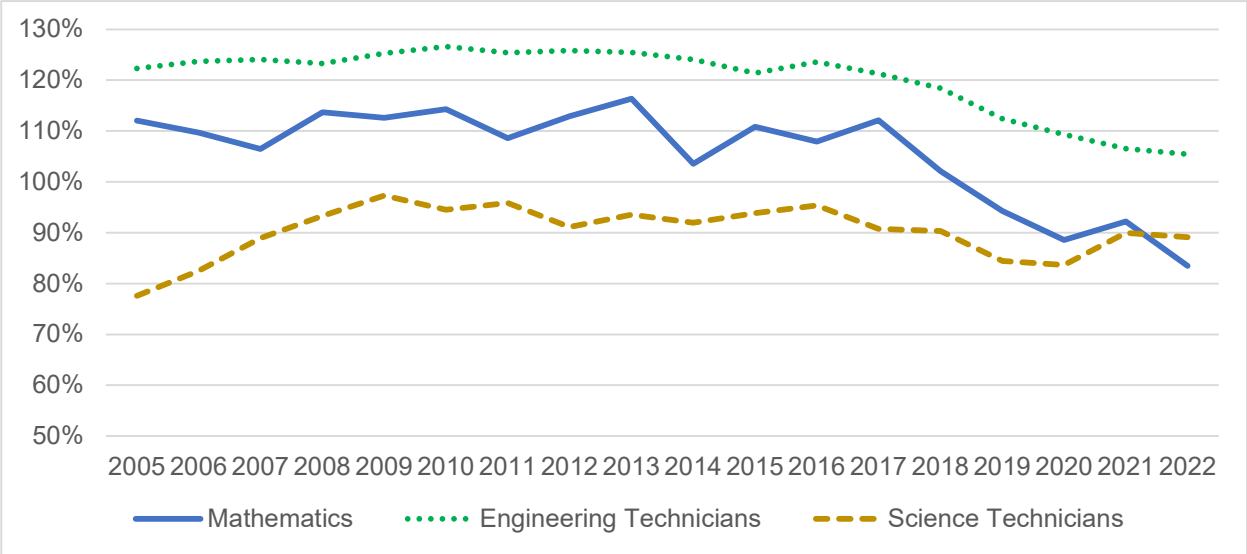
	Total	Computer	Math	Engineering	Engineering Tech	Science	Science Tech
Employment, 2022							
Arizona Share	5.91	3.71	0.19	1.17	0.42	0.25	0.19
Percentage of Nation	103	112	90	100	104	57	85
Rank Among 51 States	17	11	25	23	21	51	42
Rank Among 8 Comparison States	8	8	8	8	4	8	8
Aggregate Earnings, 2022							
Arizona Share	9.54	5.93	0.37	2.23	0.40	0.35	0.26
Percentage of Nation	96	97	83	107	105	55	89
Rank Among 51 States	19	16	26	15	27	50	37
Rank Among 8 Comparison States	8	8	8	5	4	8	8
Employment, 2012-to-2022 Change							
Arizona Share	0.52	0.80	0.03	-0.07	-0.15	-0.05	-0.05
National Share	0.53	0.54	0.09	-0.03	-0.07	0.01	-0.01
Rank Among 51 States	19	7	43	34	49	43	42
Rank Among 8 Comparison States	6	5	8	4	8	8	8
Aggregate Earnings, 2012-to-2022 Change							
Arizona Share	0.51	1.06	0.05	-0.28	-0.27	-0.05	-0.01
National Share	0.79	1.17	0.16	-0.29	-0.15	-0.10	0.00
Rank Among 51 States	26	16	44	33	50	13	34
Rank Among 8 Comparison States	7	7	8	2	8	2	6

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/ (employment and earnings). High-technology categories defined by authors.

little less than, the national average. Other than the computer category, Arizona ranked from below the middle of the states to near the bottom of the states on the 2012-to-2022 change, except in the science category based on aggregate earnings. Chart 20 provides the annual percentage of the national average based on aggregate earnings in each of the occupational categories.

CHART 20
AGGREGATE EARNINGS SHARE IN ARIZONA BY OCCUPATIONAL HIGH-TECHNOLOGY CATEGORY AS A PERCENTAGE OF THE NATIONAL AVERAGE





Source: Calculated from data from Lightcast, https://www.economicmodeling.com/ (employment and earnings). High-technology categories defined by authors.

Industry. In 2022, Arizona's high-tech share of industrial employment was 5.42 percent, slightly higher than the national average of 5.19 percent. The change in share in Arizona between 2012 and 2022 of 0.35 percentage points was less than the U.S. average of 0.77. Among all states, Arizona ranked 14th in 2022 but only 38th on the 2012-to-2022 change.

Arizona's high-tech share of industrial aggregate earnings in 2022 was 9.99 percent, less than the national average of 10.38 percent. The share in Arizona slipped 0.11 percentage points between 2012 and 2022, compared to a gain of 1.72 percentage points nationally. Among all states, Arizona ranked 12th in 2022 but 49th on the 2012-to-2022 change. As with the occupational data, Arizona industrially compares less favorably based on aggregate earnings than employment, indicating that high-tech job quality in Arizona is a little below average.

Arizona ranked last among the eight comparison states in its high-tech industrial share of the total economy in every year from 2014 through 2022, based on both employment and aggregate earnings. Arizona also ranked last on the 2012-to-2022 change in industrial share.

Among the five industrial manufacturing categories, Arizona's shares in 2022 in the computer and electronics category and the aerospace category were considerably above the national average based on both employment and aggregate earnings, with the state ranked second in the comparison group and between fourth and sixth nationally. In the other three manufacturing categories, Arizona's share was less than the national average — far less in biopharmaceuticals. Table 51 summarizes the high-tech industrial data for Arizona.

As seen in Table 51, the gain in the industrial high-tech share of employment and aggregate earnings nationally was almost entirely in the computer services category, with the gain in the research and development category offset by losses in the other categories.

Between 2012 and 2022, the change in Arizona was substantially less than the national average in six of the 10 industrial categories, based on both employment and aggregate earnings. Arizona ranked between 46th and 51st in the computer and electronics manufacturing, aerospace manufacturing, instruments manufacturing, and engineering services categories. Arizona also was well below the national average in the computer services and research and development categories. While Arizona outperformed the nation particularly in the biopharmaceuticals manufacturing category, it remained far below average in 2022. Chart 21 provides the annual percentage of the national average based on aggregate earnings in each of the industrial categories.

As was seen in Chart 19, Arizona's overall industrial high-tech share relative to the nation dropped from 2001 through 2007 and again from 2013 through 2021. The decline in the former period largely can be traced to computer and electronics manufacturing and scientific and technical consulting. The decrease in the latter period largely resulted from the computer and electronics manufacturing and instruments manufacturing categories.

TABLE 51
SUMMARY OF INDUSTRIAL HIGH TECHNOLOGY IN ARIZONA

		Manufacturing				
	Total	Computers & Electronics	Aerospace	Instruments	Biopharm-aceuticals	Other High Tech
Employment, 2022						
Arizona Share	5.42	0.74	0.88	0.22	0.14	0.11
Percentage of Nation	104	226	294	86	66	77
Rank Among 51 States	14	6	4	18	26	26
Rank Among 8 States	8	2	2	7	6	6
Aggregate Earnings, 2022						
Arizona Share	9.99	1.76	1.68	0.36	0.16	0.20
Percentage of Nation	96	218	323	83	38	80
Rank Among 51 States	12	4	4	15	31	19
Rank Among 8 States	8	2	2	6	6	5
Employment, 2012-to-2022 Change						
Arizona Share	0.35	-0.16	-0.08	-0.21	0.07	-0.02
National Share	0.77	-0.04	-0.03	-0.02	0.03	-0.03
Rank Among 51 States	38	47	47	51	11	28
Rank Among 8 States	8	7	6	8	3	2
Aggregate Earnings, 2012-to-2022 Change						
Arizona Share	-0.11	-0.40	-0.46	-0.54	0.07	-0.02
National Share	1.72	0.01	-0.13	-0.06	-0.02	-0.07
Rank Among 51 States	49	46	49	51	12	20
Rank Among 8 States	8	7	7	8	2	1

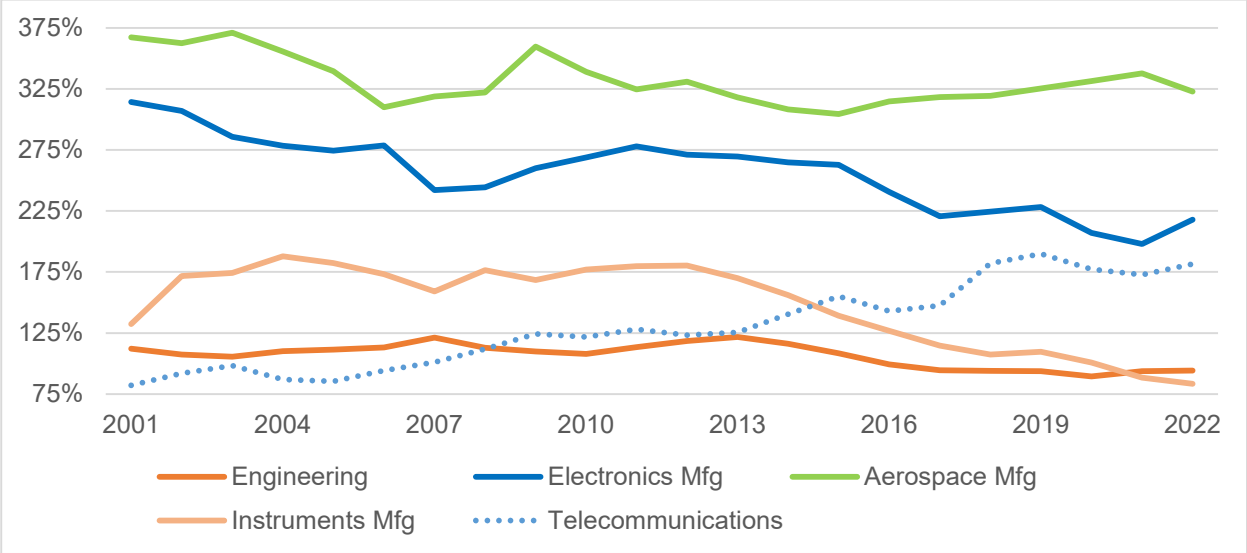
(continued)

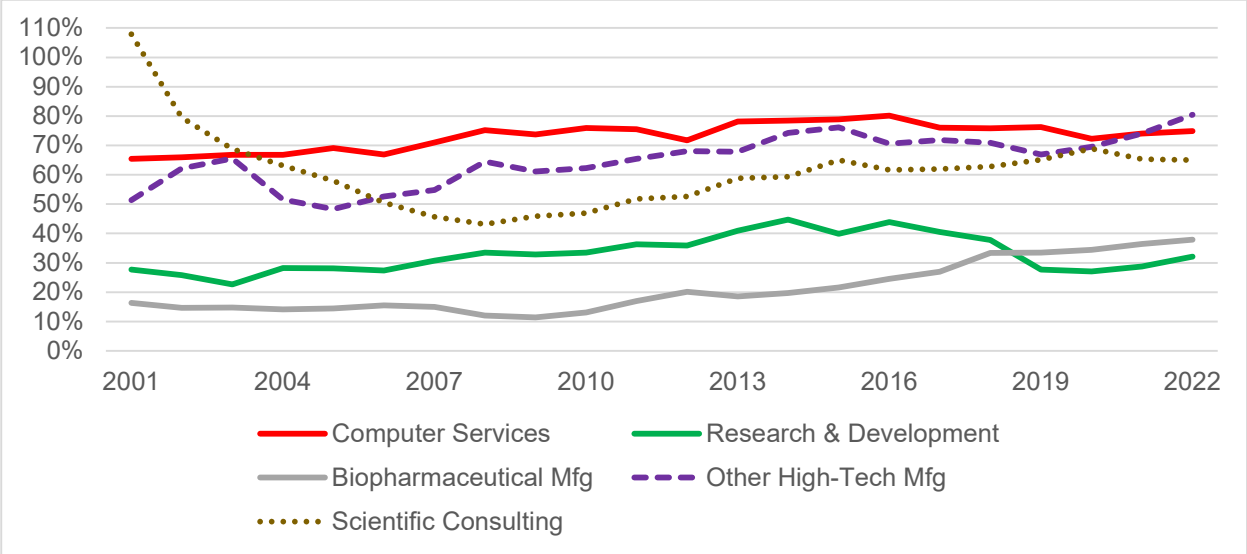
TABLE 51 (continued)
SUMMARY OF INDUSTRIAL HIGH TECHNOLOGY IN ARIZONA

	Services				
	Computer Services	**Engineering Services**	**Research & Development**	**Scientific & Technical Consulting**	**Telecommun-ications**
Employment, 2022					
Arizona Share	2.04	0.77	0.18	0.16	0.19
Percentage of Nation	88	93	36	73	207
Rank Among 51 States	18	26	35	30	4
Rank Among 8 States	8	8	8	7	2
Aggregate Earnings, 2022					
Arizona Share	3.82	1.16	0.37	0.20	0.29
Percentage of Nation	75	94	32	65	182
Rank Among 51 States	20	22	36	38	4
Rank Among 8 States	8	6	8	8	2
Employment, 2012-to-2022 Change					
Arizona Share	0.69	-0.00	0.01	0.04	0.02
National Share	0.74	0.05	0.10	0.00	-0.04
Rank Among 51 States	15	38	35	17	6
Rank Among 8 States	6	4	7	5	2
Aggregate Earnings, 2012-to-2022 Change					
Arizona Share	1.46	-0.35	0.06	0.03	0.03
National Share	1.81	-0.04	0.28	-0.01	-0.05
Rank Among 51 States	14	47	30	21	6
Rank Among 8 States	6	7	6	5	1

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/ (employment and earnings). High-technology categories defined by authors.

CHART 21
AGGREGATE EARNINGS SHARE IN ARIZONA BY HIGH-TECHNOLOGY INDUSTRIAL CATEGORY AS A PERCENTAGE OF THE NATIONAL AVERAGE





Source: Calculated from data from Lightcast, https://www.economicmodeling.com/ (employment and earnings). High-technology categories defined by authors.

Metropolitan Areas

Occupation. Metro Phoenix ranked last among 12 large metro areas in its high-tech occupational share of the total economy in every year from 2001 through 2022, based on both employment and aggregate earnings. Moreover, the Phoenix area ranked last on the 2012-to-2022 change in share, based on both employment and aggregate earnings. Thus, Metro Phoenix lost ground to the leading high-tech centers over the last decade.

Metro Tucson did not fare much better versus its comparison group of eight mid-sized metro areas in the Southwest, ranking seventh on the total high-tech share in recent years based on both employment and aggregate earnings, greater than only Metro El Paso. The 2012-to-2022 change in share in Metro Tucson ranked fourth based on employment, but just seventh based on aggregate earnings (ahead of Metro Fort Collins).

The poor overall occupational high-tech comparison in Metro Phoenix in 2022 resulted from at best an average rank in the comparison group in each of the six categories. In the large computer category, Metro Phoenix ranked 10th based on employment and 11th based on aggregate earnings, with the Portland and San Diego metro areas also ranking low. Metro Phoenix also ranked at or near the bottom in the engineering, science, and science technician categories.

On the change in occupational high-tech share between 2012 and 2022, Metro Phoenix's last-place ranking overall resulted from average-to-below-average performance in five of the six categories. The exception was engineering. In the computer category, Metro Phoenix ranked sixth on employment but only 10th on aggregate earnings.

The average-to-below-average overall occupational high-tech comparison in Metro Tucson in 2022 resulted from average-to-below-average ranks in the comparison group except in the science technician category based on aggregate earnings. In the large computer category, Metro Tucson ranked fifth based on employment and sixth based on aggregate earnings.

On the change in occupational high-tech share between 2012 and 2022, Metro Tucson ranked average-to-below-average except in the engineering technicians category, and the science technicians category based aggregate earnings. In the computer category, the Tucson area ranked fourth on employment and fifth on aggregate earnings.

Industry. Metro Phoenix ranked last in its comparison group in its high-tech industrial share of the total economy in 2022, having ranked 11th or 12th in every year from 2001 through 2022, based on both employment and aggregate earnings. (In some years, the industrial high-tech share in Metro Phoenix exceeded that of Metro Baltimore.) Moreover, the Phoenix area ranked last on the 2012-to-2022 change in share, based on both employment and aggregate earnings. Thus, Metro Phoenix lost ground to the leading high-tech centers over the last decade based on both the industrial data and the occupational data.

Metro Tucson did not fare much better in 2022 versus its comparison group, ranking seventh on the total industrial high-tech employment share and sixth based on aggregate earnings, greater than only Metro El Paso, and Metro Salt Lake City based on aggregate earnings. The 2012-to-

2022 change in share in Metro Tucson ranked fifth based on employment, but was last based on aggregate earnings.

The poor overall industrial high-tech comparison in Metro Phoenix in 2022 resulted from ranks of ninth or worse in six of the 10 categories based on employment and in seven categories based on aggregate earnings. In the large computer services category, Metro Phoenix ranked 11th based on employment (ahead of San Diego) and 12th based on aggregate earnings. Metro Phoenix also ranked at or near the bottom in the instruments manufacturing, "other high-tech" manufacturing, research and development, engineering services, and scientific and technical consulting categories. In contrast, Metro Phoenix ranked second in the aerospace manufacturing and telecommunications categories.

On the change in industrial high-tech share between 2012 and 2022, Metro Phoenix's last-place ranking overall resulted from average-to-below-average performance in all but one of the categories. The exception was biotech manufacturing. In the computer services category, Metro Phoenix ranked eighth.

The below-average overall industrial high-tech comparison in Metro Tucson in 2022 resulted from average-to-below-average ranks in the comparison group except in the aerospace manufacturing category, on which the Tucson area ranked first. In the large computer services category, Metro Tucson ranked sixth.

On the change in industrial high-tech share between 2012 and 2022, Metro Tucson's ranks were variable, ranging from first or second in the instruments manufacturing and aerospace manufacturing categories to last in the computer services category and seventh in the engineering services category.

Semiconductor Industry. The semiconductor industry is one of nine industries included in the computer and electronics manufacturing industrial category. Largely due to the construction of the Taiwan Semiconductor Manufacturing Company's sizable facility in Phoenix — which will not begin production until 2025 — and the federal government's renewed interest in the semiconductor industry, this industry has received considerable attention of late in Arizona.

Since 2001, approximately 95 percent of the employment in the state's semiconductor industry has been located in Metro Phoenix. The number employed in Metro Phoenix and Arizona decreased by 48 percent between 2001 and 2017; nationally, the decline was 38 percent. Between 2017 and 2022, semiconductor employment increased 25 percent in Arizona and 10 percent nationally. The state's employment figure of 21,800 in 2022 remained far below the 33,750 of 2001. As a share of the total economy, semiconductor employment in Arizona decreased relative to the nation from the 1970s through 2017, with only a modest improvement since then.

Electric Vehicles. Electric vehicle manufacturing also has garnered significant attention in Arizona in recent years as several companies have located facilities in the state. Since the NAICS does not distinguish between electric and traditional vehicles, it is not possible to track the development of electric vehicle manufacturing in Arizona versus other states. Automobile

manufacturing employment in Arizona rose from less than 100 prior to 2020 to 4,200 in 2022, but this represented only 0.1 percent of the state's employment.

Human Capital Indicators

As with the high-tech shares of the economy, less than half of the states are above the national average on each of the human capital indicators examined in this subsection. Using the latest data for these indicators and the 2022 high-tech shares across the 51 "states," most of these indicators are at least moderately correlated to the high-tech shares, as measured by employment and aggregate earnings using occupational and industrial data. However, the existence of a correlation does not imply cause and effect. While strong human capital may contribute to high-tech success, strong human capital may also be the result of the presence of so many high-tech jobs that require substantial educational attainment in technical fields.

Public Funding for Education

Current levels of public funding for K-12 education and higher education are only weakly correlated to high-tech shares. However, it is possible that funding levels decades ago contributed to the development of high-tech centers.

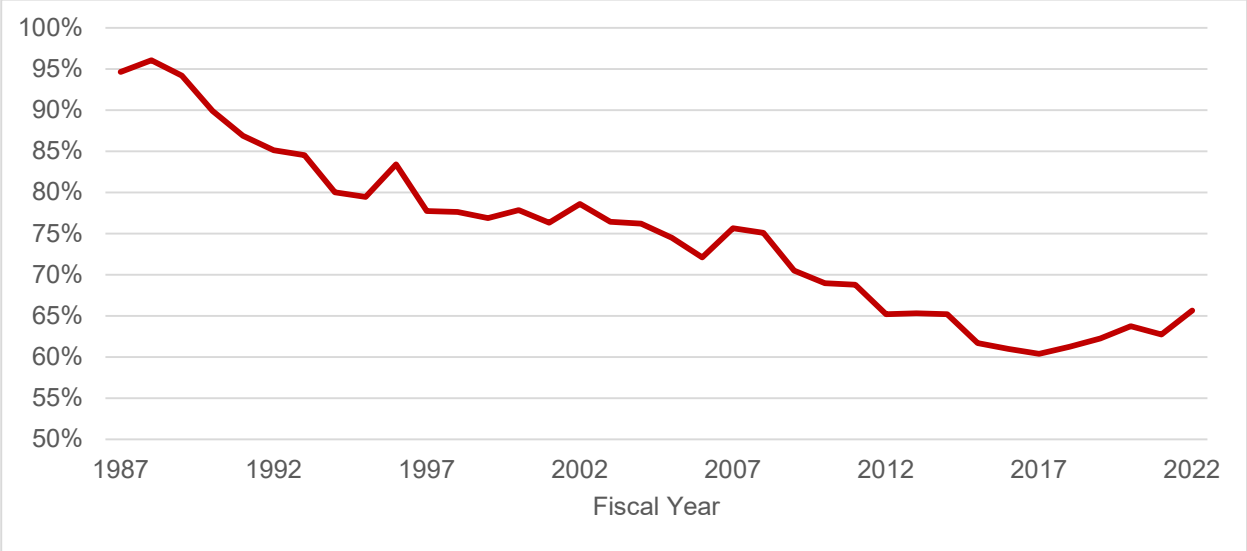
Elementary and Secondary Education. The U.S. Census Bureau has provided annual data by state on K-12 education finance since fiscal year (FY) 1987. This analysis focuses on revenue provided by state and local governments. As seen in Chart 22, per student state and local revenue in Arizona was not much less than the national average at the beginning of the time series, but fell significantly relative to the U.S. average through FY 2017. Adjusted for the cost of living, Arizona's figure in FY 2022 was 33 percent less than the national average, ranking 48th. Using unadjusted data, Arizona was 34 percent below average in FY 2022, ranking 46th.

Higher Education.[31] The State Higher Education Executive Officers Association (SHEEO) produces an annual report on "State Higher Education Finance" (https://sheeo.org/project/state-higher-education-finance/). The time series runs from fiscal year 1980 through FY 2023. By state, finance and enrollment data from all public universities and public community colleges are combined. The SHEEO report focuses on the sources of funding for higher education but does not include revenue from all sources. Three categories of revenue are examined in this paper:

- Educational Appropriations for Public Higher Education: The sum of state government appropriations and local government funding, minus appropriations for special purposes, research, and medical programs.
- Net Tuition for Public Higher Education: Tuition and fees paid by students, minus financial aid from state and institutional sources, student waivers and discounts, and medical student tuition and fees.
- Total Educational Revenue for Public Higher Education: The sum of the educational appropriations category and the net tuition category, minus tuition revenue used for capital outlays or debt service.

[31] For a more thorough discussion, see "The Financing of Public Higher Education in Arizona," July 2023, https://ccpr.wpcarey.asu.edu/sites/default/files/2023-07/highereduc07-23.pdf.

CHART 22
STATE AND LOCAL GOVERNMENT EDUCATIONAL FUNDING PER STUDENT IN ARIZONA AS A PERCENTAGE OF THE NATIONAL AVERAGE



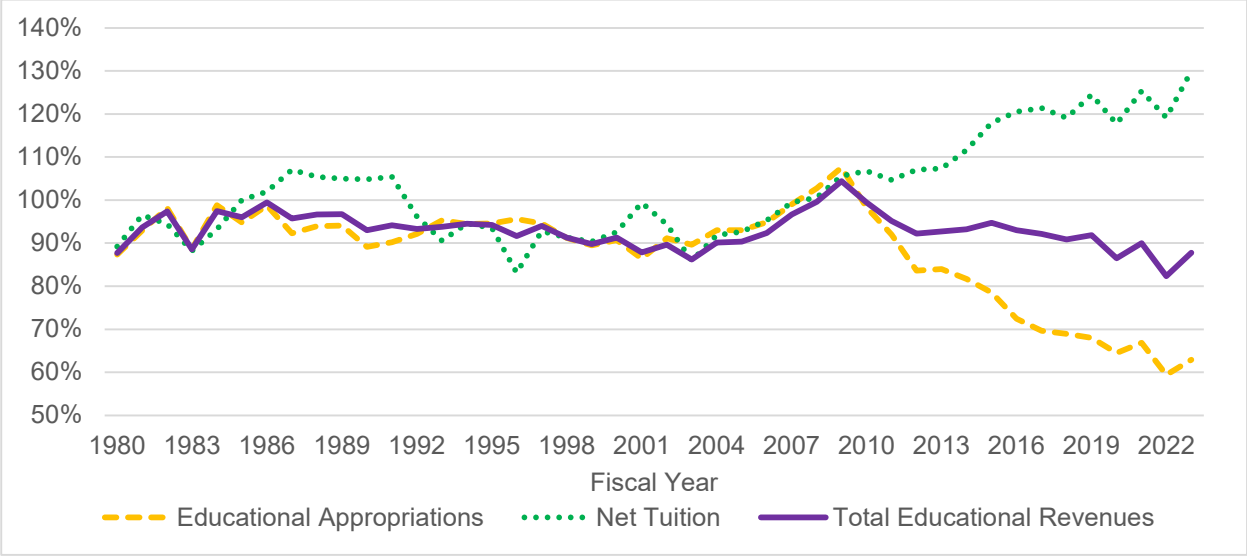
Source: Calculated from data from U.S. Department of Commerce, Census Bureau (funding and enrollment).

As seen in Chart 23, educational appropriations per full-time-equivalent (FTE) student for higher education in Arizona generally were somewhat below the national average from FYs 1980 through 2010. Since then, public support has plummeted relative to the national average; it was 37 percent below average in FY 2023, ranking 45th. Net tuition per FTE student fluctuated from somewhat above to somewhat below the U.S. average from FYs 1980 through 2008. Since then, net tuition per FTE student has increased relative to the national average; it was 30 percent above average in FY 2023, ranking 16th. Total educational revenue in Arizona generally has been slightly-to-somewhat below average, as rising tuition largely offset falling educational appropriations after FY 2010. In FY 2023, total educational revenue was 12 percent below the national average, ranking 40th.

On a cost-of-living-adjusted basis, educational appropriations for public higher education per FTE student was lower in Arizona than in each of the other seven comparison states except Colorado in FY 2023. Arizona had ranked fourth as recently as FY 2011. Only 17 states had a 2023 figure greater than the national average.

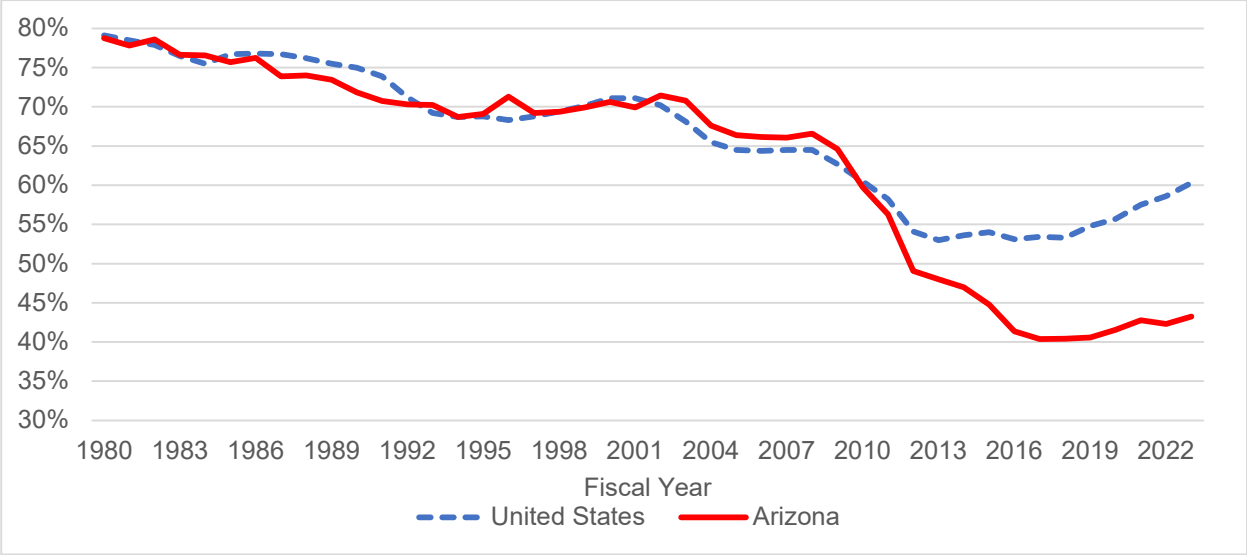
Chart 24 provides another way of viewing public support for higher education. From FY 1980 through FY 2010, the share of total educational revenue coming from educational appropriations gradually declined by about the same pace in Arizona as the national average. Since then, the appropriations share in Arizona has fallen increasingly far below the share nationally. In FY 2023, the national share was 60.3 percent, but Arizona's share was only 43.3 percent. Arizona's figure ranked seventh among the comparison states (down from third in FYs 2010 and 2011) and 39th nationally (down from 22nd in FY 2011).

CHART 23
PUBLIC HIGHER EDUCATION REVENUE PER FULL-TIME-EQUIVALENT STUDENT AS A PERCENTAGE OF THE NATIONAL AVERAGE, ARIZONA



Source: Calculated from data from State Higher Education Executive Officers Association.

CHART 24
EDUCATIONAL APPROPRIATIONS AS A SHARE OF TOTAL EDUCATIONAL REVENUE FOR PUBLIC HIGHER EDUCATION



Source: Calculated from data from State Higher Education Executive Officers Association.

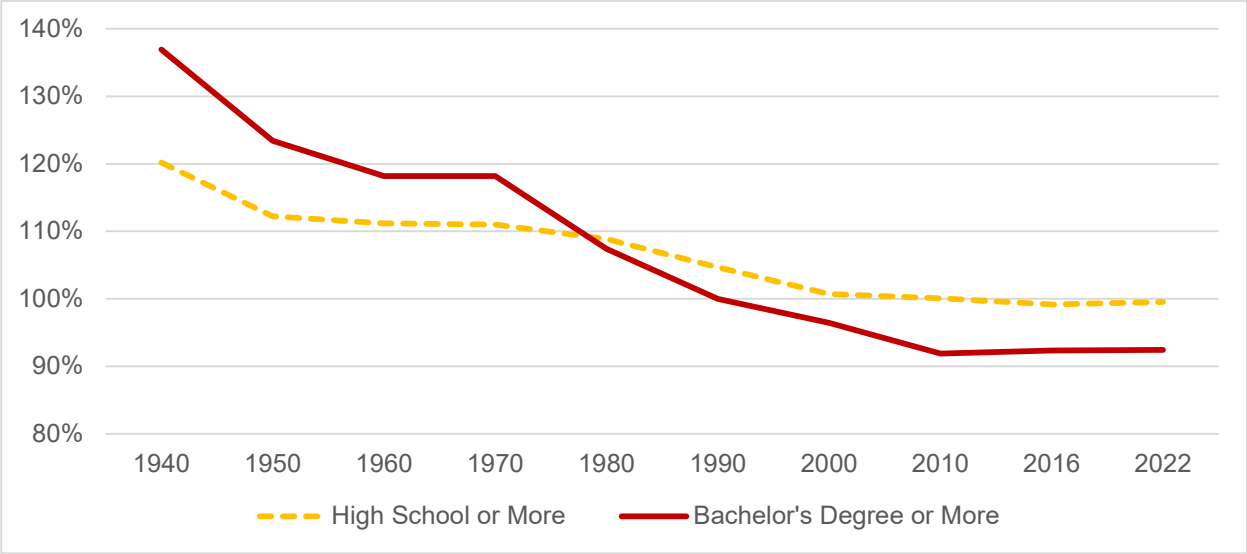
Educational Attainment

States. Educational attainment as measured by the share of the population aged 25 and older with at least a bachelor's degree is strongly correlated to high-tech share, particularly using occupational data. In 20 states in 2022, the share with at least a bachelor's degree exceeded the national average.

In the middle of the 20th century, educational attainment among adults 25 and older — measured both as the percentage with at least a high school diploma (or the equivalent) and as the percentage with at least a bachelor's degree — was considerably higher in Arizona than the national average, as seen in Chart 25. From the earliest U.S. Census Bureau data in 1940 through 2010, educational attainment in Arizona relative to the nation fell to below average; attainment relative to the U.S. average has stabilized since 2010. The educational attainment data for 1940 through 2000 come from the decennial census; subsequent data are from the American Community Survey (ACS).

Arizona has ranked last among the comparison states on the percentage with at least a bachelor's degree since 1980; it had ranked as high as second in 1940. Arizona's national rank fell from fourth in 1940 to 30th in 2022. The percentage of those 25 and older with at least a bachelor's degree was 33.0 percent in Arizona in 2022; the percentage in the other seven comparison states ranged from 37.0 to 46.6.

CHART 25
EDUCATIONAL ATTAINMENT IN ARIZONA
AS A PERCENTAGE OF THE NATIONAL AVERAGE



Note: Educational attainment is measured among those 25 years of age and older.

Source: Calculated from data from U.S. Department of Commerce, Census Bureau (decennial census, 1940 through 2000, https://www.census.gov/data/tables/time-series/demo/educational-attainment/educational-attainment-1940-2000.html and American Community Survey, 2010 through 2022, https://data.census.gov/).

Among the eight comparison states, Arizona has ranked seventh on the percentage with at least a high school diploma since 2000, down from ranks of fifth or sixth prior to 2000. Arizona's national rank fell from 11th in 1940 to 40th in 2022. The percentage of those 25 and older with at least a high school diploma was 89.2 percent in Arizona in 2022, higher than in California and not much lower than in the other comparison states, which ranged from 91.3-to-93.0 percent.

Looking at educational attainment in more detail in 2022, Arizona ranked eighth among the comparison states and 33rd nationally on the percentage with at least an associate degree. Arizona was last among the comparison states and 30th nationally on the percentage with at least a master's degree, the same ranks as for the percentage with at least a bachelor's degree. Arizona's share with some college but no degree was well above the national average.

The Census Bureau provides educational attainment by age group: 18 to 24, 25 to 34, 35 to 44, 45 to 64, and 65 and older. In 2022, the percentage in Arizona with at least a high school diploma or the equivalent ranked near the bottom in each age group younger than 65: seventh or eighth among the eight comparison states and 44th to 48th nationally. Similarly, the percentage in Arizona with at least a bachelor's degree ranked low in each age group younger than 65: seventh or eighth among the eight comparison states and 29th to 40th nationally. In contrast, educational attainment among Arizonans 65 and older exceeded the national average. Limiting the analysis to those 25-to-64 years of age, Arizona ranked seventh among the comparison states and 46th nationally on the percentage with at least a high school diploma and last in the comparison group and 37th nationally on the percentage with at least a bachelor's degree in 2022. Arizona's share of 33.2 percent was 11 percent less than the national average of 37.3 percent.

Educational attainment data for those 25 and older also are available by place of birth and by mobility. Regardless of place of birth, Arizona residents in 2022 ranked last among the comparison states on educational attainment. The national rank was higher among those born elsewhere in the United States (23rd based on the percentage with at least a high school diploma and 33rd on the percentage with at least a bachelor's degree) than those who were born in Arizona and those foreign born (ranks in the 40s).

The mobility data are based on place of residence in 2022 versus 2021, using the following categories: no move between 2021 and 2022, moved to a different housing unit in the same county, moved to a different unit in another county of the same state, moved to a different state, and moved from abroad. There was not much difference in educational attainment among Arizona residents in 2022 based on where they lived in 2021, with the percentage with at least a bachelor's degree ranking last among the comparison states in each category and ranking between 28th and 41st nationally.

Metropolitan Areas. Combining five years of ACS data from 2018 through 2022,[32] educational attainment in Mero Phoenix ranked 11th among the 12 metro areas in the comparison group based on the percentage with at least a high school diploma and last based on the percentage with at least a bachelor's degree. The latter figure was 33.7 percent in Metro Phoenix; the next-lowest

[32] Because sampling error in the ACS becomes significant in less-populous areas, the latest five years of data were combined.

figure among the 12 metro areas was 41.0 percent. In the 10 years between 2008 to 2012 and 2018 to 2022, Metro Phoenix ranked last on the change in the percentage with at least a bachelor's degree.

Among eight less-populous metro areas in the Southwest in the 2018-to-2022 period, Metro Tucson ranked seventh in the percentage with at least a high school diploma and seventh on the percentage with at least a bachelor's degree, ahead of only Metro El Paso. Metro Tucson ranked fourth on the 10-year change in educational attainment.

Patents

The number of patents granted, on both a per capita basis and relative to GDP, is highly correlated to high-tech shares, particularly using industrial data. Using the latest state patent data for 2020, only 12 states exceeded the national average on each measure.

Historically, the number of utility patents granted to Arizona inventors was considerably less than the national average, both per capita and relative to GDP, as seen in Chart 26. The number relative to GDP began to exceed the U.S. average annually in 1980, peaking in the 1980s and early 1990s at more than 20 percent above average in some years; the figure remained a little higher than the U.S. average through 2018. The per capita number varied from a little above average to a little below average during the 1980s and 1990s, but has gradually slipped since then.

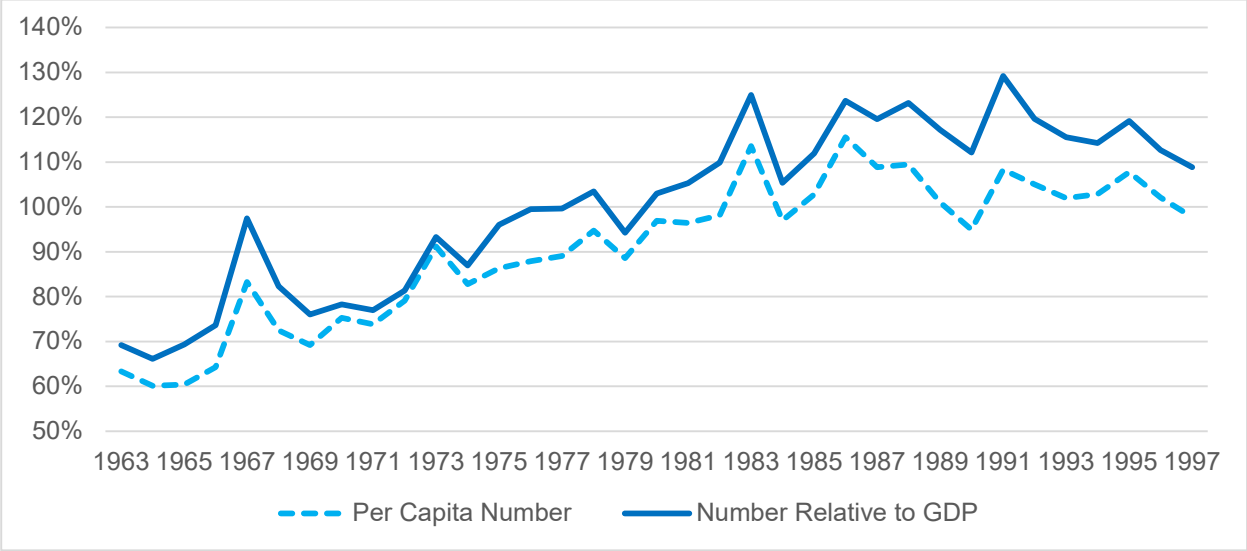
Through the mid-1990s, Arizona's rank among the eight comparison states varied mostly from third to sixth based on both the per capita number of patents and the number relative to GDP. Since then, Arizona generally has ranked fifth or sixth, ahead of Maryland and Virginia (and Utah in some years). Among all states on the per capita number of patents, Arizona ranked as high as 13th in 1986 and as low as 24th in 1964. Since 2000, the rank has varied from 14th to 20th. Arizona's ranks among all states have been somewhat higher on the number of patents relative to GDP. Arizona ranked as high as eighth in 1991 and as low as 22nd in 1964. Since 2000, the rank has varied from 11th to 14th.

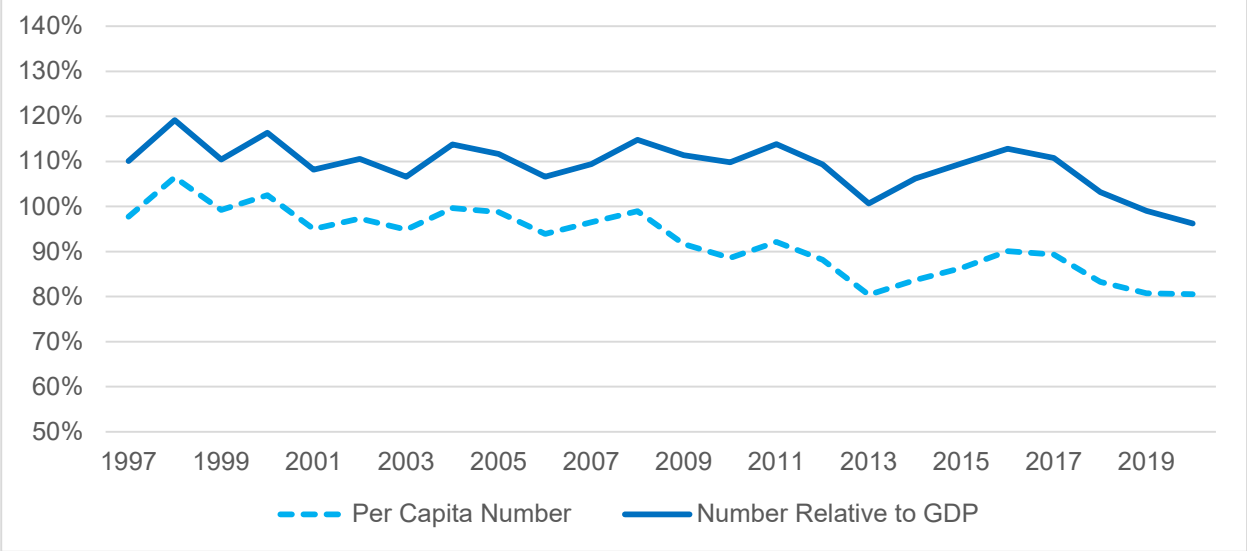
The per capita number of utility patents granted to Arizonans in 2020 was 18 percent less than the U.S. average; Arizona ranked 19th nationally and sixth in the comparison group. The number relative to GDP was less than the national average in 2019 and 2020 for the first time since 1979. The 2020 figure was 4 percent below average, ranking 13th nationally and sixth in the comparison group.

NSF Indicators

The National Science Foundation (NSF) provides a number of indicators by state. Six indicators related to higher education in science and engineering (and in some indicators, health) fields are discussed in this subsection. Correlations to high-tech shares generally were moderate across the six indicators, with correlations higher using occupational data than industrial data. The number of states with a figure greater than the U.S. average ranged from 15 to 23 across the six indicators.

CHART 26
UTILITY PATENTS IN ARIZONA
AS A PERCENTAGE OF THE NATIONAL AVERAGE





Source: Calculated from data from United States Patent and Trademark Office, https://www.uspto.gov/web/offices/ac/ido/oeip/taf/reports.htm#by_geog (patents) and U.S. Department of Commerce, Bureau of Economic Analysis, https://www.bea.gov/data/by-place-us (population and gross domestic product).

Bachelor's Degrees in Science and Engineering (S&E) Conferred per 1,000 Individuals 18-to-24 Years Old. As seen in the top graph of Chart 27, Arizona experienced considerable improvement in this measure between 2000 and 2013, but has since lost some of the gain. Arizona's national rank rose from 47th to 14th then dropped back. Among the eight comparison states, Arizona's rank went from last to fifth then back to last. In 2022, Arizona's figure was 5 percent less than the national average, ranking 27th nationally and last among the comparison states.

Advanced (Master's and Doctoral) Science and Engineering Degrees as a Percentage of S&E Degrees Conferred. As seen in the top graph of Chart 27, Arizona's performance on this measure dropped through 2008 but then improved. Arizona's national rank dropped from 14th to 39th but then improved into the top 10. Among the eight comparison states, Arizona's rank improved from fifth and sixth to second. In 2022, Arizona's figure was 24 percent higher than the national average, ranking sixth nationally and second among the comparison states.

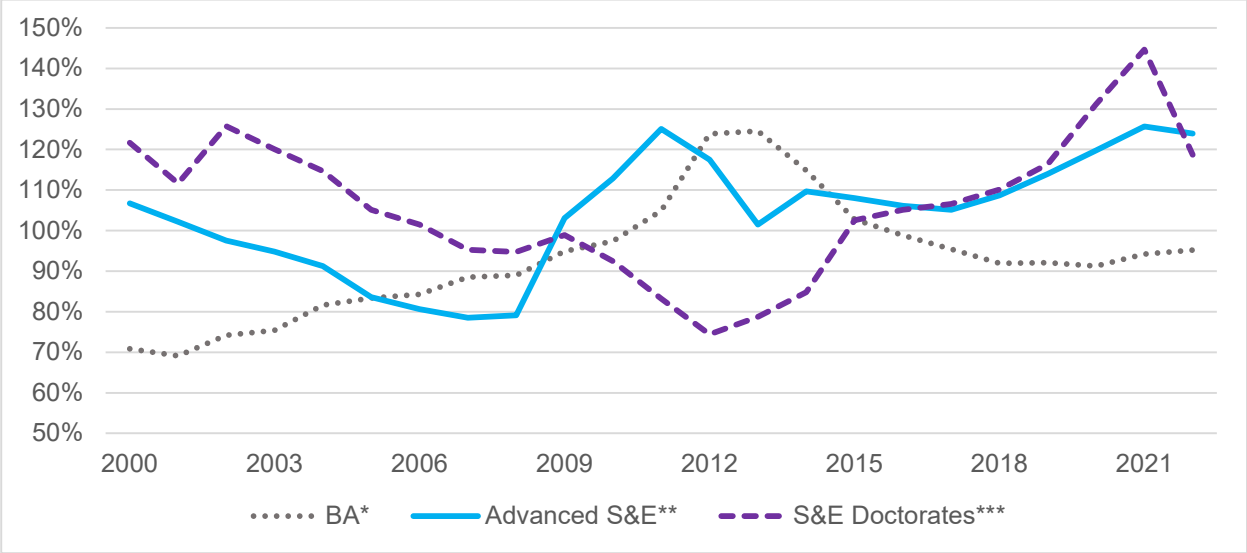
Science and Engineering Doctoral Degrees as a Percentage of Science and Engineering Degrees Conferred. This indicator was not correlated to high-tech shares. As seen in the top graph of Chart 27, Arizona's general performance on this measure was similar to that of the prior measure, dropping then rising. Arizona's national rank dropped from fourth to 42nd but then improved into the top 10. Among the eight comparison states, Arizona's rank went from second to last to first. In 2022, Arizona's figure was 19 percent higher than the national average, ranking 11th nationally and second among the comparison states.

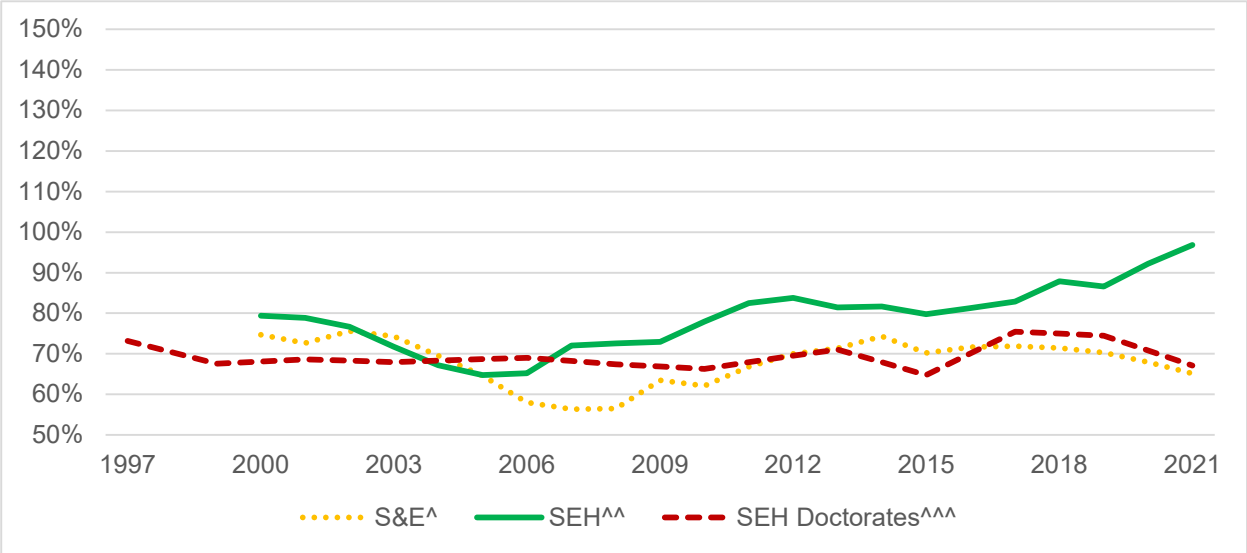
Science and Engineering Degrees as a Percentage of Higher Education Degrees Conferred. As seen in the bottom graph of Chart 27, Arizona has been considerably below the national average in this measure. Arizona's national rank has been 50th or 51st in each year. Among the eight comparison states, Arizona has ranked seventh or eighth. In 2022, Arizona's figure was 33 percent less than the national average, ranking last nationally.

Science, Engineering, and Health Graduate Students per 1,000 Individuals 25-to-34 Years Old. As seen in the bottom graph of Chart 27, Arizona has gradually improved on this measure since 2005. Arizona's national rank fell from 36th to 47th but then improved. Among the eight comparison states, Arizona generally ranked seventh but improved to fifth. In 2022, Arizona's figure was 3 percent more than the national average, ranking 19th nationally and fifth among the comparison states.

Employed Science, Engineering, and Health Doctorate Holders as a Percentage of the Workforce. This indicator is available only for selected years; values for other years in the bottom graph of Chart 27 were interpolated. Arizona has been considerably below the national average, with its national rank ranging from 32nd to 42nd. In each year, Arizona was last among the comparison states. In 2021 (the latest data), Arizona's figure was 33 percent less than the national average, ranking 37th nationally and last among the comparison states.

CHART 27
HUMAN CAPITAL INDICATORS IN ARIZONA
AS A PERCENTAGE OF THE NATIONAL AVERAGE





* Bachelor's Degrees in Science and Engineering Conferred per 1,000 Individuals 18-to-24 Years Old
** Advanced Science and Engineering Degrees as a Percentage of S&E Degrees Conferred
*** Science and Engineering Doctoral Degrees as a Percentage of Science and Engineering Degrees Conferred
^ Science and Engineering Degrees as a Percentage of Higher Education Degrees Conferred
^^ Science, Engineering, and Health Graduate Students per 1,000 Individuals 25-to-34 Years Old
^^^ Employed Science, Engineering, and Health Doctorate Holders as a Percentage of the Workforce (available only for some years; values for other years were interpolated)

Source: Calculated from data from National Science Foundation, https://ncses.nsf.gov/indicators/states/indicators.

Financial Capital Indicators

Nearly all of the financial capital indicators are moderately to strongly correlated to high-tech shares. In some of the indicators, financial capital is highly concentrated, with few states having a figure greater than the U.S. average.

Research and Development Funding

The NSF reports R&D funding by state in total and in four categories. The years for which data are available vary. Business and industry is by far the largest source of R&D spending. The federal government provides the second-highest amount, followed by academic institutions. State governments provide only a very small amount relative to the other categories.

The funding values are expressed relative to GDP, using the recently released revisions to the GDP. Arizona's figures as a percentage of the national average are presented in Chart 28.

Total. Total R&D funding relative to GDP is highly correlated to high-tech shares. In 2021 (the latest year of data), only 12 states had a figure greater than the national average.

As seen in the top graph of Chart 28, Arizona's total R&D relative to GDP was below the national average in every year for which data are available except 1999.[33] Annual values have been erratic, but generally were higher from 2008 through 2016 than in earlier or later years. Between 1991 and 2021, Arizona's national rank ranged from 15th to 28th except in 1998. Among the eight comparison states, Arizona ranked between fifth and eighth. In 2021, Arizona's total R&D relative to GDP was 22 percent less than the national average, ranking 17th nationally and fifth among the comparison states.

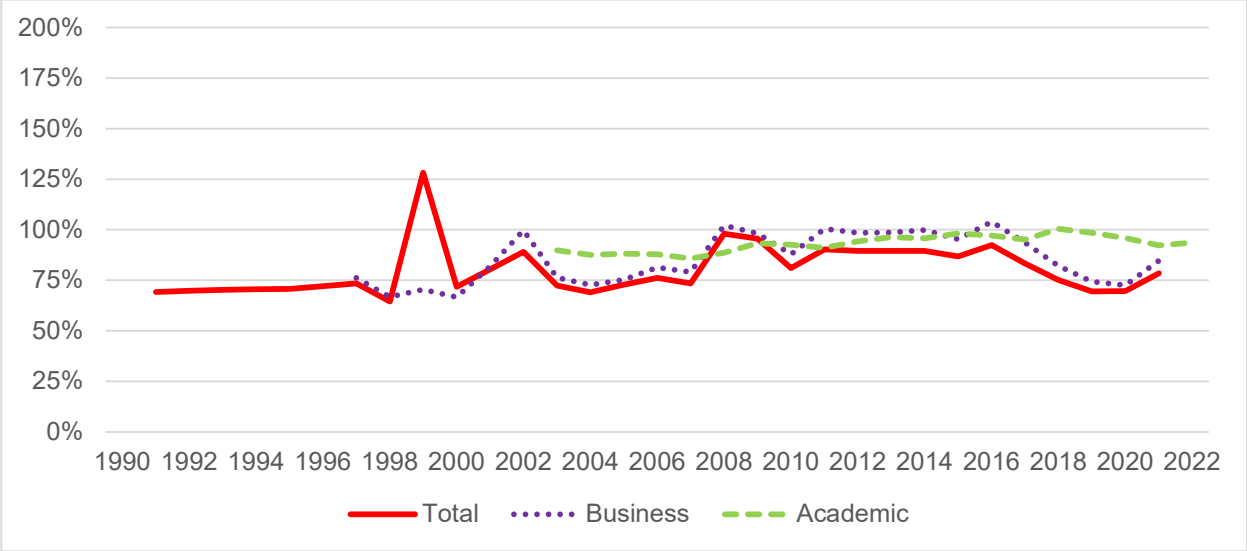
Business and Industry. R&D from this source is measured relative to private-sector GDP. Business and industry R&D funding relative to private-sector GDP is highly correlated to high-tech shares, particularly using industrial data. In 2021 (the latest year of data), only nine states had a figure greater than the national average.

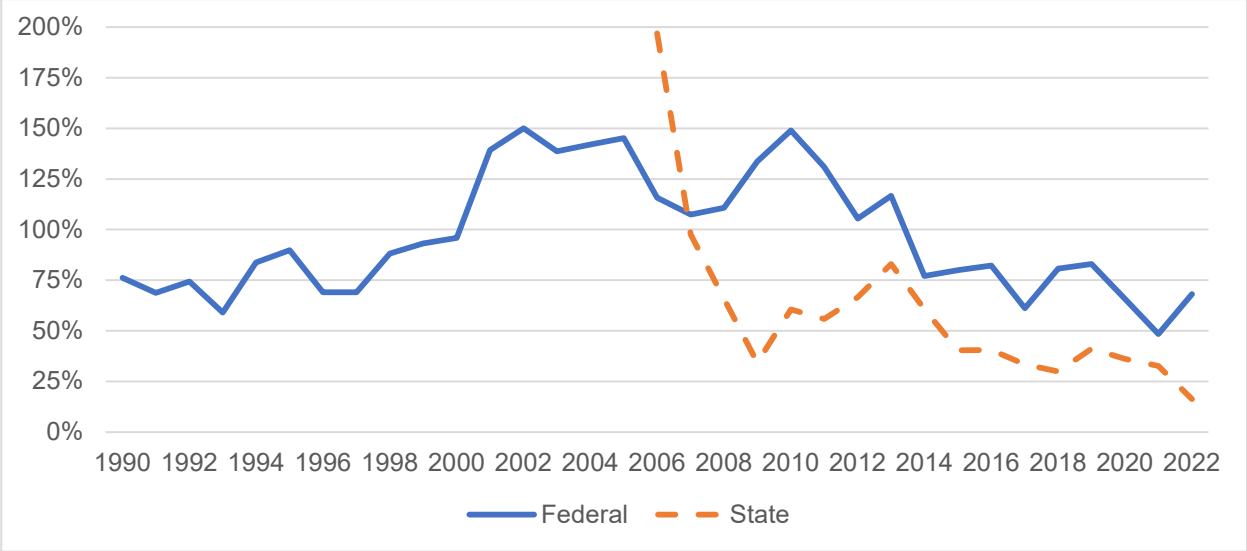
Arizona's business and industry R&D as a percentage of the national average followed the pattern of total R&D except for 1998, as seen in the top graph of Chart 28. Arizona's figure as a percent of the national average generally was higher from 2008 through 2017 (it was slightly higher than the U.S. average in two years) than in earlier or later years. Arizona's national rank improved from the 20s prior to 2006 to as high as 10th. Among the eight comparison states, Arizona generally ranked sixth or seventh from 1997 through 2005; it ranked fourth or fifth in each year after 2007. In 2021, Arizona's business and industry R&D relative to private-sector GDP was 15 percent less than the national average, ranking 13th nationally and fourth among the comparison states.

Academic. Academic R&D funding relative to GDP is moderately correlated to high-tech shares, particularly using occupational data. Academic R&D funding is not concentrated in relatively few states — in 2022 (the latest year of data), 26 states had a figure greater than the national average.

[33] The graph displays interpolated values for 1992, 1994, 1996, and 2001.

CHART 28
RESEARCH AND DEVELOPMENT FUNDING RELATIVE TO GROSS DOMESTIC PRODUCT IN ARIZONA AS A PERCENTAGE OF THE NATIONAL AVERAGE





Source: Calculated from data from National Science Foundation (R&D), https://ncses.nsf.gov/indicators/states/indicators and U.S. Department of Commerce, Bureau of Economic Analysis (revised gross domestic product).

Arizona's academic R&D relative to GDP was more than 10 percent below the national average from 2003 through 2009, but has been within 10 percent since; it was marginally above average in one year, as seen in the top graph of Chart 28. Arizona's national rank improved from the mid-30s to the mid-20s. Among the eight comparison states, Arizona ranked sixth or seventh in each year from 2003 through 2012; it ranked fourth or fifth in each after 2012. In 2022, Arizona's academic R&D relative to GDP was 6 percent less than the national average, ranking 28th nationally and fifth among the comparison states.

Federal. Federal R&D funding relative to GDP is moderately correlated to high-tech shares as measured by occupational data, but not correlated using industrial data. In 2022 (the latest year of data), only 12 states had a figure greater than the national average.

Federal government R&D funding in Arizona relative to GDP was below the national average through most of the 1990s, was above average from 2001 through 2013, but has been at least 15 percent below average since, as seen in the bottom graph of Chart 28. Arizona's national rank generally was between 10th and 22nd. Among the eight comparison states, Arizona generally ranked between sixth and eighth. In 2022, Arizona's federal R&D relative to GDP was 32 percent less than the national average, ranking 18th nationally and seventh among the comparison states.

State. State government R&D funding relative to GDP is not correlated to high-tech shares. In 2022 (the latest year of data), 19 states had a figure greater than the national average.

State government R&D funding in Arizona relative to GDP was considerably above the U.S. average in 2006, the first year of data, but was considerably below the national average in each subsequent year, as seen in the bottom graph of Chart 28. Arizona's national rank generally varied from 20th to 45th. Among the eight comparison states, Arizona ranked between fourth and eighth from 2009 through 2022. In 2022, Arizona's state government R&D relative to GDP was 84 percent less than the national average, ranking 49th nationally and last among the comparison states.

Innovation Grants

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, coordinated by the U.S. Small Business Administration, are highly competitive programs that encourage domestic small businesses to engage in federal research and development with the potential for commercialization. The SBIR program is substantially larger than the STTR program, awarding 5 times as many grants, and 7.1 times as much value, nationally in 2023.

The SBIR program began in 1983. The correlation of SBIR funding relative to GDP to high-tech shares is moderately strong, especially using industrial data. In 2023, only 18 states had a figure greater than the national average.

As seen in Chart 29, Arizona's SBIR grant value relative to the nation is erratic from year to year, with no trend apparent. In 32 of the 41 years of the program, Arizona's per capita grant value was less than the U.S. average; the value relative to GDP was less than average in 24

years. Relative to the national average, Arizona's per capita value ranged from 50 percent below to 20 percent above; the value relative to GDP varied from 46 percent below to 35 percent above.

Over the time series, Arizona's national SBIR rank ranged from 14th to 27th based on the per capita value and from 11th to 26th relative to GDP. Among the eight comparison states, Arizona ranked last in 32 of the 41 years on the per capita value and in 19 years on the value relative to GDP; the state never ranked higher than sixth.

In 2023, Arizona's per capita SBIR value was 23 percent less than the U.S. average, ranking 23rd nationally but last in the comparison group. The value relative to GDP was 8 percent below average, ranking 20th nationally but seventh in the comparison group.

The first year in which more than a few STTR grants were authorized was 1998. STTR funding relative to GDP is moderately correlated to high-tech shares. In 2023, 21 states had a figure greater than the national average.

As seen in Chart 30, Arizona's STTR grant value relative to the nation is erratic from year to year, with no trend. However, in the majority of the 26 years of the program, Arizona's value, both per capita and relative to GDP, was greater than the national average. After 1998, when Arizona received no grants, Arizona's per capita value relative to the U.S. average ranged from 48 percent below to 71 percent above; the value relative to GDP varied from 41 percent below to 92 percent above.

Arizona's national per capita STTR rank ranged from eighth to 31st; relative to GDP, the rank varied from fifth to 28th. However, Arizona's rank among the eight comparison states generally was between fifth and eighth on each measure.

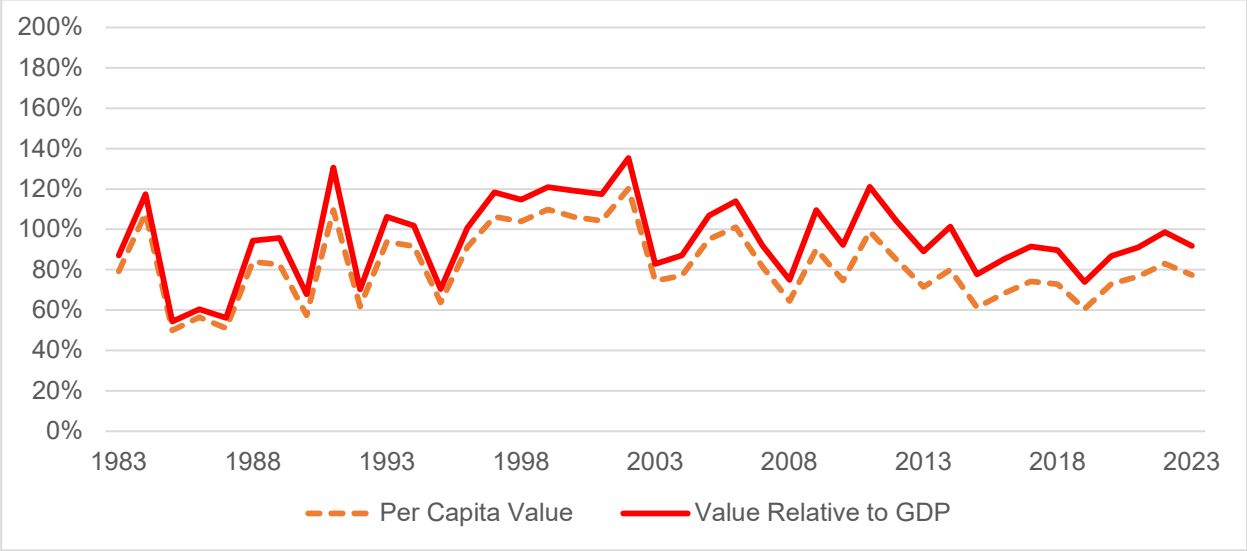
In 2023, Arizona's per capita STTR value was 20 percent less than the U.S. average, ranking 27th nationally and last in the comparison group. The value relative to GDP was 5 percent below average, ranking 22nd nationally and seventh in the comparison group.

Venture Capital

Venture capital funding relative to GDP is moderately correlated to high-tech shares. Venture capital funding largely goes to just a few states.

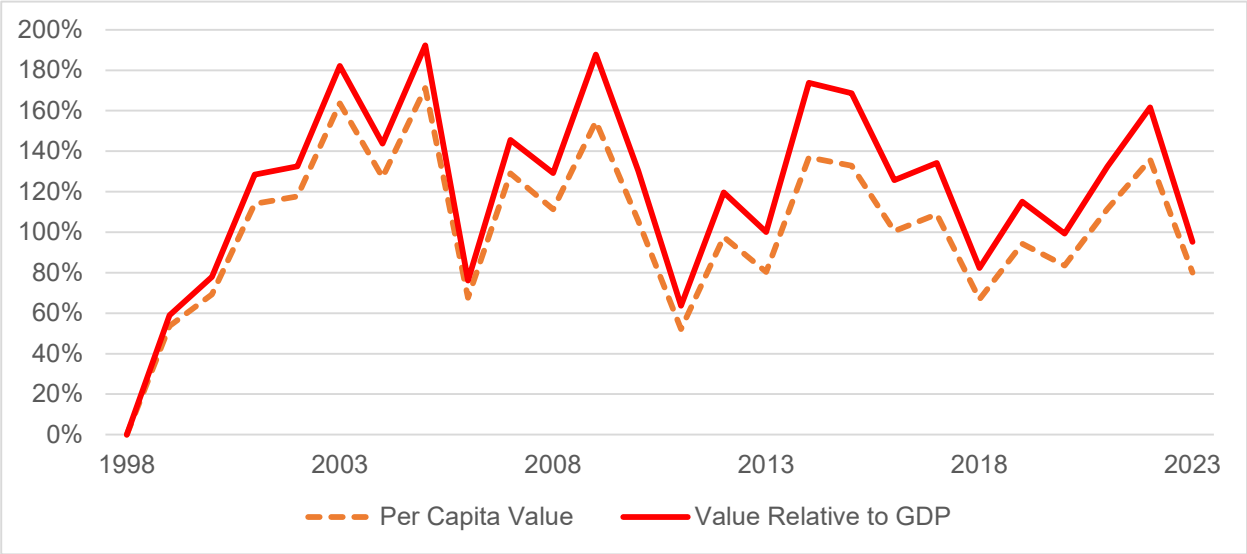
Venture capital data from Ernst & Young (E&Y) are available for 2010 through 2023. Arizona companies receive considerably less venture capital funding than the national average, regardless of the measure (per capita number of deals, per capita value of the deals, and the value of the deals relative to GDP), as seen in the first graph of Chart 31. No trend exists in any of the measures. In each year since the first year of data in 2010, Arizona ranked last among the eight comparison states on the per capita number of deals. Arizona has ranked between sixth and last on the per capita value of the deals and on the value relative to the state's GDP. Nationally, Arizona has generally ranked among the middle of the states on each of the three measures of venture capital.

CHART 29
SBIR GRANTS IN ARIZONA
AS A PERCENTAGE OF THE NATIONAL AVERAGE



Source: Calculated from data from U.S. Small Business Administration, https://www.sbir.gov/reports/state-summary?program_tid%5B%5D=105791 (grants) and U.S. Department of Commerce, Bureau of Economic Analysis, https://www.bea.gov/data/by-place-us (population and gross domestic product).

CHART 30
STTR GRANTS IN ARIZONA
AS A PERCENTAGE OF THE NATIONAL AVERAGE



Source: Calculated from data from U.S. Small Business Administration, https://www.sbir.gov/reports/state-summary?program_tid%5B%5D=105791 (grants) and U.S. Department of Commerce, Bureau of Economic Analysis, https://www.bea.gov/data/by-place-us (population and gross domestic product).

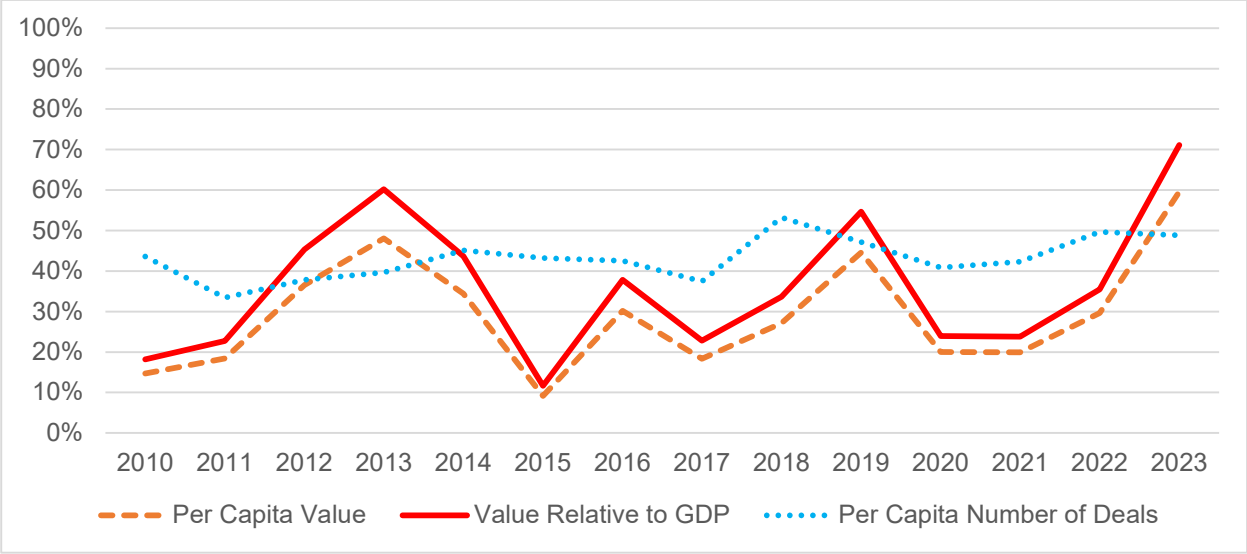
Using the latest data for 2023, the per capita number of deals in Arizona was slightly less than half of the national average, ranking 26th nationally and last in the comparison group. The per capita value in Arizona was 40 percent less than the national average, ranking 10th nationally and sixth in the comparison group. The value relative to GDP in Arizona was 29 percent less than the national average, ranking 10th nationally and sixth in the comparison group.

Since 2010, the per capita value has annually exceeded the national average in only five-to-nine states. The value relative to GDP has been greater than the U.S. average in only three-to-nine states. California and Massachusetts dominate the venture capital funding, with per capita values and values relative to GDP typically three-to-four times as high as the national average. New York usually has adjusted values 1.5-to-2 times the U.S. average. Other states that frequently have above-average adjusted values include Colorado, Utah, and Washington; the District of Columbia is considerably above average on the per capita value.

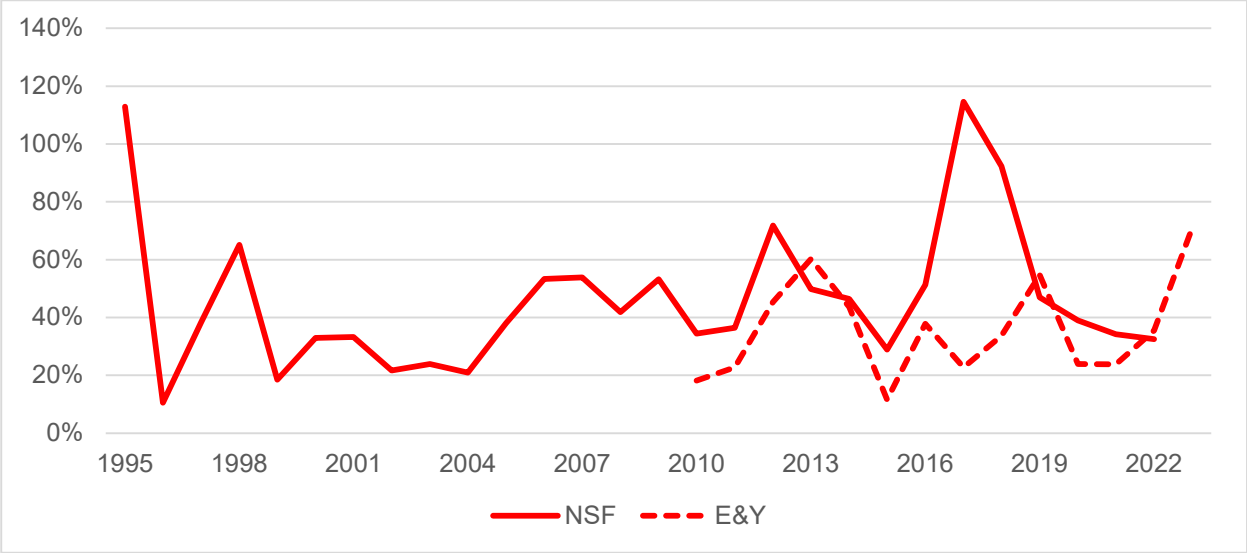
A second source of venture capital is provided by the NSF, using proprietary data from PitchBook from 1995 through 2022. The value relative to GDP is shown in the second graph of Chart 31 for both the NSF series and the E&Y series. The NSF series verifies that venture capital funding relative to GDP in Arizona is far below the national average and ranks near the bottom of the comparison states, but that Arizona generally ranks near or above the middle of all states.

CHART 31
VENTURE CAPITAL IN ARIZONA
AS A PERCENTAGE OF THE NATIONAL AVERAGE

Based on Data From Ernst & Young



Comparison of E&Y and NSF Data, Value Relative to GDP



Source: Calculated from data from Ernst & Young Global Limited, https://www.ey.com/en_us/growth/tracking-venture-capital-deployment-and-deal-trends-over-time (venture capital), National Science Foundation, https://ncses.nsf.gov/indicators/states/indicator/venture-capital-per-1-million-state-gdp (using venture capital from PitchBook), and U.S. Department of Commerce, Bureau of Economic Analysis, https://www.bea.gov/data/by-place-us (population and gross domestic product).

REFERENCES

High-Tech Literature Review

Asheim, Bjorn T. and Meric S. Gertler, "The Geography of Innovation: Regional Innovation Systems." In Jan Fagerberg, David C. Mowery and Richard R. Nelson, eds., *The Oxford Handbook of Innovation.* Oxford: Oxford University Press, 2005, pp. 291-317.

Cortright, Joseph. and Heike Mayer, *Signs of Life: The Growth of Biotechnology Centers in the U.S.* Washington, D.C.: The Brookings Institution, June 2002.

Darby, Michael R. and Lynne G. Zucker, "Growing by Leaps and Inches: Creative Destruction, Real Cost Reduction, and Inching Up," *Economic Inquiry* 41:1 (2003): 1-19.

Ellison, Glenn and Edward L. Glaeser, "Geographic Concentration in U.S. Manufacturing Industries: A Dartboard Approach," *Journal of Political Economy*, 105:5 (1997): 889-927.

Feldman, Maryann, "Location and Innovation: The New Economic Geography of Innovation, Spillovers, and Agglomeration," In Gordon L. Clark, Maryann Feldman and Meric S. Gertler, eds., *The Oxford Handbook of Economic Geography.* Oxford: Oxford University Press, 2000, 373-394.

Feldman, Maryann and Dieter F. Kogler, "Stylized Facts in the Geography of Innovation." In Brinwyn H. Hall and Nathan Rosenberg, eds., *Handbook of the Economics of Innovation, Vol. 1* Elsevier, 2010, 381-410.

Glaeser, Edward L., *Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier*. London, U.K.: Penguin Press, 2008.

Glaeser, Edward L. and Jesse M. Shapiro, "Urban Growth in the 1990s: Is City Living Back?" *Journal of Regional Science*, 43:1 (2003): 139-165.

Glaeser, Edward L. and Albert Saiz, "The Rise of the Skilled City," *Brookings-Wharton Papers on Urban Affairs*, 5 (2004): 47-94.

Glaeser, Edward L. and Kristina Tobio, "The Rise of the Sunbelt," *Southern Economic Journal*, 74:3 (2008): 609-643.

Glaeser, Edward L. and Josua D. Gottlieb, "The Wealth of Cities: Agglomeration Economies and Spatial Equilibrium in the United States," *Journal of Economic Literature*, 47:4 (2009): 983-1028.

Glaeser, Edward L. and Joseph Gyourko, "The Economic Implications of Housing Supply," *Journal of Economic Perspectives*, 32:1 (2018): 3-30.

Hill, Kent, "Determinants of Growth and Prosperity in U.S. Metro Areas," Center for Competitiveness and Prosperity Research, Arizona State University, January 2021.

Hill, Kent, Dennis Hoffman, Eva Madly, and Tom Rex, "STEM Economic Activity in Arizona," Center for Competitiveness and Prosperity Research, Arizona State University, February 2021.

Hsieh, Chang-Tai and Enrico Moretti, "Housing Constraints and Spatial Misallocation," *American Economic Journal: Macroeconomics*, 11:2 (2019): 1-39.

Jacobs, Jane, *The Economy of Cities*. New York: Random House, 1969.

Kenney, Martin and David C. Mowery (eds.), *Public Universities and Regional Growth: Insights from the University of California,* Stanford, CA: Stanford University Press, 2014.

Krugman, Paul, *Geography and Trade*. Cambridge, Mass.: The MIT Press, 1991.

Lecuyer, Christopher, *Making Silicon Valley: Innovation and the Growth of High Tech, 1930-1970.* Cambridge, Mass.: The MIT Press, 2005.

Leslie, Stuart W., "The Biggest Angel of Them All: The Military and the Making of Silicon Valley," In Martin Kenney, ed., *Understanding Silicon Valley: The Anatomy of an Entrepreneurial Region*. Stanford, CA: Stanford University Press, 2000.

Moretti, Enrico, *The New Geography of Jobs*, New York: Houghton Mifflin Harcourt, 2012.

Mowery, David C. and Bhaven N. Sampat, "Universities in National Innovation Systems." In Jan Fagerberg, David C. Mowery and Richard R. Nelson, eds., *The Oxford Handbook of Innovation.* Oxford: Oxford University Press, 2005, pp. 209-239.

Muro, Mark, Johnathan Rothwell, Scott Andes, Kenan Fikri, and Siddharth Kulkarni, "America's Advanced Industries: What They Are, Where They Are, and Why They Matter," Brookings Institution, February 2015.

National Research Council, "Annex B: North Carolina's Research Triangle Park." In Charles W. Wessner, ed., *Best Practices in State and Regional Innovation Initiatives: Competing in the 21st Century.* Washington, D.C.: National Academies Press, 2013.

Nelson, Richard R., "Institutions Supporting Technical Advance in Industry," *American Economic Review,* 76:2 (May 1986): 186-189.

Porter, Michael, "Locations, Clusters, and Company Strategy." In Gordon L. Clark, Maryann Feldman and Meric S. Gertler, eds., *The Oxford Handbook of Economic Geography.* Oxford: Oxford University Press, 2000, pp. 253-274.

Rauch, James E., "Productivity Gains from Geographic Concentration of Human Capital: Evidence from the Cities," *Journal of Urban Economics*, 34:3 (1993): 380-400.

Rothwell, Johnathan, Jose Lobo, Deborah Strumsky, and Mark Muro, "Patenting Prosperity: Invention and Economic Performance in the United States and its Metropolitan Areas, " Washington, D.C.: Brookings Institution, February 2013.

Rothwell, Johnathan, "The Hidden STEM Economy," Washington, D. C.: Brookings Institution, June 2013.

Saiz, Albert, "The Geographic Determinants of Housing Supply," *Quarterly Journal of Economics*, 125:3 (2010): 1253-1296.

Saxenian, Annalee, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*. Cambridge, Mass.: Harvard University Press, 1994.

Simon, Curtis J. and Clark Nardinelli, "Human Capital and the Rise of American Cities: 1900-1990," *Regional Science and Urban Economics*, 32 (2002): 59-96.

Sturgeon, Timothy J., "How Silicon Valley Came to Be." In Martin Kenney, ed., *Understanding Silicon Valley: The Anatomy of an Entrepreneurial Region.* Stanford, CA: Stanford University Press, 2000.

Tartari, Valentina and Scott Stern, "More Than an Ivory Tower: The Impact of Research Institutions on the Quantity and Quality of Entrepreneurship," NBER Working Paper 28846, May 2021.

Zucker, Lynne G. and Michael R. Darby, "Star Scientists and Institutional Transformation: Patterns of Invention and Innovation in the Formation of the Biotechnology Industry," *Proceedings of the National Academy of Science*, 93:23 (1996): 12709-16.

Zucker, Lynne G., Michael R. Darby, and Marilynn B. Brewer, "Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises," *American Economic Review* 88:1 (March 1998): 290-306.

Zucker, Lynne G., Michael R. Darby, and Jeff S. Armstrong, "Commercializing Knowledge: University Science, Knowledge Capture, and Firm Performance in Biotechnology," *Management Science* 48:1 (2002): 138-53.

Definitions of STEM Occupations

Carnevale, Anthony, Nicole Smith, and Michelle Melton. "STEM: Science, Technology, Engineering, and Mathematics," 2011, Georgetown University Center on Education and the Workforce.

Goldschlag, Nathan and Javier Miranda. "Business Dynamics Statistics of High Tech Industries," December 2016, U.S. Department of Commerce, Census Bureau, Center for Economic Studies.

Hathaway, Ian. “Tech Starts: High-Technology Business Formation and Job Creation in the United States,” August 2013, Ewing Marion Kauffman Foundation.

Hecker, Daniel. “High-Technology Employment: A NAICS-Based Update,” *Monthly Labor Review*, July 2005.

National Science Foundation, National Science Board. “Science and Engineering Indicators: 2018.”

Noonan, Ryan. “STEM Jobs: 2017 Update,” March 2017, U.S. Department of Commerce, Economics and Statistics Administration, Office of the Chief Economist.

Definitions of STEM-Intensive Industries

Goldschlag, Nathan and Javier Miranda. “Business Dynamics Statistics of High Tech Industries,” December 2016, U.S. Department of Commerce, Census Bureau, Center for Economic Studies.

Hathaway, Ian. “Tech Starts: High-Technology Business Formation and Job Creation in the United States,” August 2013, Ewing Marion Kauffman Foundation.

Hecker, Daniel. “High-Technology Employment: A NAICS-Based Update,” *Monthly Labor Review*, July 2005.

National Science Foundation, National Science Board. “Science and Engineering Indicators: 2006,” Chapter 8: State Indicators, Technical Note: Defining High-Technology Industries.

Roberts, Brian and Michael Wolfe. “High-Tech Industries: An Analysis of Employment, Wages, and Output,” *Beyond the Numbers*, May 2018, U.S. Department of Labor, Bureau of Labor Statistics.

APPENDIX A: STEM OCCUPATIONS, STANDARD OCCUPATIONAL CLASSIFICATION, 2018

Occupation	Description
	COMPUTER CATEGORY
11-3021	Computer and Information Systems Managers
15-1211	Computer Systems Analysts
15-1212	Information Security Analysts
15-1221	Computer and Information Research Scientists
15-1231	Computer Network Support Specialists
15-1232	Computer User Support Specialists
15-1241	Computer Network Architects
15-1242	Database Administrators
15-1243	Database Architects
15-1244	Network and Computer Systems Administrators
15-1251	Computer Programmers
15-1252	Software Developers
15-1253	Software Quality Assurance Analysts and Testers
15-1254	Web Developers
15-1255	Web and Digital Interface Designers
15-1299	Computer Occupations, All Other
	MATH CATEGORY
15-2011	Actuaries
15-2021	Mathematicians
15-2031	Operations Research Analysts
15-2041	Statisticians
15-2051	Data Scientists
15-2099	Mathematical Science Occupations, All Other
	ENGINEERING CATEGORY
11-9041	Architectural and Engineering Managers
17-2011	Aerospace Engineers
17-2021	Agricultural Engineers
17-2031	Bioengineers and Biomedical Engineers
17-2041	Chemical Engineers
17-2051	Civil Engineers
17-2061	Computer Hardware Engineers
17-2071	Electrical Engineers
17-2072	Electronics Engineers, Except Computer
17-2081	Environmental Engineers
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors
17-2112	Industrial Engineers
17-2121	Marine Engineers and Naval Architects
17-2131	Materials Engineers
17-2141	Mechanical Engineers
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers
17-2161	Nuclear Engineers
17-2171	Petroleum Engineers
17-2199	Engineers, All Other
	ENGINEERING TECHNICIAN CATEGORY
17-3011	Architectural and Civil Drafters
17-3012	Electrical and Electronics Drafters
17-3013	Mechanical Drafters
17-3019	Drafters, All Other

(continued)

APPENDIX A: STEM OCCUPATIONS (continued)

Occupation	Description
17-3021	Aerospace Engineering and Operations Technologists and Technicians
17-3022	Civil Engineering Technologists and Technicians
17-3023	Electrical and Electronic Engineering Technologists and Technicians
17-3024	Electro-Mechanical & Mechatronics Technologists and Technicians
17-3025	Environmental Engineering Technologists and Technicians
17-3026	Industrial Engineering Technologists and Technicians
17-3027	Mechanical Engineering Technologists and Technicians
17-3028	Calibration Technologists and Technicians
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other
17-3031	Surveying and Mapping Technicians
	SCIENCE CATEGORY
11-9121	Natural Sciences Managers
19-1011	Animal Scientists
19-1012	Food Scientists and Technologists
19-1013	Soil and Plant Scientists
19-1021	Biochemists and Biophysicists
19-1022	Microbiologists
19-1023	Zoologists and Wildlife Biologists
19-1029	Biological Scientists, All Other
19-1031	Conservation Scientists
19-1032	Foresters
19-1041	Epidemiologists
19-1042	Medical Scientists, Except Epidemiologists
19-1099	Life Scientists, All Other
19-2011	Astronomers
19-2012	Physicists
19-2021	Atmospheric and Space Scientists
19-2031	Chemists
19-2032	Materials Scientists
19-2041	Environmental Scientists and Specialists, Including Health
19-2042	Geoscientists, Except Hydrologists and Geographers
19-2043	Hydrologists
19-2099	Physical Scientists, All Other
	SCIENCE TECHNICIAN CATEGORY
19-4012	Agricultural Technicians
19-4013	Food Science Technicians
19-4021	Biological Technicians
19-4031	Chemical Technicians
19-4042	Environmental Science and Protection Technicians, Including Health
19-4043	Geological Technicians, Except Hydrologic Technicians
19-4044	Hydrologic Technicians
19-4051	Nuclear Technicians
19-4071	Forest and Conservation Technicians
19-4092	Forensic Science Technicians
19-4099	Life, Physical, and Social Science Technicians, All Other

Note: These occupations apply to the 2001-to-2022 time series obtained from Lightcast.

Sources: Executive Office of the President, Office of Management and Budget, “Standard Occupational Classification Manual: United States, 2018,” https://www.bls.gov/soc/2018/soc_2018_manual.pdf. Definition of STEM occupations produced by authors.

APPENDIX B: STEM INDUSTRIES, NORTH AMERICAN INDUSTRY CLASSIFICATION SYSTEM, 2022

Industry	Description
	BIOPHARMACEUTICAL MANUFACTURING
325411	Medicinal and Botanical
325412	Pharmaceutical Preparation
325413	In-Vitro Diagnostic Substance
325414	Biological Product (except Diagnostic)
	COMPUTING EQUIPMENT MANUFACTURING
334111	Electronic Computers
334112	Computer Storage Devices
334118	Computer Terminal and Other Computer Peripheral Equipment
	COMMUNICATIONS EQUIPMENT MANUFACTURING
334210	Telephone Apparatus
334220	Radio and Television Broadcasting and Wireless Communications Equipment
334290	Other Communications Equipment
334310	Audio and Video Equipment
	ELECTRONICS MANUFACTURING
334412	Bare Printed Circuit Boards
334413	Semiconductor and Related Devices
334416	Capacitor, Resistor, Coil, Transformer, and Other Inductors
334417	Electronic Connectors
334418	Printed Circuit Assembly (Electronic Assembly)
334419	Other Electronic Components
	INSTRUMENTS MANUFACTURING
334510	Electromedical and Electrotherapeutic Apparatus
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instruments
334512	Automatic Environmental Controls for Residential, Commercial, and Appliance Use
334513	Instruments and Related Products for Measuring, Displaying, and Controlling Industrial Process Variables
334514	Totalizing Fluid Meter and Counting Devices
334515	Instruments for Measuring and Testing Electricity and Electrical Signals
334516	Analytical Laboratory Instruments
334517	Irradiation Apparatus
334519	Other Measuring and Controlling Devices
	AEROSPACE MANUFACTURING
336411	Aircraft
336412	Aircraft Engines and Engine Parts
336413	Other Aircraft Parts and Auxiliary Equipment
336414	Guided Missiles and Space Vehicles
336415	Guided Missile and Space Vehicle Propulsion Units and Propulsion Unit Parts
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment
	MISCELLANEOUS MANUFACTURING
333242	Semiconductor Machinery
333310	Commercial and Service Industry Machinery
334610	Manufacturing and Reproducing Magnetic and Optical Media

(continued)

APPENDIX B: STEM INDUSTRIES, NORTH AMERICAN INDUSTRY CLASSIFICATION SYSTEM, 2022 (continued)

Industry	Description
	COMPUTER SERVICES
513210	Software Publishers
518210	Computing Infrastructure Providers Data Processing, Web Hosting, and Related Services
519290	Web Search Portals and All Other Information Services
541511	Custom Computer Programming Services
541512	Computer Systems Design Services
541513	Computer Facilities Management Services
541519	Other Computer Related Services
	OTHER PROFESSIONAL SERVICES
541330	Engineering Services
541340	Drafting Services
541360	Geophysical Surveying and Mapping Services
541370	Surveying and Mapping (except Geophysical) Services
541380	Testing Laboratories
541713	Research and Development in Nanotechnology
541714	Research and Development in Biotechnology (except Nanotechnology)
541715	Research and Development in Other Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)
	MISCELLANEOUS SERVICES
517112	Wireless Telecommunications Carriers (except Satellite)
517410	Satellite Telecommunications
517810	All Other Telecommunications
541620	Environmental Consulting Services
541690	Other Scientific and Technical Consulting Services

Note: These industries apply to the 2001-to-2022 time series obtained from Lightcast.

Sources: Executive Office of the President, Office of Management and Budget, “North American Industry Classification System: United States, 2022,” https://www.census.gov/naics/reference_files_tools/2022_NAICS_Manual.pdf. Definition of STEM-intensive industries produced by authors.

APPENDIX C: BIOTECHNOLOGY

One of the high-technology categories defined for this report is biopharmaceuticals, which consists of four manufacturing industries. The definition of this category is identical to the biopharmaceuticals traded cluster as defined by Harvard's Institute for Strategy and Competitiveness.

The term "biotechnology" has a broader definition than biopharmaceuticals manufacturing. The NAICS includes one separate biotechnology industry: "research and development in biotechnology (except nanobiotechnology)."

Nationally in 2022, employment in biopharmaceuticals manufacturing was 23 percent higher than employment in the R&D in biotechnology industry. However, in seven of the 12 large metro areas examined in this report, employment was higher in the R&D in biotechnology industry.

For the 12 large metropolitan areas examined in this report, the biopharmaceuticals employment share in 2022 was fairly highly correlated (a correlation coefficient of 0.64[34]) to the R&D in biotechnology share. Table C1 provides the shares of total employment in 2022 produced by biopharmaceuticals, R&D in biotechnology, and the sum of these two categories (referred to as biotech), expressed as a ratio to the national average. The metro areas are listed in order of the biotech rank.

TABLE C1
BIOTECHNOLOGY EMPLOYMENT SHARES
AS A RATIO TO THE NATIONAL AVERAGE, 2022

	Ratio to National Average			Rank		
Metro Area	**Biopharm**	**R&D**	**Biotech**	**Biopharm**	**R&D**	**Biotech**
Boston	1.51	11.80	6.13	4	1	1
San Diego	2.47	7.85	4.89	3	2	2
Raleigh-Durham	3.88	5.91	4.79	1	4	3
San Francisco	2.69	6.99	4.62	2	3	4
Seattle	0.42	2.72	1.45	12	5	5
Washington, D.C.	1.00	1.77	1.35	5	7	6
San Jose	0.84	1.82	1.28	9	6	7
Baltimore	0.98	1.08	1.03	6	8	8
Austin	0.86	0.86	0.86	8	9	9
Phoenix	0.89	0.39	0.67	7	10	10
Portland	0.47	0.33	0.41	11	11	11
Denver	0.48	0.23	0.37	10	12	12

Note: "Biotech" is the sum of biopharmaceuticals and research and development in biotechnology.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

[34] A correlation coefficient of 1.00 indicates perfect positive correlation, a value of 0.00 indicates absolutely no correlation, and a value of -1.00 indicates perfect negative correlation.

As seen in Table C1, more geographic variation exists in the R&D industry than in biopharmaceuticals. The R&D in biotechnology concentration in 2022 was quite high in the Boston, San Diego, San Francisco, and Raleigh-Durham metro areas.

The change in employment share between 2001 and 2022, expressed relative to the U.S. average, is displayed in Table C2. Unlike the 2022 share, the change in share in biopharmaceuticals was only slightly (0.18) correlated to the change in share in R&D in biotechnology. Three of the top four metro areas in biotech in 2022 — Boston, San Diego, and San Francisco — were the leaders on the 2001-to-2022 change in share.

TABLE C2
CHANGE IN BIOTECHNOLOGY EMPLOYMENT SHARES
AS A RATIO TO THE NATIONAL AVERAGE, 2001 TO 2022

	Ratio to National Average			Rank		
Metro Area	**Biopharm**	**R&D**	**Biotech**	**Biopharm**	**R&D**	**Biotech**
Boston	0.14	3.30	2.67	5	2	2
San Diego	0.91	1.80	2.00	2	3	3
Raleigh-Durham	-2.63	0.88	-1.28	12	5	12
San Francisco	1.03	4.77	2.80	1	1	1
Seattle	-0.08	1.41	0.71	8	4	4
Washington, D.C.	0.69	-1.47	0.17	3	11	6
San Jose	-0.82	-1.88	-0.98	11	12	11
Baltimore	-0.20	-1.21	-0.48	9	10	10
Austin	-0.41	-0.34	-0.39	10	9	9
Phoenix	0.58	0.20	0.39	4	6	5
Portland	0.13	0.15	0.11	6	7	7
Denver	0.06	-0.21	-0.06	7	8	8

Note: Biotech is the sum of biopharmaceuticals and research and development in biotechnology.

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

APPENDIX D: RESEARCH AND DEVELOPMENT

Research and development plays a key role in a high-technology economy. The NAICS identifies four research and development industries, three of which are related to high technology: "nanotechnology," "biotechnology (except nanobiotechnology)," and "physical, engineering, and life sciences (except nanotechnology and biotechnology)." The latter industry is referred to below as "other R&D." Nationally in 2022, employment in nanotechnology accounted for only 3 percent of the employment in the three R&D industries combined. The biotechnology industry accounted for 34 percent of the total.

For the 12 large metropolitan areas examined in this report, the R&D shares in 2022 were moderately to highly correlated to each other: 0.61 between nanotechnology and biotechnology, 0.81 between nanotechnology and other R&D, and 0.52 between biotechnology and other R&D.

Table D1 provides the shares of total employment in 2022 produced by each of the three R&D industries and the sum of the three industries, expressed as a ratio to the national average. The metro areas are listed in order of the overall rank.

As seen in Table D1, more geographic variation exists in the biotech R&D industry than in the other R&D industries. Note the sizable difference in the overall ratio to the U.S. average between the top eight metro areas and the other four metro areas.

TABLE D1
RESEARCH AND DEVELOPMENT EMPLOYMENT SHARES AS A RATIO TO THE NATIONAL AVERAGE, 2022

	Ratio to National Average				Rank			
Metro Area	Nano-tech	Bio-tech	Other*	Total	Nano-tech	Bio-tech	Other*	Total
Boston	1.93	11.80	3.19	6.07	4	1	5	1
San Francisco	3.42	6.99	4.10	5.06	1	3	2	2
San Diego	2.19	7.85	3.58	4.99	3	2	3	3
San Jose	2.76	1.82	5.61	4.23	2	6	1	4
Raleigh-Durham	1.38	5.91	3.29	4.12	5	4	4	5
Washington, D.C.	0.64	1.77	2.47	2.18	10	7	7	6
Baltimore	0.66	1.08	2.57	2.01	9	8	6	7
Seattle	0.81	2.72	1.06	1.61	8	5	8	8
Austin	0.99	0.86	0.72	0.77	6	9	11	9
Denver	0.09	0.23	0.96	0.68	12	12	9	10
Portland	0.97	0.33	0.77	0.63	7	11	10	11
Phoenix	0.59	0.39	0.28	0.33	11	10	12	12

* Research and development in the physical, engineering, and life sciences (except nanotechnology and biotechnology).

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

The change in employment share between 2001 and 2022, expressed relative to the U.S. average, is displayed in Table D2. While the change is share in nanotechnology R&D was unrelated (0.08) to the change in biotechnology R&D, moderate correlation (0.42) was present between nanotechnology R&D and other R&D and strong correlation existed between biotechnology R&D and other R&D (0.70). Boston and San Francisco — the leaders in overall R&D in 2022 — were the leaders on the 2001-to-2022 change in share.

TABLE D2
CHANGE IN RESEARCH AND DEVELOPMENT EMPLOYMENT SHARES AS A RATIO TO THE NATIONAL AVERAGE, 2001 TO 2022

	Ratio to National Average				Rank			
Metro Area	Nano-tech	Bio-tech	Other*	Total	Nano-tech	Bio-tech	Other*	Total
Boston	1.46	3.30	2.03	3.11	1	2	1	1
San Francisco	-2.54	4.77	1.54	2.45	8	1	2	2
San Diego	-3.49	1.80	-0.63	0.25	10	3	10	4
San Jose	0.54	-1.88	-0.32	-0.99	4	12	8	12
Raleigh-Durham	1.06	0.88	1.06	1.27	2	5	3	3
Washington, D.C.	0.33	-1.47	-0.82	-0.98	5	11	12	11
Baltimore	-2.91	-1.21	0.64	-0.08	9	10	4	9
Seattle	-4.55	1.41	-0.41	0.03	12	4	9	7
Austin	-3.66	-0.34	-0.64	-0.67	11	9	11	10
Denver	-0.51	-0.21	0.13	-0.03	6	8	6	8
Portland	0.94	0.15	0.23	0.20	3	7	5	5
Phoenix	-0.73	0.20	0.10	0.09	7	6	7	6

* Research and development in the physical, engineering, and life sciences (except nanotechnology and biotechnology).

Source: Calculated from data from Lightcast, https://www.economicmodeling.com/.

APPENDIX E: TABLES DISPLAYING ALL 53 TRADED CLUSTERS

Source (all industrial cluster tables): Calculated from data from Lightcast, https://www.economicmodeling.com/. Cluster definitions largely are from the Institute for Strategy and Competitiveness at the Harvard Business School.

TABLE E1
TRADED CLUSTERS, ARIZONA, 2022

	Employment			Aggregate Earnings		
	Share of Total	Ratio to Nation	Rank*	Share of Total	Ratio to Nation	Rank*
Aerospace Vehicles and Defense	0.99%	2.62	2	1.86%	2.81	2
Agricultural Inputs and Services	0.31	0.97	3	0.22	1.09	3
Apparel	0.03	0.43	8	0.02	0.40	6
Automotive	0.25	0.40	4	0.32	0.47	3
Biopharmaceuticals	0.14	0.66	6	0.16	0.38	6
Business Services	7.70	1.17	5	10.20	0.93	8
Coal Mining	0.00	0.07	5	0.01	0.16	5
Communications Equipment and Services	0.30	0.94	5	0.46	0.64	7
Construction Products and Services	0.44	0.77	4	0.60	0.83	3
Distribution and Electronic Commerce	3.91	1.03	1	4.87	1.04	1
Downstream Chemical Products	0.07	0.42	7	0.09	0.38	6
Downstream Metal Products	0.30	1.04	2	0.37	1.25	2
Education and Knowledge Creation	1.50	0.73	8	1.44	0.57	8
Electric Power Generation and Transmission	0.06	0.58	6	0.12	0.52	6
Environmental Services	0.06	0.68	7	0.06	0.66	7
Financial Services	2.14	1.61	1	3.67	1.02	3
Fishing and Fishing Products	0.00	0.07	8	0.00	0.06	8
Food Processing and Manufacturing	0.48	0.63	6	0.48	0.67	5
Footwear	0.00	0.13	8	0.00	0.05	8
Forestry	0.01	0.25	5	0.01	0.26	4
Furniture	0.21	0.88	2	0.17	0.95	2
Hospitality and Tourism	1.93	1.06	3	1.58	1.21	2
Information Technology/Analytical Instruments	1.21	1.33	5	2.80	1.26	5
Insurance Services	0.95	1.05	2	1.27	0.93	2
Jewelry and Precious Metals	0.01	0.75	4	0.01	0.56	4
Leather and Related Products	0.01	0.45	7	0.01	0.43	7
Lighting and Electrical Equipment	0.09	0.49	6	0.12	0.53	6
Livestock Processing	0.06	0.20	8	0.06	0.23	7
Marketing, Design, and Publishing	0.83	0.81	6	0.99	0.63	6
Medical Devices	0.23	1.34	4	0.35	1.34	4
Metal Mining	0.33	11.45	1	0.53	11.46	1
Metalworking Technology	0.11	0.42	6	0.14	0.50	5
Music and Sound Recording	0.00	0.23	8	0.00	0.14	8
Nonmetal Mining	0.04	0.63	5	0.05	0.72	4
Oil and Gas Production and Transportation	0.03	0.08	7	0.04	0.06	5
Paper and Packaging	0.09	0.41	6	0.10	0.40	6
Performing Arts	0.36	0.90	5	0.17	0.55	5
Plastics	0.19	0.46	7	0.17	0.41	8
Printing Services	0.17	0.68	6	0.15	0.72	5
Production Technology and Heavy Machinery	0.22	0.37	8	0.30	0.43	7
Recreational and Small Electric Goods	0.11	0.88	6	0.12	0.92	6
Textile Manufacturing	0.03	0.26	6	0.02	0.23	6
Tobacco	0.00	0.25	4	0.00	0.18	4
Trailers, Motor Homes, and Appliances	0.03	0.32	3	0.03	0.31	3
Transportation and Logistics	1.32	0.99	3	1.61	1.04	3
Upstream Chemical Products	0.04	0.39	3	0.06	0.31	4
Upstream Metal Manufacturing	0.12	0.50	2	0.14	0.49	2
Video Production and Distribution	0.06	0.26	8	0.05	0.17	8
Vulcanized and Fired Materials	0.07	0.43	6	0.06	0.43	4
Water Transportation	0.01	0.07	6	0.01	0.06	6
Wood Products	0.11	0.42	7	0.09	0.44	7
Farming and Ranching	0.41	0.52	4	0.32	0.62	4
Federal Government	2.71	0.93	6	3.49	0.97	6

* Among eight comparison states

TABLE E2
TRADED CLUSTERS, ARIZONA AND UNITED STATES, 2012-TO-2022 CHANGE IN SHARE

	Employment			Aggregate Earnings		
	Arizona	United States	Arizona Rank*	Arizona	United States	Arizona Rank*
Aerospace Vehicles and Defense	-0.27	-0.05	7	-0.94	-0.17	7
Agricultural Inputs and Services	-0.16	-0.02	8	-0.06	0.01	8
Apparel	0.00	-0.04	1	0.01	-0.03	1
Automotive	0.10	0.03	2	0.13	-0.06	2
Biopharmaceuticals	0.07	0.03	3	0.07	-0.02	2
Business Services	0.79	1.11	7	1.30	1.79	6
Coal Mining	-0.02	-0.04	5	-0.03	-0.06	5
Communications Equipment and Services	-0.02	-0.04	4	0.00	0.04	4
Construction Products and Services	0.05	0.02	3	0.10	-0.01	1
Distribution and Electronic Commerce	0.91	0.43	1	0.01	-0.06	3
Downstream Chemical Products	0.01	-0.01	1	0.01	-0.04	1
Downstream Metal Products	0.09	0.01	1	0.14	-0.01	1
Education and Knowledge Creation	-0.68	-0.04	8	-0.20	0.19	8
Electric Power Generation and Transmission	-0.01	-0.02	5	-0.04	-0.06	7
Environmental Services	0.01	0.01	3	-0.04	0.00	7
Financial Services	0.04	-0.09	2	0.25	-0.11	3
Fishing and Fishing Products	0.00	-0.01	1	-0.01	-0.01	4
Food Processing and Manufacturing	0.12	0.10	4	0.08	-0.02	1
Footwear	0.00	0.00	6	0.00	0.00	7
Forestry	0.00	-0.01	1	0.01	-0.01	1
Furniture	0.01	-0.01	2	0.01	-0.01	2
Hospitality and Tourism	-0.46	-0.19	8	-0.23	-0.03	8
Information Technology/Analytical Instruments	0.04	0.15	7	0.10	0.51	6
Insurance Services	0.14	-0.06	1	0.08	-0.19	1
Jewelry and Precious Metals	0.00	0.00	2	0.00	-0.01	2
Leather and Related Products	-0.01	0.00	5	-0.01	0.00	6
Lighting and Electrical Equipment	0.02	-0.02	2	0.03	-0.06	1
Livestock Processing	0.01	-0.01	3	0.02	0.02	3
Marketing, Design, and Publishing	0.08	0.07	3	0.18	0.24	3
Medical Devices	0.07	0.00	2	0.07	-0.03	2
Metal Mining	-0.05	0.00	7	-0.16	-0.01	7
Metalworking Technology	-0.03	-0.05	5	-0.01	-0.08	2
Music and Sound Recording	-0.01	0.00	8	-0.01	0.00	8
Nonmetal Mining	-0.01	0.00	8	-0.01	0.00	8
Oil and Gas Production and Transportation	0.00	-0.21	1	-0.01	-0.54	2
Paper and Packaging	0.01	-0.04	1	0.01	-0.08	1
Performing Arts	-0.02	0.02	7	-0.02	0.01	7
Plastics	0.05	0.02	2	0.04	-0.01	2
Printing Services	-0.06	-0.09	3	-0.06	-0.11	1
Production Technology and Heavy Machinery	0.00	-0.06	2	0.01	-0.17	1
Recreational and Small Electric Goods	-0.04	0.00	7	-0.01	-0.01	3
Textile Manufacturing	-0.01	-0.04	3	-0.01	-0.04	4
Tobacco	0.00	0.00	6	0.00	-0.01	4
Trailers, Motor Homes, and Appliances	0.01	0.02	1	0.01	0.02	1
Transportation and Logistics	-0.07	0.04	7	-0.23	0.05	7
Upstream Chemical Products	0.02	-0.01	1	0.03	-0.03	1
Upstream Metal Manufacturing	-0.03	-0.04	3	-0.06	-0.08	5
Video Production and Distribution	0.00	0.02	7	0.01	-0.01	3
Vulcanized and Fired Materials	0.00	-0.02	1	0.00	-0.03	1
Water Transportation	0.01	-0.01	3	0.01	-0.03	2
Wood Products	0.01	0.02	7	0.02	0.03	5
Farming and Ranching	-0.13	-0.08	6	-0.10	-0.08	7
Federal Government	-0.52	-0.39	4	-1.16	-0.88	4

* Among eight comparison states

TABLE E3
TRADED CLUSTERS, METROPOLITAN PHOENIX, 2022

	Employment			Aggregate Earnings		
	Share of Total	Ratio to Nation	Rank*	Share of Total	Ratio to Nation	Rank*
Aerospace Vehicles and Defense	0.77%	2.05	4	1.32%	1.99	4
Agricultural Inputs and Services	0.08	0.24	6	0.06	0.30	4
Apparel	0.04	0.50	8	0.03	0.47	7
Automotive	0.30	0.49	3	0.39	0.57	3
Biopharmaceuticals	0.18	0.89	7	0.20	0.48	9
Business Services	8.31	1.26	9	10.85	0.99	11
Coal Mining	0.00	0.06	3	0.01	0.17	2
Communications Equipment and Services	0.34	1.08	9	0.51	0.72	10
Construction Products and Services	0.48	0.83	3	0.65	0.90	1
Distribution and Electronic Commerce	4.29	1.13	2	5.30	1.13	3
Downstream Chemical Products	0.09	0.54	3	0.10	0.47	4
Downstream Metal Products	0.35	1.22	2	0.44	1.49	1
Education and Knowledge Creation	1.71	0.83	10	1.52	0.60	10
Electric Power Generation and Transmission	0.01	0.08	12	0.02	0.08	11
Environmental Services	0.06	0.70	9	0.06	0.68	5
Financial Services	2.57	1.94	1	4.27	1.19	4
Fishing and Fishing Products	0.00	0.04	11	0.00	0.02	11
Food Processing and Manufacturing	0.52	0.68	6	0.53	0.74	4
Footwear	0.00	0.11	9	0.00	0.05	11
Forestry	0.01	0.14	7	0.01	0.17	6
Furniture	0.23	0.98	2	0.20	1.06	1
Hospitality and Tourism	1.68	0.92	4	1.60	1.22	2
Information Technology/Analytical Instruments	1.41	1.54	9	3.20	1.44	8
Insurance Services	0.95	1.04	3	1.27	0.93	3
Jewelry and Precious Metals	0.01	0.54	4	0.01	0.41	4
Leather and Related Products	0.01	0.44	10	0.01	0.48	7
Lighting and Electrical Equipment	0.10	0.59	8	0.14	0.62	7
Livestock Processing	0.08	0.23	3	0.07	0.26	2
Marketing, Design, and Publishing	0.94	0.91	11	1.08	0.68	11
Medical Devices	0.21	1.23	7	0.33	1.26	5
Metal Mining	0.09	3.17	1	0.19	4.13	1
Metalworking Technology	0.13	0.48	6	0.15	0.55	2
Music and Sound Recording	0.01	0.25	12	0.00	0.15	12
Nonmetal Mining	0.03	0.41	6	0.04	0.52	3
Oil and Gas Production and Transportation	0.02	0.05	10	0.03	0.04	7
Paper and Packaging	0.11	0.53	3	0.12	0.49	3
Performing Arts	0.35	0.90	11	0.17	0.55	8
Plastics	0.18	0.44	5	0.16	0.39	5
Printing Services	0.18	0.75	4	0.16	0.80	3
Production Technology and Heavy Machinery	0.20	0.33	11	0.24	0.35	8
Recreational and Small Electric Goods	0.12	0.97	5	0.14	1.05	3
Textile Manufacturing	0.02	0.19	4	0.02	0.18	3
Tobacco	0.00	0.31	7	0.00	0.22	7
Trailers, Motor Homes, and Appliances	0.04	0.36	2	0.04	0.34	2
Transportation and Logistics	1.44	1.07	3	1.72	1.10	2
Upstream Chemical Products	0.03	0.31	5	0.05	0.29	5
Upstream Metal Manufacturing	0.09	0.40	2	0.10	0.35	2
Video Production and Distribution	0.06	0.27	11	0.05	0.17	10
Vulcanized and Fired Materials	0.06	0.42	5	0.06	0.43	4
Water Transportation	0.01	0.07	9	0.02	0.06	8
Wood Products	0.10	0.40	5	0.08	0.39	5
Farming and Ranching	0.29	0.37	5	0.21	0.42	3
Federal Government	1.59	0.54	9	1.78	0.49	8

* Among 12 large comparison metropolitan areas

TABLE E4
TRADED CLUSTERS, METROPOLITAN PHOENIX AND UNITED STATES, 2012-TO-2022 CHANGE IN SHARE

	Employment			Aggregate Earnings		
	Phoenix	United States	Phoenix Rank*	Phoenix	United States	Phoenix Rank*
Aerospace Vehicles and Defense	-0.40	-0.05	10	-1.11	-0.17	11
Agricultural Inputs and Services	-0.04	-0.02	11	-0.03	0.01	11
Apparel	0.01	-0.04	1	0.02	-0.03	2
Automotive	0.13	0.03	2	0.18	-0.06	2
Biopharmaceuticals	0.09	0.03	2	0.09	-0.02	2
Business Services	0.54	1.11	12	0.90	1.79	9
Coal Mining	0.00	-0.04	1	0.01	-0.06	1
Communications Equipment and Services	0.00	-0.04	4	0.00	0.04	4
Construction Products and Services	0.08	0.02	2	0.14	-0.01	2
Distribution and Electronic Commerce	0.81	0.43	2	-0.27	-0.06	5
Downstream Chemical Products	0.01	-0.01	3	0.01	-0.04	3
Downstream Metal Products	0.10	0.01	1	0.17	-0.01	1
Education and Knowledge Creation	-0.93	-0.04	12	-0.18	0.19	10
Electric Power Generation and Transmission	0.00	-0.02	6	0.00	-0.06	7
Environmental Services	0.00	0.01	9	-0.07	0.00	12
Financial Services	-0.16	-0.09	9	-0.02	-0.11	5
Fishing and Fishing Products	0.00	-0.01	6	-0.01	-0.01	9
Food Processing and Manufacturing	0.12	0.10	7	0.08	-0.02	3
Footwear	0.00	0.00	5	0.00	0.00	5
Forestry	0.00	-0.01	3	0.01	-0.01	3
Furniture	0.00	-0.01	3	0.02	-0.01	1
Hospitality and Tourism	-0.47	-0.19	11	-0.28	-0.03	12
Information Tech/Analytical Instruments	-0.06	0.15	10	-0.11	0.51	9
Insurance Services	-0.10	-0.06	3	-0.21	-0.19	5
Jewelry and Precious Metals	0.00	0.00	4	0.00	-0.01	6
Leather and Related Products	-0.01	0.00	8	0.00	0.00	8
Lighting and Electrical Equipment	0.05	-0.02	2	0.07	-0.06	1
Livestock Processing	0.00	-0.01	9	0.01	0.02	5
Marketing, Design, and Publishing	0.03	0.07	7	0.12	0.24	7
Medical Devices	0.13	0.00	1	0.20	-0.03	1
Metal Mining	-0.05	0.00	12	-0.12	-0.01	12
Metalworking Technology	-0.05	-0.05	10	-0.02	-0.08	5
Music and Sound Recording	-0.01	0.00	11	-0.01	0.00	11
Nonmetal Mining	-0.01	0.00	12	-0.02	0.00	12
Oil and Gas Production and Transportation	0.00	-0.21	4	0.00	-0.54	4
Paper and Packaging	0.04	-0.04	2	0.05	-0.08	2
Performing Arts	-0.04	0.02	11	-0.03	0.01	8
Plastics	0.03	0.02	2	0.02	-0.01	2
Printing Services	-0.07	-0.09	4	-0.06	-0.11	5
Production Technology and Heavy Machinery	-0.04	-0.06	7	-0.06	-0.17	4
Recreational and Small Electric Goods	-0.02	0.00	6	0.01	-0.01	3
Textile Manufacturing	-0.01	-0.04	10	-0.01	-0.04	9
Tobacco	0.00	0.00	8	0.00	-0.01	7
Trailers, Motor Homes, and Appliances	0.01	0.02	2	0.01	0.02	2
Transportation and Logistics	-0.14	0.04	10	-0.32	0.05	11
Upstream Chemical Products	0.02	-0.01	2	0.03	-0.03	2
Upstream Metal Manufacturing	-0.03	-0.04	9	-0.05	-0.08	9
Video Production and Distribution	-0.01	0.02	5	0.01	-0.01	4
Vulcanized and Fired Materials	0.00	-0.02	4	0.00	-0.03	4
Water Transportation	0.01	-0.01	4	0.01	-0.03	3
Wood Products	0.01	0.02	7	0.02	0.03	4
Farming and Ranching	-0.09	-0.08	12	-0.07	-0.08	12
Federal Government	-0.22	-0.39	2	-0.53	-0.88	3

* Among 12 large comparison metropolitan areas

TABLE E5
TRADED CLUSTERS, METROPOLITAN TUCSON, 2022

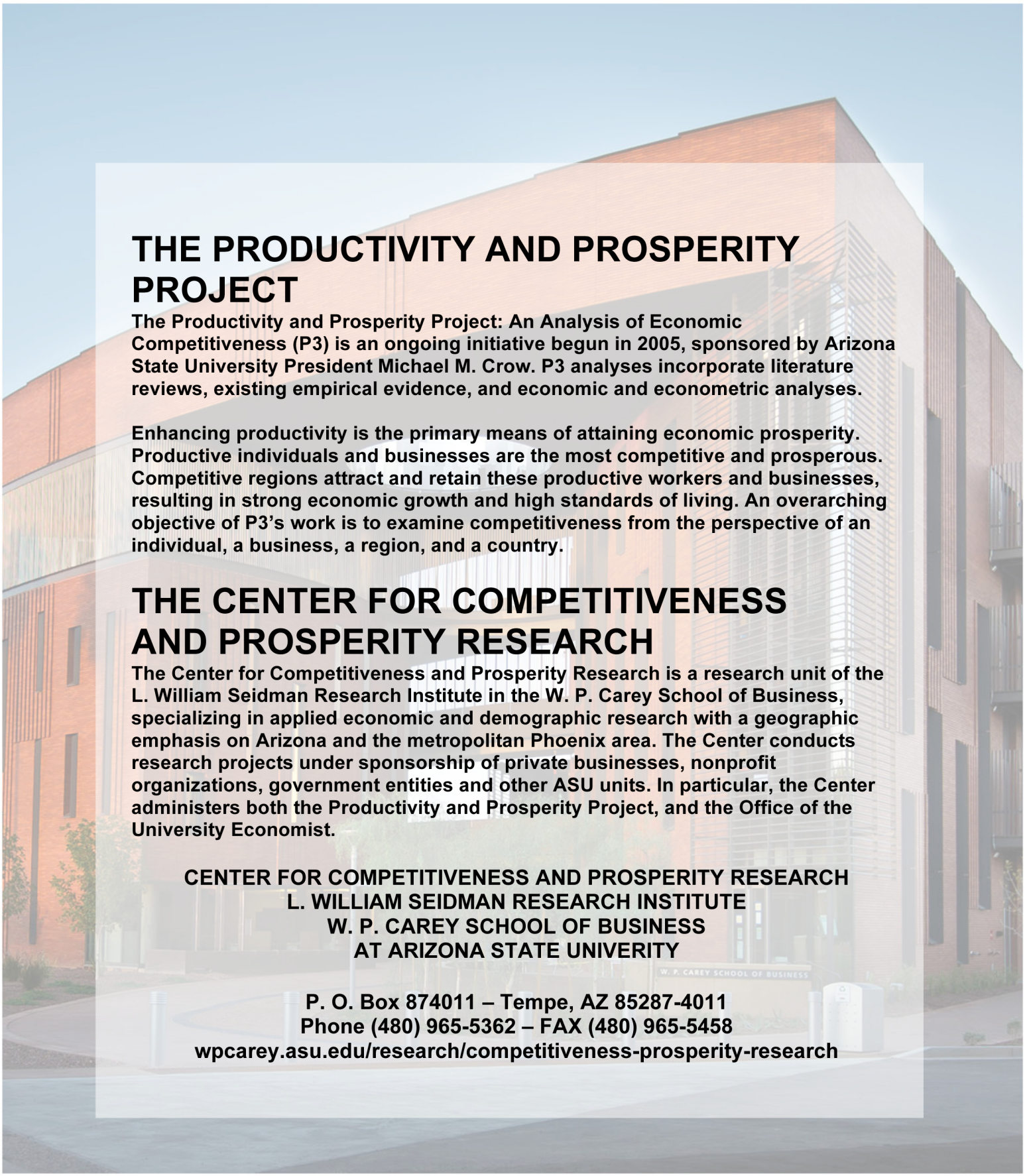
	Employment			Aggregate Earnings		
	Share of Total	Ratio to Nation	Rank*	Share of Total	Ratio to Nation	Rank*
Aerospace Vehicles and Defense	3.15%	8.38	1	7.27%	10.96	1
Agricultural Inputs and Services	0.04	0.11	6	0.03	0.13	6
Apparel	0.02	0.24	7	0.01	0.19	7
Automotive	0.04	0.07	7	0.05	0.07	7
Biopharmaceuticals	0.00	0.02	8	0.02	0.04	7
Business Services	6.22	0.94	5	7.35	0.67	7
Coal Mining	0.00	0.12	2	0.01	0.25	2
Communications Equipment and Services	0.14	0.44	6	0.18	0.25	7
Construction Products and Services	0.28	0.48	7	0.38	0.52	7
Distribution and Electronic Commerce	3.49	0.91	2	2.87	0.61	6
Downstream Chemical Products	0.02	0.15	4	0.03	0.13	4
Downstream Metal Products	0.27	0.92	3	0.26	0.87	4
Education and Knowledge Creation	0.99	0.48	7	1.21	0.48	7
Electric Power Generation and Transmission	0.30	2.96	1	0.69	2.88	1
Environmental Services	0.05	0.54	6	0.04	0.45	6
Financial Services	0.84	0.63	5	1.52	0.42	6
Fishing and Fishing Products	0.00	0.03	3	0.00	0.03	3
Food Processing and Manufacturing	0.31	0.41	7	0.24	0.34	7
Footwear	0.00	0.08	7	0.00	0.04	7
Forestry	0.01	0.10	5	0.00	0.09	5
Furniture	0.05	0.22	8	0.04	0.21	8
Hospitality and Tourism	1.96	1.07	2	1.25	0.96	3
Information Technology/Analytical Instruments	1.06	1.16	7	2.40	1.09	5
Insurance Services	0.89	0.98	4	1.11	0.81	4
Jewelry and Precious Metals	0.01	0.43	8	0.00	0.26	8
Leather and Related Products	0.01	0.33	8	0.00	0.20	7
Lighting and Electrical Equipment	0.07	0.40	4	0.11	0.46	5
Livestock Processing	0.01	0.03	8	0.01	0.03	8
Marketing, Design, and Publishing	0.49	0.47	6	0.58	0.37	6
Medical Devices	0.14	0.81	4	0.16	0.62	6
Metal Mining	0.38	13.38	1	0.67	14.35	1
Metalworking Technology	0.11	0.42	4	0.15	0.55	1
Music and Sound Recording	0.00	0.20	8	0.00	0.09	7
Nonmetal Mining	0.05	0.75	4	0.09	1.18	3
Oil and Gas Production and Transportation	0.04	0.13	8	0.07	0.11	8
Paper and Packaging	0.02	0.10	6	0.03	0.13	5
Performing Arts	0.45	1.13	3	0.20	0.65	3
Plastics	0.09	0.22	8	0.10	0.25	8
Printing Services	0.16	0.66	4	0.14	0.68	4
Production Technology and Heavy Machinery	0.41	0.69	3	0.82	1.17	2
Recreational and Small Electric Goods	0.07	0.58	5	0.05	0.41	5
Textile Manufacturing	0.01	0.06	6	0.00	0.03	7
Tobacco	0.00	0.08	3	0.00	0.04	3
Trailers, Motor Homes, and Appliances	0.01	0.07	7	0.01	0.10	6
Transportation and Logistics	0.85	0.64	4	1.04	0.67	4
Upstream Chemical Products	0.03	0.34	3	0.05	0.29	3
Upstream Metal Manufacturing	0.08	0.35	5	0.07	0.25	6
Video Production and Distribution	0.04	0.20	7	0.04	0.12	7
Vulcanized and Fired Materials	0.03	0.21	7	0.02	0.17	7
Water Transportation	0.00	0.01	4	0.00	0.02	4
Wood Products	0.11	0.43	6	0.11	0.51	4
Farming and Ranching	0.13	0.16	7	0.12	0.24	6
Federal Government	4.91	1.68	3	7.55	2.10	4

* Among eight moderately large comparison metropolitan areas

TABLE E6
TRADED CLUSTERS, METROPOLITAN TUCSON AND UNITED STATES, 2012-TO-2022 CHANGE IN SHARE

	Employment			Aggregate Earnings		
	Tucson	United States	Tucson Rank*	Tucson	United States	Tucson Rank*
Aerospace Vehicles and Defense	0.35	-0.05	2	-0.03	-0.17	4
Agricultural Inputs and Services	0.00	-0.02	3	0.00	0.01	4
Apparel	-0.01	-0.04	3	0.00	-0.03	3
Automotive	-0.01	0.03	4	-0.08	-0.06	7
Biopharmaceuticals	-0.01	0.03	8	-0.01	-0.02	4
Business Services	-0.20	1.11	8	-0.07	1.79	8
Coal Mining	0.00	-0.04	7	0.00	-0.06	1
Communications Equipment and Services	0.00	-0.04	2	0.00	0.04	2
Construction Products and Services	-0.02	0.02	7	-0.03	-0.01	6
Distribution and Electronic Commerce	1.97	0.43	1	0.82	-0.06	2
Downstream Chemical Products	0.01	-0.01	3	0.00	-0.04	2
Downstream Metal Products	0.18	0.01	1	0.17	-0.01	1
Education and Knowledge Creation	-0.34	-0.04	6	-0.59	0.19	5
Electric Power Generation and Transmission	0.06	-0.02	2	0.07	-0.06	5
Environmental Services	0.02	0.01	5	0.02	0.00	4
Financial Services	-0.01	-0.09	4	0.18	-0.11	4
Fishing and Fishing Products	0.00	-0.01	7	-0.01	-0.01	8
Food Processing and Manufacturing	0.11	0.10	5	0.06	-0.02	5
Footwear	0.00	0.00	7	0.00	0.00	7
Forestry	0.00	-0.01	2	0.00	-0.01	4
Furniture	0.00	-0.01	4	-0.01	-0.01	5
Hospitality and Tourism	-0.52	-0.19	8	-0.21	-0.03	8
Information Tech/Analytical Instruments	0.15	0.15	3	0.48	0.51	3
Insurance Services	0.70	-0.06	1	0.79	-0.19	1
Jewelry and Precious Metals	0.00	0.00	2	0.00	-0.01	2
Leather and Related Products	-0.02	0.00	7	-0.02	0.00	7
Lighting and Electrical Equipment	-0.09	-0.02	8	-0.16	-0.06	8
Livestock Processing	0.01	-0.01	5	0.01	0.02	5
Marketing, Design, and Publishing	-0.03	0.07	4	0.11	0.24	2
Medical Devices	0.05	0.00	3	0.06	-0.03	4
Metal Mining	-0.11	0.00	6	-0.23	-0.01	7
Metalworking Technology	0.00	-0.05	3	0.00	-0.08	2
Music and Sound Recording	-0.03	0.00	8	-0.04	0.00	8
Nonmetal Mining	0.03	0.00	1	0.07	0.00	1
Oil and Gas Production and Transportation	-0.01	-0.21	4	-0.02	-0.54	4
Paper and Packaging	-0.01	-0.04	3	0.01	-0.08	3
Performing Arts	0.04	0.02	1	0.00	0.01	6
Plastics	0.03	0.02	8	0.03	-0.01	8
Printing Services	-0.04	-0.09	2	-0.04	-0.11	2
Production Technology and Heavy Machinery	0.14	-0.06	1	0.36	-0.17	1
Recreational and Small Electric Goods	-0.04	0.00	3	-0.05	-0.01	4
Textile Manufacturing	0.00	-0.04	2	0.00	-0.04	3
Tobacco	-0.01	0.00	8	0.00	-0.01	8
Trailers, Motor Homes, and Appliances	0.01	0.02	5	0.01	0.02	5
Transportation and Logistics	-0.01	0.04	4	0.02	0.05	2
Upstream Chemical Products	0.01	-0.01	2	0.01	-0.03	2
Upstream Metal Manufacturing	-0.02	-0.04	5	-0.03	-0.08	6
Video Production and Distribution	-0.03	0.02	7	0.00	-0.01	7
Vulcanized and Fired Materials	-0.04	-0.02	6	-0.04	-0.03	6
Water Transportation	0.00	-0.01	4	0.00	-0.03	3
Wood Products	0.00	0.02	6	0.03	0.03	6
Farming and Ranching	-0.04	-0.08	6	-0.04	-0.08	6
Federal Government	-0.23	-0.39	1	-0.73	-0.88	2

* Among eight moderately large comparison metropolitan areas



THE PRODUCTIVITY AND PROSPERITY PROJECT

The Productivity and Prosperity Project: An Analysis of Economic Competitiveness (P3) is an ongoing initiative begun in 2005, sponsored by Arizona State University President Michael M. Crow. P3 analyses incorporate literature reviews, existing empirical evidence, and economic and econometric analyses.

Enhancing productivity is the primary means of attaining economic prosperity. Productive individuals and businesses are the most competitive and prosperous. Competitive regions attract and retain these productive workers and businesses, resulting in strong economic growth and high standards of living. An overarching objective of P3's work is to examine competitiveness from the perspective of an individual, a business, a region, and a country.

THE CENTER FOR COMPETITIVENESS AND PROSPERITY RESEARCH

The Center for Competitiveness and Prosperity Research is a research unit of the L. William Seidman Research Institute in the W. P. Carey School of Business, specializing in applied economic and demographic research with a geographic emphasis on Arizona and the metropolitan Phoenix area. The Center conducts research projects under sponsorship of private businesses, nonprofit organizations, government entities and other ASU units. In particular, the Center administers both the Productivity and Prosperity Project, and the Office of the University Economist.

CENTER FOR COMPETITIVENESS AND PROSPERITY RESEARCH
L. WILLIAM SEIDMAN RESEARCH INSTITUTE
W. P. CAREY SCHOOL OF BUSINESS
AT ARIZONA STATE UNIVERITY

P. O. Box 874011 – Tempe, AZ 85287-4011
Phone (480) 965-5362 – FAX (480) 965-5458
wpcarey.asu.edu/research/competitiveness-prosperity-research

ASU W. P. CAREY SCHOOL of BUSINESS
ARIZONA STATE UNIVERSITY

wpcarey.asu.edu

P3 PRODUCTIVITY AND PROSPERITY PROJECT

economist.asu.edu