How High Tech Is the Tenth District?

By Chad Wilkerson

Newspapers in the Tenth Federal Reserve District generally keep a close eye on where their cities rank in national studies of high-tech activity.[1] Readers have good reason to be interested in how "high tech" their communities are, despite the recent downturn in the sector. High-tech workers are among the best paid of all workers and, if these recent studies are correct, an area's failure to embrace the "New Economy" could result in a lower standard of living and fewer opportunities for residents down the road. But studies of high-tech cities, which are usually produced by think tanks, trade groups, or business magazines, have varying results and usually focus only on major metropolitan areas. As a result, it is often difficult for policymakers, businesses, and residents in the Tenth District to understand where they really stand in the "New Economy" and how they got there.

This article shows that much of the Tenth District is quite high tech, once the geographic distribution of the region's population is taken into account. Across the country, the overarching determinant for the amount of local high-tech activity appears to be a metro's size. Because the Tenth District has relatively few large cities, the level of high-tech activity in most district states falls short of the national average. But analysis of high-tech activity in metro areas shows that nearly all of the

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district's larger metros exceed national averages for cities their size. In fact, several of the region's larger cities rank among the most high-tech places in the nation.

The first section of the article defines "high tech" and documents the overall level of high-tech activity in the Tenth District. The second section explains why high-tech firms and workers concentrate in metro areas and shows that, given the size of its cities, the district is quite high tech. The third section uses a set of case studies to explain why high-tech activity in many Tenth District cities exceeds national averages.

I. OVERVIEW OF HIGH TECH IN THE NATION AND DISTRICT

Determining how high tech the Tenth District is requires defining "high tech" in a measurable way. Agreement has been fairly wide among researchers about what high tech means in general. Some quote a 1982 definition by the Congressional Office of Technology Assessment: "The design, development, and introduction of new products and innovative manufacturing processes, or both, through the systematic application of scientific and technical knowledge" (Hecker). In practice, most studies have used some measure for the output—or the value of goods and services produced—of certain local industries classified as high tech to rank cities according to their level of high-tech activity.[2]

But despite this general agreement about a definition of "high tech" and the type of measure to be used, there has been considerable disagreement on which industries should be considered high tech. One common method of industry selection is to simply choose industries whose products and services are widely considered as high tech—such as computer manufacturing and online information services. Another fairly common approach is to determine the percentage of an industry's national employment in high-tech occupations and to consider the industry high tech if this percentage significantly exceeds the national average across all industries. For example, one recent study considered an industry high tech if at least 9 percent—or three times the national average—of its employees were engineers, physical scientists, life scientists, computer scientists, math scientists, and science/engineering man-

agers (Markusen and others). This study identified 30 such industries, led by the "Guided Missiles and Space Vehicles" industry, which had 43 percent of its employment in high-tech occupations.

This article uses two distinct measures to assess the level of high-tech activity in the Tenth District. Examining two very different measures provides robustness to the study's results. And, in some cases, it underscores how the choice of measure can affect an area's claim to being high tech.

The occupational measure

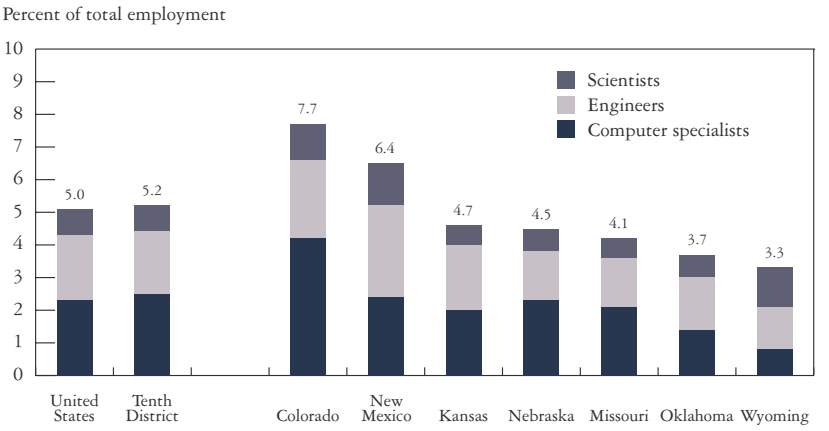
The first high-tech measure focuses on occupations. The occupational measure is the percentage of an area's employees who are scientists, engineers, or computer specialists (Appendix 1 provides a further breakdown of the occupations).[3] Instead of focusing only on industries that have a high percentage of such knowledge workers, as most recent studies do, this article's measure includes these workers across all industries. Presumably, most of the workers in these highly skilled occupations are performing high-tech work regardless of the industry in which they are employed. Moreover, local areas benefit from having these workers and their high wages, regardless of their industry.

According to the occupational measure, high-tech activity in the Tenth District looks very similar to the national average (Chart 1). In the district, 5.2 percent of the workforce was employed in high-tech occupations in 2000, compared with 5.0 percent in the country as a whole. As a share of its total employment, the region has slightly fewer engineers than the country as a whole, but has an equal number of scientists and somewhat more computer specialists.

Perhaps not surprisingly, workers in high-tech occupations are not distributed evenly across the region. Among the seven states that comprise the Tenth District, only two—Colorado and New Mexico—score higher than the nation on the occupational measure. Although the remaining states all trail the countrywide average, these states often fare well in some occupations. For example, Nebraska has a slightly higher share of computer specialists than the nation, Kansas has more engineers, and Wyoming has more scientists.

Chart 1

EMPLOYMENT IN HIGH-TECH OCCUPATIONS, 2000



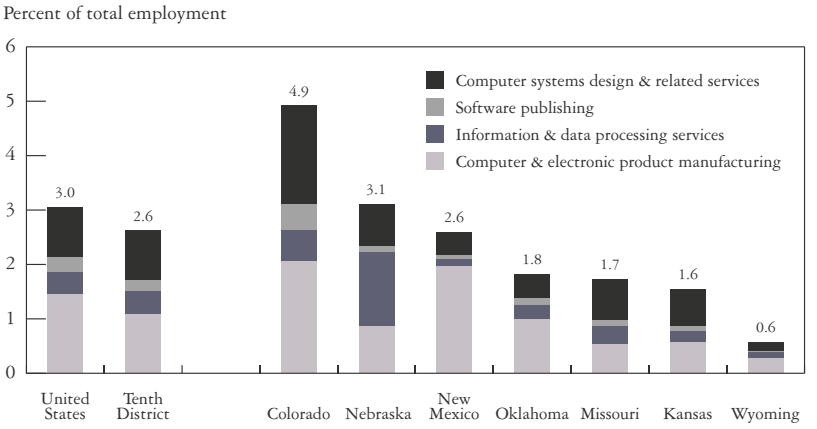
Source: Occupational Employment Statistics

The industry measure

The second high-tech measure used in the article focuses on industries. The industry measure is the share of an area's total employment in four key high-tech industries: computer and electronics manufacturing; software publishing; information and data processing services; and computer systems design and related services (Appendix 2 shows a further breakdown of the industries).[4] The industry measure is the same as the one used in a recent Brookings Institution study by Joseph Cortright and Heike Mayer, and is similar to the measures used by most other recent studies of high-tech cities.[5] Unlike the occupational measure, which looks at the level of high-tech activity occurring across all industries, this measure focuses on how concentrated a place is in the most high-tech of industries.

According to the most recent data, high-tech activity in the Tenth District slightly trails the nation on the industry measure (Chart 2). In the nation, 3.0 percent of the workforce was employed in a high-tech industry in 1999, compared with 2.6 percent in the district. On an industry-by-industry basis, the district has much smaller concentrations in the software publishing and computer and electronic manufacturing

Chart 2
EMPLOYMENT IN HIGH-TECH INDUSTRIES, 1999



Source: *County Business Patterns*

industries than the national average, but has a similar share of workers in computer systems design and a slightly larger presence in information and data processing services.

Among the seven district states, only Colorado scores well above the national average on the industry measure—and does so for all four high-tech industries. Nebraska and New Mexico have similar shares of workers in high-tech industries as the nation, while Oklahoma, Missouri, Kansas, and Wyoming trail the nation considerably. Still, two of these district states have especially high concentrations of one or more of the individual high-tech industries. Nebraska's concentration of data and information processing services is more than three times the national average. And New Mexico's share of computer and electronic product manufacturing workers is roughly twice the national average.

Looking at the amount of high-tech activity occurring in the Tenth District as a whole and in the states that comprise it makes for an interesting first take on where the region stands relative to the nation in the "New Economy." But getting a more complete understanding of high-tech activity in the district requires looking at metropolitan areas, where high-tech activity is concentrated.

II. DISTRICT CITIES ARE HIGH TECH FOR THEIR SIZE

Basic economic theory suggests that high-tech activity is more likely to locate in more populous areas than in less populous ones. With the Tenth District having relatively few large cities, any tendency for high-tech activity to locate in large markets may explain why many district states trail national high-tech averages. This section first discusses why high-tech firms and workers may prefer larger markets and shows that, across the nation, there appears to be a correlation between city size and high-tech activity. The section then examines high-tech activity in the district at the metro area level, finding that the Tenth District appears to be quite high tech once the geographic distribution of its population is taken into account.

Why do high-tech firms and workers prefer big cities?

Economic theory offers several different—but in some cases mutually reinforcing—explanations for why high-tech activity might locate in larger markets. One is the employment benefit to workers of being in a large market. Since much high-tech work is relatively specialized, high-tech workers will prefer to locate where job opportunities are greatest, typically in large metropolitan areas, so they can minimize the likelihood of going without work. High-tech firms will consequently prefer to locate near these reliable supplies of high-tech laborers.

Highly skilled high-tech workers may also prefer certain recreational and cultural amenities—such as high-quality museums, zoos, performing arts venues, and professional sports teams—which are more typically available in urban areas. Several studies have found that workers in high-tech occupations seem to place a premium on these quality-of-life benefits (Atkinson and Gottlieb; Kotkin and Devol). As a result, such workers may decide to live in large cities and high-tech firms will follow them.

Another benefit of larger markets is the cost advantages they can provide to high-tech businesses. Many high-tech firms require intermediate goods and services in producing their products. Firms that provide these goods and services often prefer to locate in metro areas where they

can be near customers, thus saving on such costs as transportation. High-tech firms, in turn, can save costs in a similar way by locating near these suppliers of intermediate products.

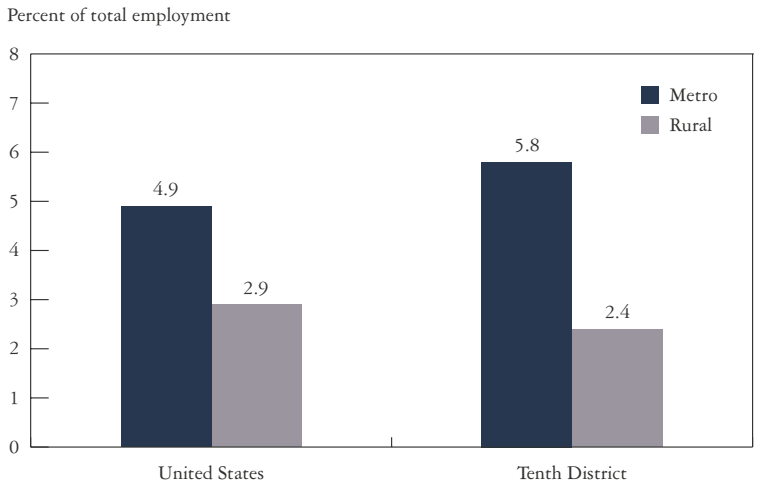
Finally, the potential for knowledge spillovers provides another reason that high-tech firms may choose to be in a large market. Due to the knowledge-based nature of most high-tech activity, high-tech workers may be relatively more productive when they are clustered together and can take advantage of one another's ideas (Orlando; Audretsch and Feldman). Therefore, high-tech firms will prefer to locate in dense population centers where their workers can potentially be more productive. This higher productivity means firms can pay employees more, making their urban location more attractive to high-tech workers.

Of course, despite all of these benefits, larger markets often have downsides as well. Crime, pollution, and taxes are all generally higher in big cities. In addition, a city experiencing an influx of people and firms due to the benefits mentioned above could also experience increases in housing prices and traffic congestion, thus eventually making it a less attractive place to live and do business. Given recent developments in information technology—primarily the Internet—that make it easier for workers to interact with colleagues and customers regardless of location, lower cost rural areas and small cities might appear to have some advantage in the "New Economy." However, in most cases the benefits to being in large markets appear to outweigh the costs for high-tech firms and workers, as recent research shows that these nonurban areas have fallen further behind larger metropolitan areas over the past decade (Kolko; Gaspar and Glaeser).

Data for the nation show that high-tech activity tends to increase with the size of an area. Based on the occupational measure, high-tech workers clearly prefer urban to rural areas of the United States (Chart 3).[6] In fact, workers in high-tech occupations were nearly twice as likely to be located in metro areas than nonmetro areas in 1999. In addition, high-tech concentration clearly intensifies with metro size (Table 1). Regardless of whether the occupational or industry measure is used, the nation's very large metros (those with populations over 2 million) are at least twice as concentrated in high-tech activity as very small cities (those with populations under 200,000). And the national high-tech leaders among the large and very large metro areas—such as Austin

Chart 3

EMPLOYMENT IN HIGH-TECH OCCUPATIONS, METRO VS. RURAL AREAS, 1999



Source: Occupational Employment Statistics

and the San Francisco Bay area—tend to be more concentrated than the leaders among the smaller metro areas—such as Colorado Springs and Cedar Rapids. Exceptions to this trend are the national leaders among small metro areas (population 200,000 to 500,000)—Huntsville, Melbourne-Titusville-Palm Bay, and Binghamton. However, each of these metros has a unique reason for its extremely high concentration of high-tech activity. Huntsville and Melbourne are both important NASA centers, and Binghamton is the birthplace of IBM.

How do district cities measure up?

The fact that, all else equal, high-tech firms and workers tend to locate in metro areas, especially in very large ones, has significant ramifications for the Tenth District. In the country as a whole, 80 percent of the population lives in metro areas, with 44 percent living in very large ones. In the Tenth District, these percentages are only 67 percent and

Table 1

HIGH-TECH EMPLOYMENT IN U.S. METROPOLITAN AREAS

Metro size	Percent of workers in high-tech occupations, 2000 (National leaders)	Percent of workers in high-tech industries, 1999** (National leaders)
Very large (over 2 million) 22 metros	**7.4** San Francisco-Oakland-San Jose, CA: 12.7 Seattle-Tacoma-Bremerton, WA: 10.8	**4.4** San Francisco-Oakland-San Jose, CA: 10.9 Boston-Worcester-Lawrence, MA-NH-ME-CT: 7.7
Large (1–2 million) 27 metros	**6.0** Raleigh-Durham, NC: 12.2 Austin-San Marcos, TX: 11.0	**2.7** Austin-San Marcos, TX: 9.2 Raleigh-Durham, NC: 5.2
Mid-sized (500,000–1 million) 32 metros	**5.2** Colorado Springs, CO: 9.6 Albuquerque, NM: 9.1	**2.3** Colorado Springs, CO: 8.7 Omaha, NE: 5.1
Small (200,000–500,000) 84 metros	**4.9** Huntsville, AL: 15.7 Melbourne-Titusville-Palm Bay, FL: 12.9	**2.0** Huntsville, AL: 13.8 Binghamton, NY: 12.5
Very small (under 200,000) 108 metros	**3.7** Cedar Rapids, IA: 10.4 Richland-Kennewick-Pasco, WA: 9.6	**1.9** State College, PA: 8.5 Sherman-Denison, TX: 8.3
Rural portions of states*	**2.9** Maryland: 6.1 California: 5.3	**n/a**
National average	**5.0**	**3.0**

* Rural occupational data are for 1999.
** Industry data for some metropolitan areas reflect the midpoint of a range of employment.

Sources: Occupational Employment Statistics, *County Business Patterns*

17 percent, respectively. So not only does the region have a larger rural population than the country as a whole, but its metro areas are also generally smaller. Considering the distribution of the region's population, it is remarkable then that, on an overall basis, the Tenth District compares so favorably with national high-tech averages.

Data on the 21 metropolitan statistical areas (MSAs) located in the Tenth District show much of the region can be considered quite high tech (Table 2). Indeed, nearly all of the Tenth District's larger metro areas exceed national high-tech averages for their city size. Nine of the ten MSAs in the region with populations over 200,000 score above their respective countrywide averages on the occupational measure. Only Oklahoma City, one of the smaller metros in its size category, trails its national benchmark. Seven of these larger cities also score above the national average on the industry measure for cities their size, while Tulsa and Oklahoma City trail only slightly. The only real aberration is mid-sized Wichita, which lags the nation considerably on the industry measure despite scoring well above the countrywide average on the occupational measure. This discrepancy is likely due to the large number of scientists and engineers working in research and development in Wichita's important aircraft manufacturing industry, an industry not classified as high tech.

Moreover, several of the larger Tenth District cities are among the nation's high-tech leaders for their city size. Colorado Springs, for example, is the nation's mid-sized metro leader on both the industry and occupational measures, and Albuquerque and Omaha rank second among mid-sized cities on the occupational and industry measures, respectively. In addition, Denver-Boulder-Greeley ranks third among the nation's 22 very large metros on the occupational measure and fourth on the industry measure, while Fort Collins-Loveland ranks fourth out of 84 small metros on the industry measure and fifth on the occupational measure.

Although the district's larger metros seem well positioned in the "New Economy," the high-tech story is not as encouraging among the region's smallest metros and rural areas. None of the Tenth District's 11 very small metros ranks above the countrywide average for its metro size on both high-tech measures. Indeed, only four of these cities exceed the national benchmark on the occupational measure and just two have

Table 2

HIGH-TECH EMPLOYMENT IN TENTH DISTRICT METROPOLITAN AREAS

Metro size	Tenth district metros	Percent of workers in high-tech occupations, 2000	Percent of workers in high-tech industries, 1999**
Very large (over 2 million)	Denver-Boulder-Greeley, CO	**10.3**	**5.7**
Large (1-2 million)	Kansas City, MO-KS	**6.9**	**2.8**
	Oklahoma City, OK	4.9	2.3
Mid-sized (500,000-1 million)	Colorado Springs, CO	**9.6**	**8.7**
	Albuquerque, NM	**9.1**	**3.8**
	Wichita, KS	**7.6**	0.9
	Omaha, NE	**6.7**	**5.1**
	Tulsa, OK	**5.3**	2.0
Small (200,000-500,000)	Fort Collins-Loveland, CO	**8.8**	**7.2**
	Lincoln, NE	**6.6**	**2.7**
Very small (under 200,000)	Santa Fe, NM	**5.6**	1.5
	Topeka, KS	**5.2**	0.4
	Cheyenne, WY	**4.3**	1.0
	Lawrence, KS	**4.0**	1.8
	Grand Junction, CO	3.5	**2.7**
	Casper, WY	3.5	0.2
	St. Joseph, MO	2.8	0.3
	Lawton, OK	2.8	**1.9**
	Pueblo, CO	2.7	0.1
	Joplin, MO	1.6	0.6
	Enid, OK	1.4	0.2
Rural portions of states*	Wyoming	**3.6**	n/a
	Colorado	**3.3**	n/a
	New Mexico	**3.2**	n/a
	Nebraska	2.2	n/a
	Missouri	2.2	n/a
	Kansas	2.1	n/a
	Oklahoma	1.9	n/a

* Rural occupational data are for 1999.

** Industry data for some metropolitan areas reflect the midpoint of a range of employment.

Note: Bold figures indicate values above the national average for metro size.

Sources: Occupational Employment Statistics, *County Business Patterns*

CITY SIZE PREFERENCES OF HIGH-TECH INDUSTRIES

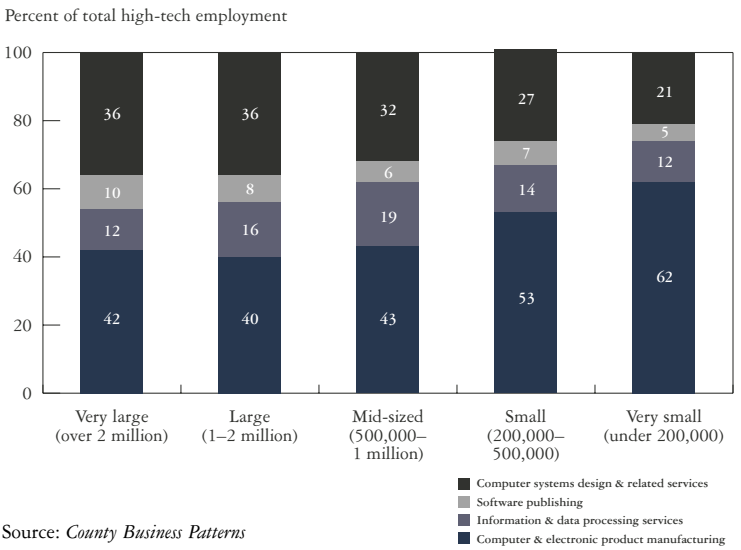
While high-tech firms in general clearly prefer larger markets to smaller ones, not all high-tech industries are the same in this respect. The four high-tech industries that make up the industry measure in this article each appear to have preferences for different sizes of metro areas. This phenomenon could obviously have implications for the mix of high-tech activity in the Tenth District, given its relative lack of large metros.

The software publishing and computer systems design industries typically make up a larger share of overall high-tech activity in the biggest metros (chart). Joel Kotkin and Ross Devol, in a 2001 study for The Milken Institute, explain why this might be: "To a large extent first-tier cities—with their enormous appeal to younger creative talent and cultural institutions—are most likely to reap the benefits of the expanding 'soft' or content part of the technological revolution."

Information and data processing firms, on the other hand, make up a sizable share of high-tech activity in mid-sized metros, while computer and electronic manufacturing companies dominate high-tech activity in the smallest metro

Chart

COMPOSITION OF EMPLOYMENT IN HIGH-TECH INDUSTRIES BY METRO SIZE, 1999



Source: *County Business Patterns*

areas of the country. Like software and design companies, each of these two industries relies to some degree on highly skilled workers and often must have a certain level of telecommunications infrastructure. However, these industries generally do not require as highly educated and creative of a workforce as the content industries. Such firms therefore tend to base more of their location decisions on traditional cost-of-doing-business factors, such as office rents and local wages, rather than on the quality-of-life factors that help attract workers in software and design. Kotkin and Devol suggest, "Lower cost, emerging-technology cities are most often best suited to take advantage of the infrastructural and blue-collar functions associated with the digital economy."

These national trends appear to largely hold true in the Tenth District. With its relatively larger number of mid-sized metros and relative lack of very large cities, the region has a somewhat larger overall presence in the information and data processing industries than the nation and a slightly smaller presence in software publishing. The region also has a smaller presence in computer and electronic manufacturing, as many of its smallest metros, where such industries tend to locate, trail national high-tech averages. The district has a similar presence in computer systems design as the nation, despite its dearth of large cities, as Denver and Colorado Springs have especially high concentrations of these firms.

higher percentages on the industry measure. Many of these very small cities fare poorly on the industry measure despite scoring near or above the national average on the occupational measure, perhaps suggesting that a critical mass of people is necessary for some types of high-tech industries to locate in a place (see the accompanying box). Rural areas of the Tenth District also tend to be slightly less high tech than rural areas in the rest of the country (Chart 3). A dichotomy clearly exists, however, between the Plains states (Kansas, Missouri, Nebraska, and Oklahoma) and Mountain states (Colorado, New Mexico, and Wyoming). The Mountain states score considerably higher on the occupational measure. This difference could be due to several factors, such as the larger number of scientists and engineers in the rural Mountain states due to greater mining activity there, or farming's large percentage of total employment in many rural areas of the Plains states.

Like the nation, the Tenth District's larger metro areas tend to be more high tech than its smaller metros and rural areas. Beyond this trend, most of the district's larger metros score well above national high-tech averages for cities their size. What is it about certain Tenth District cities that make them more high tech than their size might suggest?

III. CASE STUDIES OF HIGH-TECH DISTRICT CITIES

This section takes a more detailed look at what makes some district cities so high tech. It considers brief case studies of 11 metros in the region that score particularly well on the high-tech measures used in the article. These case studies suggest three primary reasons for why a metro might be more high tech than expected given its size. First, the metro has a large military-related research institution located within its borders. Second, the metro hosts a major research university. And third, the metro has long been home to employers of large numbers of creative people. The case studies also suggest a secondary reason why many district cities are attractive to high-tech workers and firms—proximity to significant cultural and recreational opportunities.

Military-related research institutions

Government military institutions have almost certainly increased high-tech activity in several metro areas in the Tenth District. In particular, the opening of military research centers near Omaha, Albuquerque, Santa Fe, and Colorado Springs in the 1940s and 1950s still contributes to high-tech activity in those cities. Such institutions attracted and produced scores of scientists, engineers, and computer specialists over the years, many of whom, in time, have started high-tech businesses of their own.

Omaha, Nebraska, identified by some recent studies as an "emerging" high-tech center, was aided tremendously by the location of the U.S. military's Strategic Air Command at nearby Offutt Air Force Base following World War II. The Command has laid miles of fiber optic cable, helping the city become one of nation's back-office high-tech leaders (Rogers; Atkinson and Gottlieb). Omaha is now home to a large number of data processing centers and computer-outsourcing firms. In

addition, after losing perhaps the city's highest-profile employer of high-tech workers—Level 3 Communications—to Denver in 1997, local universities created several technology-focused institutions to ensure the development of future generations of high-tech workers. As a result, its "emerging" label notwithstanding, Omaha is already quite high tech, as only Colorado Springs has a higher percentage of workers in high-tech industries among the nation's mid-sized metro areas.

Another city frequently cited in recent studies of high-tech activity, ***Albuquerque***, New Mexico, has almost certainly benefited from having the Sandia National Laboratory located within its boundaries and the Los Alamos National Laboratory located nearby. Established during World War II, these government labs have worked closely with electronics firms, helping Albuquerque attract large Intel, Honeywell, and Phillips Semiconductors plants. The presence of these plants has resulted in the metro being considered the most concentrated of any city in the country in terms of high-tech manufacturing output (Devol). In addition to the big factories, Albuquerque is also home to many smaller technology firms, many of them started by former lab employees. The metro also hosts the University of New Mexico, providing another source of high-tech workers and ideas.

The Los Alamos National Laboratory has also undoubtedly helped supply scenic ***Santa Fe***, New Mexico, with a large number of scientists and engineers over the years. Santa Fe hosts relatively few high-tech companies for a city its size, yet it is still the center of a considerable amount of high-tech activity. The city ranks among the top 20 percent of very small metros on the occupational measure. This dense supply of knowledge workers in the metro has led to the development of a couple of relatively new high-tech fields—complexity science and informatics (German). Firms in these fields mine and analyze complex data produced by companies to help them enhance productivity and improve the quality of their goods and services.

Important military institutions—including the North American Space Command at Cheyenne Mountain and the U.S. Air Force Academy—have also endowed ***Colorado Springs***, Colorado, with an abundance of high-tech workers over the years. In fact, the city ranks as the national leader among the country's mid-sized metros (population 500,000 to 1 million) on both the occupational and industry measures. While the metro does not serve as

the headquarters city for major high-tech players, it is home to large branch plants for Apple, Digital Equipment, and Hewlett-Packard. In addition to computer manufacturers, the city also has burgeoning software and computer systems design industries.

Large research universities

While mid-20th century decisions about where to locate important military centers appear to be the major contributor to current high-tech activity in several district metros, much earlier government decisions about where to locate major state universities has aided high-tech development in several other cities in the region. As big university towns, Lincoln, Lawrence, and Fort Collins have benefited from their dense supplies of researchers and scientists for many years, positioning them well to compete in the "New Economy."[7]

While Omaha gets most of the attention as Nebraska's high-tech center, ***Lincoln*** also has a high percentage of workers in both high-tech industries and high-tech occupations. As home to the University of Nebraska, Lincoln has benefited for many years from a steady supply of potential high-tech workers and should continue to do so in the future. Nebraska's state capital is home to many information processing and computer systems design firms, as well as branch plants of several manufacturers of communications equipment.

Lawrence, Kansas, also benefits greatly from hosting a major state university. Students and researchers from the University of Kansas have served as potential high-tech entrepreneurs and employees in the metro for many years. Indeed, the city ranks above the very small metro average on the occupational measure and is right at the national benchmark on the industry measure. For a city its size, Lawrence has a relatively large number of software and design firms—types of companies often started by young, creative minds. In addition to these businesses, the very small metro has spawned several successful biotechnology companies over the years and is also home to a Honeywell electronics plant.

Hosting the Colorado State University has likely helped the ***Fort Collins-Loveland*** metro area become one of the most high-tech places in the country for its size. Only Huntsville, Alabama, and Melbourne-Titusville-Palm Bay, Florida—metros chosen as important NASA cen-

ters in the late 1950s—rank higher on both measures of high-tech activity among the nation's small metro areas (population 200,000 to 500,000). Fort Collins-Loveland is home to large Hewlett-Packard and Agilent Technologies plants, as well as a growing number of computer systems design companies.

History of innovative companies

Long-standing institutions also appear to have played an important role in developing a culture of high technology in the Denver-Boulder-Greeley, Kansas City, and Tulsa metros over the years. However, unlike in the previous case studies in this section, these cities appear to have benefited most from hosting private companies with a long history of employing large numbers of highly skilled and creative people. To some degree, these cities have always been high tech, for reasons that are difficult to pinpoint.

The ***Denver-Boulder-Greeley*** metro area in Colorado has generally been acknowledged as one of the country's high-tech leaders in the recent studies of high-tech cities. While many factors may have contributed to this status, including the location of the University of Colorado in Boulder, perhaps none is as important as the metro's history of innovative companies. Denver has a long-standing presence in a variety of high-tech industries. Storage Tech and IBM have had large data storage facilities in the metro for quite some time. Several big telecommunications firms, with large numbers of workers in high-tech occupations, also have long been headquartered or had large facilities in Denver, and the metro is home to some of the largest cable television companies in the country. Among very large metro areas, only the San Francisco Bay area ranks higher than Denver-Boulder-Greeley on both high-tech measures used in this article. In fact, roughly a third of all the high-tech workers in the Tenth District work in the metro. Denver had nearly 70,000 workers in high-tech industries and about 110,000 workers in high-tech occupations in 1999. The Boulder portion of the metro is particularly high tech, with only the Silicon Valley (San Jose) portion of the San Francisco Bay area having a larger percentage of high-tech workers among the country's sub-metros.

The ***Kansas City*** metro area, which straddles the Kansas-Missouri border, has also long been home to several private companies that employed sizable numbers of workers in high-tech occupations, including Sprint, Hallmark Cards, the Midwest Research Institute, and the former Marion Laboratories (now part of Aventis Pharma). Indeed, the city ranks among the top five large metropolitan areas on the occupational measure. Kansas City scores less well on the industry measure, although it still ranks above the national average for its city size. The software publishing and computer systems design industries have a large presence, with Cerner and DST Systems headquartered in the metro. Life sciences research is also becoming a fixture in Kansas City, anchored by the Stowers Institute for Medical Research, the Life Sciences Institute, Bayer Cropsciences, and the University of Kansas Medical Center.

Whereas Denver and Kansas City have a history of hosting innovative companies in a variety of industries, ***Tulsa***, Oklahoma's source of innovative talent has come primarily from its long-important energy sector. Although the city's last great energy boom ended in the mid-1980s, the oil companies left an abundance of highly skilled workers. In addition, one pipeline company—The Williams Company—has largely transformed itself into a "New Economy" giant. In the early 1990s, Williams took advantage of its vast underground rights-of-way to lay miles upon miles of fiber optic cable. In 1998, Williams Communications was spun off from The Williams Companies and, despite the recent financial difficulties that have plagued the telecommunications industry, Wil-Com has helped push Tulsa into the "New Economy." Tulsa also hosts a number of small software and design firms.

High amenity levels

In addition to city size and hosting long-standing government and private institutions, a secondary feature of many district cities appears to aid their level of high-tech activity as well—proximity to abundant recreational and cultural opportunities.

The Colorado metros are the most obvious beneficiaries of natural amenities, given their proximity to the Rocky Mountains. In fact, the final metro included in these case studies, ***Grand Junction***, Colorado,

probably owes most of its above average standing on the high-tech industry measure (and near average standing on the occupational measure) to its scenic beauty. While not as high tech as the larger cities on the eastern slope of the Rockies, the metro hosts several relatively large high-tech plants, including CoorsTek, a maker of high-tech components, and AMETEK/Dixson, a producer of intricate measuring instruments.

Beyond the Rocky Mountains, however, other examples of recreational and cultural opportunities across the district more than likely have helped several metros become and stay more high tech than their size might suggest. Santa Fe, for example, has become a national tourist destination and cultural mecca. Moreover, the same long-standing companies that have provided Denver, Kansas City, and Tulsa with large numbers of high-tech workers have also served as philanthropic giants in those cities over the years, providing each city with a wealth of cultural institutions. Finally, cities such as Fort Collins, Colorado Springs, and Lawrence undoubtedly benefit from being within an hour's drive of the cultural opportunities of Denver or Kansas City.

IV. CONCLUSIONS

The Tenth District is remarkably high tech given its relatively large rural population and shortage of major metro areas. For various reasons, all of the metro areas in the region with more than 200,000 people compare favorably with other cities their size in high-tech concentration. Several metros are among the most high-tech places in the nation for their size.

Accordingly, much of the Tenth District seems well positioned in the "New Economy." Perhaps the biggest positive factor heading forward is that the district as a whole is just as concentrated in workers in high-tech occupations as the country. This concentration of knowledge workers is important given how quickly high-tech goods and services can become not so high tech. Several decades ago, the production of dishwashers and coffeemakers constituted high-tech activity. Having a large number of people with high-tech knowledge and skills should make transition to new types of high-tech activity easier for most of the region's metropolitan areas.

To be sure, though, being high tech is no guarantee of continuous prosperity. The district's high-tech leader—Colorado—was hit very hard by the high-tech downturn of 2001. According to the *Denver Post*, over 10,000 technology workers in that state lost their jobs last year (Hudson). This significant decline illustrates that, while high-tech concentration can lead to sizable increases in local incomes and rapid job growth at times, the potential for periodic sharp downturns also exists.

APPENDIX I
HIGH-TECH OCCUPATIONS

SOC	Occupation title
15	**Computer Specialists**
15-1011	Computer and Information Scientists, Research
15-1021	Computer Programmers
15-1031	Computer Software Engineers, Applications
15-1032	Computer Software Engineers, Systems Software
15-1041	Computer Support Specialists
15-1051	Computer Systems Analysts
15-1061	Database Administrators
15-1071	Network and Computer Systems Administrators
15-1081	Network Systems and Data Communications Analysts
15-2011	Actuaries*
15-2021	Mathematicians
15-2031	Operations Research Analysts
15-2041	Statisticians
15-2091	Mathematical Technicians
17	**Engineers**
17-1011	Architects, Except Landscape and Naval*
17-1012	Landscape Architects*
17-1021	Cartographers and Photogrammetrists*
17-1022	Surveyors*
17-2011	Aerospace Engineers
17-2021	Agricultural Engineers
17-2031	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
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
17-2161	Nuclear Engineers
17-2171	Petroleum Engineers
17-3011	Architectural and Civil Drafters*

SOC	Occupation title
17-3012	Electrical and Electronics Drafters*
17-3013	Mechanical Drafters*
17-3021	Aerospace Engineering and Operations Technicians
17-3022	Civil Engineering Technicians
17-3023	Electrical and Electronic Engineering Technicians
17-3024	Electro-Mechanical Technicians
17-3025	Environmental Engineering Technicians
17-3026	Industrial Engineering Technicians
17-3027	Mechanical Engineering Technicians
17-3031	Surveying and Mapping Technicians*
19	**Scientists**
19-1010	Agricultural and Food Scientists
19-1021	Biochemists and Biophysicists
19-1022	Microbiologists
19-1023	Zoologists and Wildlife Biologists
19-1031	Conservation Scientists
19-1032	Foresters
19-1041	Epidemiologists
19-1042	Medical Scientists, Except Epidemiologists
19-2011	Astronomers
19-2012	Physicists
19-2021	Atmospheric and Space Scientists
19-2031	Chemists
19-2032	Materials Scientists
19-2041	Environmental Scientists, Including Health
19-2042	Geoscientists, Except Hydrologists and Geographers
19-2043	Hydrologists
19-3011	Economists*
19-3021	Market Research Analysts*
19-3022	Survey Researchers*
19-3031	Clinical, Counseling, and School Psychologists*
19-3032	Industrial-Organizational Psychologists*
19-3041	Sociologists*
19-3051	Urban and Regional Planners*
19-3091	Anthropologists and Archeologists*
19-3092	Geographers*
19-3093	Historians*
19-3094	Political Scientists*
19-4011	Agricultural and Food Science Technicians
19-4021	Biological Technicians
19-4031	Chemical Technicians

SOC	Occupation title
19-4041	Geological and Petroleum Technicians
19-4051	Nuclear Technicians
19-4091	Environmental Science Techs, Including Health
19-4092	Forensic Science Technicians
19-4093	Forest and Conservation Technicians

Note: Occupations marked with an asterisk (*) are not considered high tech by some or all of the recent studies of high-tech cities. They are included in order to have comparable data across all geographic levels.

APPENDIX 2
HIGH-TECH INDUSTRIES

NAICS	Industry title
334	**Computer and Electronic Product Manufacturing**
334111	Electronic Computer Manufacturing
334112	Computer Storage Device Manufacturing
334113	Computer Terminal Manufacturing
334119	Other Computer Peripheral Equipment Manufacturing
334210	Telephone Apparatus Manufacturing
334220	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing
334290	Other Communications Equipment Manufacturing
334310	Audio and Video Equipment Manufacturing
334411	Electron Tube Manufacturing
334412	Bare Printed Circuit Board Manufacturing
334413	Semiconductor and Related Device Manufacturing
334414	Electronic Capacitor Manufacturing
334415	Electronic Resistor Manufacturing
334416	Electronic Coil, Transformer, and Other Inductor Manufacturing
334417	Electronic Connector Manufacturing
334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing
334419	Other Electronic Component Manufacturing
334510	Electromedical and Electrotherapeutic Apparatus Manufacturing
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing
334512	Automatic Environmental Control Manufacturing for Residential, Commercial, and Appliance Use
334513	Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables
334514	Totalizing Fluid Meter and Counting Device Manufacturing
334515	Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals
334516	Analytical Laboratory Instrument Manufacturing
334517	Irradiation Apparatus Manufacturing
334518	Watch, Clock, and Part Manufacturing
334519	Other Measuring and Controlling Device Manufacturing
334611	Software Reproducing
334612	Prerecorded Compact Disc (except Software), Tape, and Record Reproducing
334613	Magnetic and Optical Recording Media Manufacturing

NAICS	Industry title
5112	**Software Publishers**
511210	Software Publishers
514	**Information and Data Processing Services**
514110	News Syndicates*
514120	Libraries and Archives*
514191	On-Line Information Services
514199	All Other Information Services*
514210	Data Processing Services
5415	**Computer Systems Design and Related Services**
541511	Custom Computer Programming Services
541512	Computer Systems Design Services
541513	Computer Facilities Management Services
541519	Other Computer Related Services

Note: Industries marked with an asterisk (*) are not considered high tech by some or all of the recent studies of high-tech cities. They are included in order to have comparable data across all geographic levels.

ENDNOTES

[1] The Tenth Federal Reserve District includes the entire states of Colorado, Kansas, Nebraska, Oklahoma, and Wyoming, plus the northern half of New Mexico and the western third of Missouri.

[2] Quite often, total employment in these chosen industries is used as an approximation for their output, due to lack of data on actual output.

[3] The measure also includes architects and social scientists, which are not considered high-tech occupations by many studies. Excluding these occupations, however, would involve using occupational data below the major group level, which is missing for many areas. At the national level, architects and social scientists account for only 6 percent of the "high-tech" total, so including them in a high-tech measure likely still gives a fairly accurate view of how high tech a place is. The high-tech occupational measure, when possible, is based on the new Standard Occupational Codes (SOC) produced by the Bureau of Labor Statistics in 2001. The data used for analysis are 2000 Occupational Employment Statistics.

[4] The use of employment data rather than output data in the measure is due largely to the lack of detailed output data at smaller levels of geography, which prevents comparison across all geography groups. In addition, employment levels are quite often more important to local areas than output levels, given employment's impact on local incomes. Definitions of the high-tech industries used in this article are based on the new North American Industrial Classification System (NAICS) produced for the 1997 Economic Census results. The data used for analysis are 1999 County Business Patterns. Data for 2000 were available at the state level through the ES-202 program. However, much data were missing at the substate level. In addition, the program uses the old SIC classification system rather than the new NAICS.

[5] One difference from many of the recent studies is the exclusion of telecommunications services as a high-tech industry. While telecom companies are certainly involved in high-tech work, a significant portion of their employment is involved in low-tech service provision. Moreover, telecom equipment manufacturing is already included in computer and electronic product manufacturing. Furthermore, in those areas with high concentrations of telecom firms (such as Denver and Kansas City in the Tenth District), high-tech telecom workers are already captured by the occupational measure.

[6] Rural industry data were unavailable.

[7] Lincoln, Lawrence, and Fort Collins have also all undoubtedly benefited from being within an hour's drive of a much larger metro area (Omaha, Kansas City, and Denver, respectively).

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