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A Leaner, More Skilled U.S. Manufacturing Workforce *Richard Deitz and James Orr*

While the U.S. manufacturing sector has contracted sharply since the early 1980s, employment in high-skill manufacturing occupations has risen by an impressive 37 percent. An investigation of the growth in high-skill manufacturing jobs reveals that virtually all of the nation's industries have shared in this trend. Moreover, skill upgrading has occurred in all parts of the country, even those experiencing severe employment losses.

Over the past three decades, the United States has lost almost 5 million manufacturing jobs. As a result, the share of the nation's workforce employed in this sector has dropped sharply, from 20 percent in 1979 to about 11 percent today. Productivity growth and mounting competition in labor-intensive goods production from lower-cost foreign manufacturers have in large part driven this decline. Because these forces are likely to persist in the coming years, manufacturing job losses are almost certain to continue.

However, at the same time that the U.S. manufacturing sector is losing jobs across the nation, it is undergoing a profound transformation. High-skill manufacturing employment, an area in which the United States has a competitive edge, has been expanding. Moreover, the growth of high-skill jobs has led to a significant skill upgrading of the manufacturing workforce throughout the country, even as overall manufacturing employment has declined.

In this edition of *Current Issues*, we analyze the long-term upgrading of skills in the U.S. manufacturing workforce since the peak of manufacturing employment in the early 1980s. We quantify the growth in high-skill

manufacturing jobs and show that skill upgrading has been occurring across industries, even in those experiencing employment losses, and in all parts of the country, even in regions where employment losses have been severe. We also find some evidence that the industries and states that have had the strongest growth in high-skill jobs have had better overall employment performance.

While skill upgrading is pervasive, we find that its nature and pace vary across industries and regions. In some industries, such as primary metals, a combination of modest gains in high-skill jobs and the erosion of low-skill jobs has shifted the composition of employment toward the more skilled end of the spectrum; in others, such as the chemicals industry, significant growth in high-skill jobs is driving the upgrading.

In the Northeast, skill upgrading has occurred in the context of steep job losses, although the region continues to possess one of the highest-skilled workforces in the nation. The Southwest is notable for the rapid upgrading of its manufacturing jobs. Some parts of the Great Lakes region, often perceived as a symbol of industrial decline, have in fact upgraded their manufacturing jobs at roughly the same pace as the nation.

Change in the Nation's Manufacturing Workforce

The nation's manufacturing workforce reached a high of roughly 21 million workers in 1979, and subsequent employment peaks have trended down through the present.¹ In 2003, the U.S. manufacturing sector employed roughly the same number of workers, 16 million, as it did in 1961.² The decline in manufacturing employment in recent decades has been attributed in large part to improvements in labor productivity and the expansion of international trade. Productivity growth has allowed manufacturers to utilize less labor per unit of output in the production process. At the same time, the U.S. economy has been more open to international trade, particularly with countries that have access to relatively low-cost labor. Increased imports of manufactured goods from abroad have forced less competitive domestic manufacturers to cut back production or cease operations.

The employment effects of productivity growth and liberalized trade tend to be felt disproportionately by low-skilled workers.³ Productivity advances result in the substitution of capital for relatively homogeneous low-skilled labor. Similarly, international competition tends to displace U.S. workers at the low end of the skill spectrum, where foreign labor is most plentiful and least expensive.

Nevertheless, while heightened productivity and globalization have led to job losses for less-skilled U.S. workers, they have also helped create high-skill jobs. Technology advances promote the development of high-skill jobs in engineering, research and development, and other specialized fields. Increased trade can also lead to an expansion of these same kinds of jobs in export industries.⁴

Together, the job-creating and job-displacing effects of trade and technology have led to a reallocation, or restructuring, of the types of jobs performed in the manufacturing sector. To determine the nature and extent of this restructuring, we examine the changing composition of the manufacturing workforce using 1983-2002 data on occupations and wages from the Current Population Survey, a monthly household survey conducted by the Bureau of the Census for the Bureau of Labor Statistics.

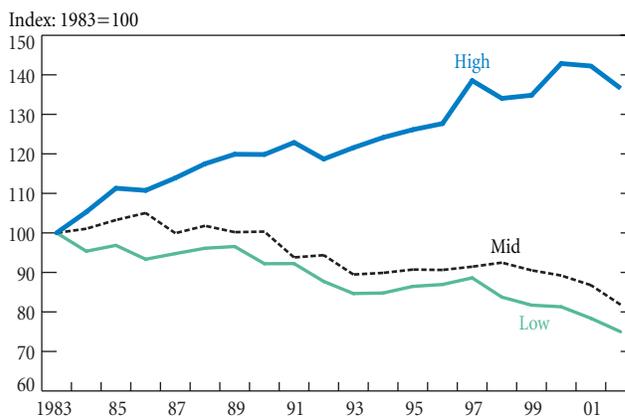
¹We use the Standard Industrial Classification (SIC) definition of manufacturing since the definition used in the North American Industry Classification System (NAICS) is much narrower and applies primarily to production workers. In addition, NAICS data are available only from 1990.

²Although employment has declined, productivity advances have enabled manufacturing output to continue growing at roughly the same rate as the overall economy.

³See, for example, Berman, Bound, and Griliches (1994).

⁴See Groshen, Hobijn, and McConnell (2005) for new estimates of the net effects of international trade on manufacturing employment.

Chart 1
Manufacturing Employment by Skill Group, 1983 to 2002



Source: U.S. Bureau of the Census, Current Population Survey.

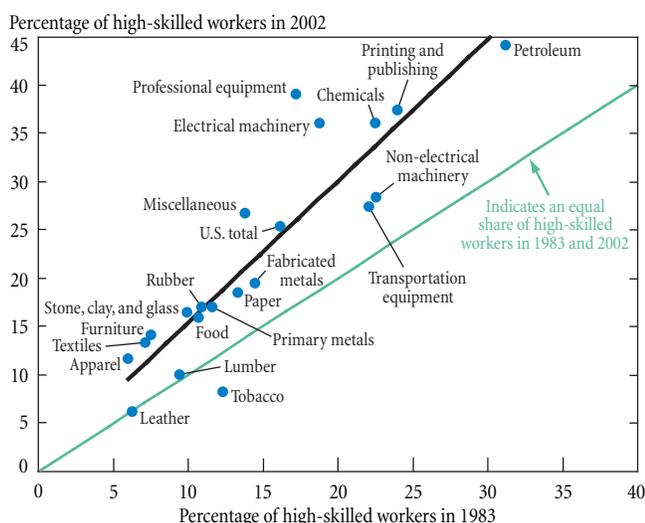
Note: Skill groups are defined in the text.

Using median wage as a proxy for the skill level of each broad occupational category, we separate workers into three skill classes—high, mid, and low.⁵ The high-skilled group is made up of the managerial and professional specialty occupations. In 2002, this group had a national median hourly wage of about \$24. The mid-skilled group consists of technical, sales, administrative, precision production, craft, and repair occupations; the median hourly wage of this group in 2002 was \$14.60. The low-skilled group is made up of service occupations as well as operators, fabricators, and laborers; these workers had a median hourly wage of about \$11.00.

Our 1983-2002 sample period roughly coincides with the national decline in manufacturing employment. A look at the employment trends in the three broad occupational groups over this period reveals a clear pattern of restructuring: the nation's manufacturing workforce has become increasingly high-skilled (Chart 1). Employment in high-skill manufacturing occupations rose 37 percent, an increase of roughly 1.2 million jobs. The share of these high-skilled workers in the overall manufacturing workforce rose 9 percentage points. High-skill jobs were the only source of job growth in the U.S. manufacturing sector during the period, and these workers now represent one-quarter of the sector's workforce. Low-skill jobs declined 25 percent from 1983 to 2002, a loss of roughly 2 million workers, and mid-skill positions declined by almost 18 percent, or roughly 1.3 million

⁵This classification scheme is similar to that used in an analysis of occupational employment trends in the 1990s (Ilg and Haughen 2000). It also corresponds broadly to the production-worker/non-production-worker indicator of skill used in a study of employment demand in the aggregate U.S. manufacturing sector (Berman, Bound, and Griliches 1994). The scheme is based on the 1990 Standard Occupational Classification system.

Chart 2
Change in the Share of High-Skilled Workers in U.S. Manufacturing Industries, 1983 to 2002



Source: U.S. Bureau of the Census, Current Population Survey.
Note: The black regression line coefficient = 1.4 (standard error = 0.20).

jobs. In the next two sections, we consider how the expansion of high-skill job shares observed in the manufacturing sector as a whole has played out across industries and regions.⁶

Restructuring in Manufacturing Industries

While the reallocation of jobs among skill groups has occurred throughout the manufacturing sector, the degree of restructuring differs across industries. One measure of the extent of skill upgrading is the percentage point change in the share of high-skilled workers in each major manufacturing industry—that is, each of the two-digit industries in the Standard Industrial Classification (SIC) system (Chart 2). Nearly all of these twenty industries had a greater percentage of high-skilled workers in 2002 than they did in 1983 (indicated in the chart by an industry’s position above the 45-degree line); the only industries that failed to upgrade were leather and tobacco manufacturing. However, some industries—professional equipment, electrical machinery, miscellaneous manufacturing, printing and publishing, chemicals, and petroleum—experienced extraordinarily large gains in the share of high-skilled workers. While the combined share of total manufacturing employment in these industries held steady over the period at roughly 30 percent, their share of the nation’s high-skill jobs rose

from 39 percent to 47 percent. Moreover, in two industries—professional equipment and electrical machinery—the share of high-skill jobs doubled.

A notable feature of this skill upgrading is that the higher-skill industries in 1983 tended to upgrade more than industries that began the period with lower-skilled workforces. The estimated slope of a regression line relating industry high-skill shares in 1983 to high-skill shares in 2002 was 1.4, indicating that traditionally higher-skill industries increased their share of high-skilled workers more than traditionally lower-skill industries did. Except for the miscellaneous manufacturing industry, each of the industries with especially large gains in their high-skill shares had above-average shares of high-skill jobs in 1983 and 2002.

This pattern of upgrading was not uniform, however. Only modest skill upgrading occurred in two relatively large industries with high-skilled workforces—transportation equipment and non-electrical machinery—while significant upgrading occurred in the miscellaneous manufacturing industry, which began the period with a below-average share. The extent of upgrading in the remaining industries tended to be smaller and less variable, with increases in the share of high-skilled workers ranging from 5 to 10 percentage points.

Skill upgrading over the period occurred both in industries where manufacturing employment grew and in industries where employment declined (Table 1). In fact, employment in thirteen of the twenty manufacturing industries declined over the period, and in all but four of the thirteen, high-skill jobs expanded. Still, the fact that high-skill jobs have been the only source of job growth in the aggregate manufacturing sector suggests a link between the extent of skill upgrading and industry employment performance. Among the twenty industries, those with faster growth in their high-skilled workforces and those with greater increases in their share of high-skilled workers tended to experience higher overall job growth (or, in some cases, less of a decline in overall employment). The correlation coefficient between industry employment growth and high-skill job growth was 0.85 and highly statistically significant, while the correlation coefficient between industry employment growth and the percentage point change in skill shares was 0.4 and also significant.⁷ These correlations suggest that an expansion of high-skill jobs and more aggressive skill upgrading were important factors in the employment performance of manufacturing industries.

⁶See Deitz (2004) for a fuller discussion of these broad national manufacturing job trends.

⁷The correlation coefficient between overall job growth and high-skill job growth by industry was significant at the 99 percent level; the correlation coefficient between job growth and the change in high-skill share by industry was significant at the 94 percent level.

Table 1
Change in Manufacturing Industry Employment, 1983 to 2002
 Percentage Change

Industry	Total	High-Skilled
Furniture	36.9	170.8
Miscellaneous	30.0	178.2
Chemicals	5.7	68.8
Printing and publishing	5.0	64.0
Professional equipment	2.0	131.9
Rubber	1.9	58.0
Lumber	1.0	5.1
Stone, clay, and glass	-3.5	59.7
Transportation equipment	-4.6	18.3
Food	-6.4	38.5
Paper	-7.1	23.9
Petroleum	-9.8	27.1
Fabricated metals	-17.4	10.9
Machinery, except electrical	-21.8	-2.1
Electrical machinery	-21.9	49.2
Primary metals	-25.6	8.5
Tobacco	-36.4	-57.5
Textiles	-44.6	17.5
Apparel	-52.2	-8.0
Leather	-77.4	-77.7
United States	-9.3	36.6

Source: U.S. Bureau of the Census, Current Population Survey.

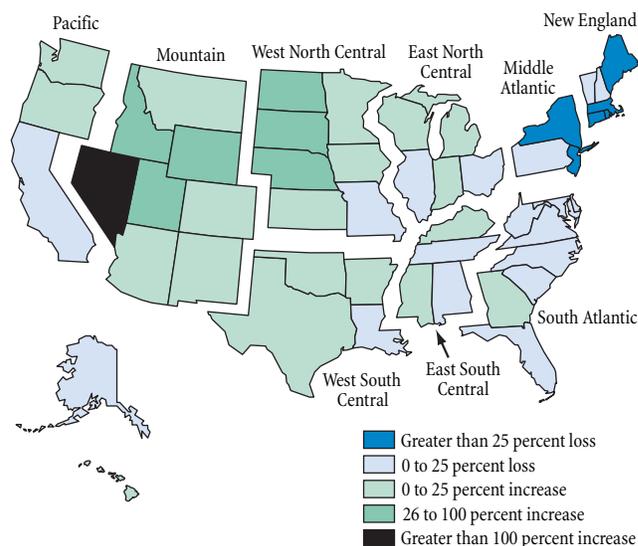
Restructuring of Manufacturing Employment within Regions

Manufacturing employment changes between 1983 and 2002 varied not only across industries but also across regions (see the map). The biggest manufacturing job losses, both in the absolute and as a percentage of employment, were in the contiguous New England, Middle Atlantic, and South Atlantic regions.⁸ Together, these three regions lost almost 2 million manufacturing jobs, just slightly below the net nationwide manufacturing job decline over the period. The East North Central region shed almost half a million manufacturing jobs, although there was some modest offset to these losses from the gains in the adjacent West North Central region. Job gains in the Mountain region countered sizable losses in the Pacific region, leaving overall manufacturing employment in the western part of the country roughly constant over the period; similarly, manufacturing job gains in the West South Central region offset a roughly equal reduction in jobs in the East South Central region.

⁸The factors driving the regional reallocation of manufacturing employment over this period are analyzed in Crandall (1993) and Bram and Anderson (2001).

Manufacturing Employment Growth, by Region

Percentage Change, 1983 to 2002



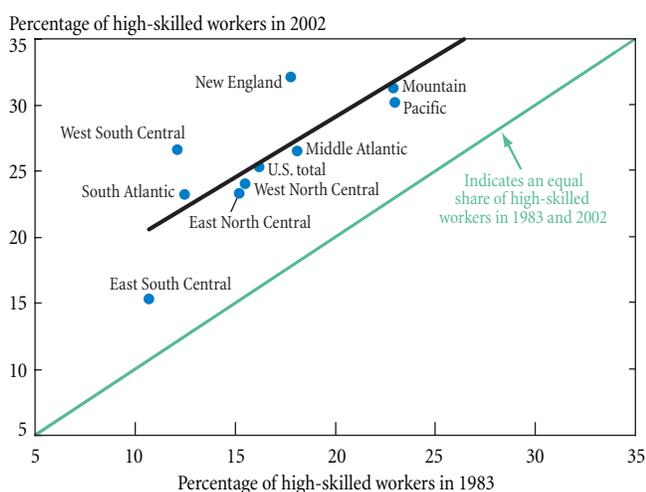
Source: U.S. Department of Labor, Bureau of Labor Statistics.

Despite this varied job performance, all regions except the Middle Atlantic saw an increase in the number of high-skilled manufacturing workers over the 1983-2002 period, and the share of high-skilled workers increased in all regions of the country (Chart 3). The New England region in the Northeast and the Mountain and Pacific regions in the West retained the distinction of having the largest shares of high-skilled manufacturing workers in the nation.

Contrary to the pattern we saw for industries, regions with traditionally higher-skilled workforces did not increase their share of high-skill jobs more than regions with traditionally lower-skilled workforces. The estimated slope of a regression line relating regional high-skill job shares in 1983 to high-skill shares in 2002 is slightly less than 1.0, suggesting that lower-skilled regions began to catch up over the period, increasing their share of high-skilled workers more than higher-skilled regions.

The expansion of high-skill shares of regional manufacturing workforces came against a backdrop of diverse employment trends. Of the nine regions, the four showing an increase in their overall manufacturing employment—the Mountain, West North Central, West South Central, and East South Central regions—raised their high-skill shares as a result of a relatively strong expansion in high-skill employment (Table 2). In contrast, the New England and Middle Atlantic regions effectively raised their high-skill shares by shedding sizable amounts of low-skill jobs, with little or no increase in high-skill jobs. The major manufacturing employment centers in the country—the East North

Chart 3
Change in the Share of High-Skilled Workers in Manufacturing,
by Region, 1983 to 2002



Source: U.S. Bureau of the Census, Current Population Survey.

Note: The black regression line coefficient = 0.91 (standard error = 0.26).

Central, South Atlantic, and Pacific regions—raised their high-skill shares of workers by adding high-skill jobs in sufficient numbers to offset much of the loss of low-skill jobs.

Although all regions saw a rise in the skill levels of their manufacturing workforces, the degree of each region’s skill upgrading shows a mild positive correlation with the change in its overall manufacturing employment. Thus, the four regions experiencing some substantial manufacturing job growth also had relatively strong growth in their high-skilled workforces, while the two regions exhibiting the least overall job growth had the weakest high-skill job growth. Sizable

Table 2
Change in Regional Manufacturing Employment,
1983 to 2002

Percentage Change

Region	Total	High-Skilled
Mountain	24.3	91.7
West North Central	12.1	60.9
West South Central	5.0	144.2
East South Central	3.5	29.2
East North Central	0.2	37.2
Pacific	-1.9	18.8
South Atlantic	-8.8	63.4
Middle Atlantic	-33.5	-0.2
New England	-34.4	12.8
United States	-9.3	36.6

Source: U.S. Bureau of the Census, Current Population Survey.

skill upgrading, however, was also seen in some regions that experienced only modest job growth (see box).

Because each of the nine regions examined covers a large and diverse geographical area, providing relatively few observations from which to discern patterns, we examined state-level skill upgrading patterns to obtain a more detailed picture of these developments. The correlation coefficient at the state level between overall manufacturing job growth and high-skill job growth was 0.7 and highly statistically significant; the correlation coefficient between job growth and the percentage point change in these high-skill shares of employment was 0.3 and also statistically significant.⁹ These correlations provide some additional evidence that an expansion of high-skill employment is a positive influence on overall manufacturing employment performance.

Changes in the Concentration of High-Skill Manufacturing Jobs across Regions

At the start of our sample period in 1983, roughly the peak in postwar manufacturing employment, almost 40 percent of the U.S. manufacturing workforce was employed in the East North Central and Middle Atlantic regions bordering the Great Lakes, a part of the country frequently termed the nation’s *manufacturing belt*. These same regions were also the leading locations for high-skill jobs, with the East North Central region alone possessing nearly one-quarter of the nation’s high-skill manufacturing employment.

In subsequent years, however, a large shift took place in manufacturing employment, with jobs moving from the New England and Middle Atlantic regions to states in the South and West. As a result, by the beginning of this century, the Great Lakes states had come to be dubbed the *rust belt*, a name that captures the popular view of this region as a place defined by factory closings and industrial decay. In fact, however, the only states that might have warranted such a description were the Middle Atlantic states, which saw their share of the nation’s manufacturing jobs decline by 4 percentage points. Indeed, the East North Central region actually retained its share of overall manufacturing jobs—24 percent—and the distinction of having the largest manufacturing workforce.

To compare the concentration of high-skill manufacturing employment across regions, we construct location quotients that measure the share of high-skilled workers in a region relative to the share of high-skilled workers in the

⁹The correlation coefficient between overall job growth and high-skill job growth by state was significant at the 99 percent level; the correlation coefficient between job growth and the change in high-skill share by industry was significant at the 93 percent level.

A Closer Look at Regional Upgrading

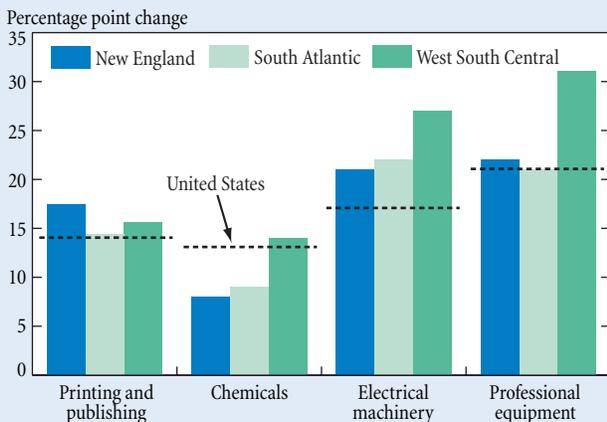
To explore the pattern of regional upgrading in more detail, we examine three regions notable for relatively large gains in their high-skill shares of manufacturing employment over the period: the New England, South Atlantic, and West South Central regions. The West South Central region, in particular, saw its share of high-skilled workers increase sharply, from a below-average 12 percent in 1983 to an above-average 26 percent in 2002. We can gain some insight into the regional skill upgrading process by considering how each region fared in restructuring employment in four of the manufacturing industries that, on a national scale, upgraded most extensively over the 1983-2002 period: printing and publishing, chemicals, electrical machinery, and professional equipment (Chart A1).

Significantly, in three of the four industries, all three regions saw percentage point increases in their share of high-skilled workers that matched or exceeded the nationwide average increase. Moreover, the West South Central

region experienced large gains in high-skill shares in *all* of the industries that upgraded extensively over the period.

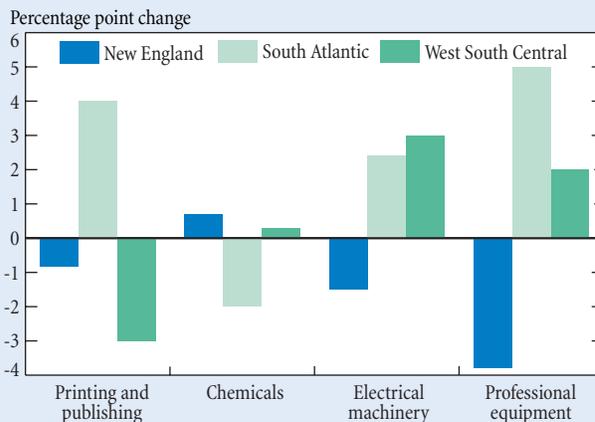
An examination of the shifting regional composition of employment in these four industries shows that, with the exception of the chemicals industry, regional employment reallocations in these high-skilled manufacturing industries favored the South Atlantic and West South Central regions. In particular, sizable percentage point gains in employment were seen in both regions in two industries with especially large high-skill gains nationally—electrical machinery and professional equipment (Chart A2). The two regions have thus shown themselves to be attractive locations to expand high-skill employment as well as overall manufacturing employment. The New England region lost employment in three of the four industries, suggesting that the region increased its high-skill job share primarily by shedding low-skill jobs rather than by expanding high-skill jobs.

Chart A1
Change in Regional High-Skill Share, 1983 to 2002:
Selected Region/Industry Pairs



Source: U.S. Bureau of the Census, Current Population Survey.

Chart A2
Change in Regional Share of Nationwide Industry Employment,
1983 to 2002: Selected Region/Industry Pairs



Source: U.S. Bureau of the Census, Current Population Survey.

nation. A location quotient greater than one indicates an above-average concentration of high-skilled workers and a specialization in high-skill employment, while a value less than one indicates a below-average concentration.

In 1983, the Mountain and Pacific regions and the New England and Middle Atlantic regions had the highest location quotients, suggesting that the most significant intensities of high-skilled employment were in the West and Northeast (Table 3). The East North Central region had a concentration of high-skilled workers that was just slightly below average. In 2002, the intensity of high-skill manufacturing

employment remained high in the West and Northeast. Although the location quotients for the Mountain and Pacific regions declined from 1.4 to 1.2, both regions retained their specialization in high-skill employment. The Middle Atlantic region retained a location quotient of 1.1 and the New England region increased its location quotient to 1.3, despite steep losses in manufacturing jobs in the two regions.

Although the manufacturing sector underwent extensive changes between 1983 and 2002, the East North Central region remained the nation's central manufacturing location. At the end of this period, the region could still claim the

Table 3

Concentration of High-Skill Manufacturing Employment, by Region

Region	Location Quotient	
	1983	2002
Mountain	1.4	1.2
Pacific	1.4	1.2
New England	1.1	1.3
Middle Atlantic	1.1	1.1
West North Central	1.0	1.0
East North Central	0.9	0.9
South Atlantic	0.8	0.9
East South Central	0.7	0.6
West South Central	0.7	1.0

Source: U.S. Bureau of the Census, Current Population Survey.

Note: The location quotient is defined as the ratio of the share of high-skilled workers in the region to the share of high-skilled workers nationwide.

most manufacturing workers and the most high-skilled manufacturing workers. Moreover, its intensity of high-skill employment was roughly comparable to that of the nation. The region showing the biggest gain in high-skill employment intensity, however, was the West South Central region. Over the 1983-2002 period, it increased its share of manufacturing workers, its share of high-skilled workers, and its concentration of high-skilled workers.

Conclusion

There is little doubt that the U.S. manufacturing workforce is shrinking, both in absolute and relative terms. At the same time, however, the workforce is undergoing a quite remarkable transformation. Technology and increased globalization have, on the one hand, reduced the number of low-skill jobs and, on the other, provided opportunities for high-skill manufacturing employment to expand. As a result, a manufacturing workforce is emerging that is at once leaner and more skilled. Given the likely persistence of

the economic forces driving this restructuring, this trend can be expected to continue.

Nearly all manufacturing industries have become higher-skilled—some by shedding lower-skilled workers while they retain or add to their higher-skilled workers, others by creating many new jobs for high-skilled workers. Similarly, every region of the country has undergone skill upgrading, even regions that lost significant numbers of manufacturing workers, such as the Great Lakes states. In addition, the concentration of high-skilled workers across regions is subtly shifting, with the West South Central region attracting more of the nation's high-skilled workers.

Together, these developments suggest that the very nature of manufacturing work is changing. The sector has historically been regarded as one offering employment opportunities for lower-skilled workers. Recent trends, however, provide strong evidence that manufacturing jobs in virtually all industries and regions of the country will increasingly demand higher skills.

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