

Federal Reserve Bank of Cleveland

Regional Productivity Growth and Plant-Level Dynamics

by Yoonsoo Lee

Explaining variations in productivity growth across regions has become an important goal for economists and policymakers for several reasons: Labor productivity growth is closely tied to long-term gains in wages and living standards. At the regional level, it also gauges a region's competitive position over time. Moreover, per capita personal income, a common indicator of the standard of living, can grow faster if labor productivity grows faster.

One way productivity growth occurs is when individual manufacturing plants or places of business increase their workers' output per hour (that is to say, their productivity, and in what follows, "productivity" always means "labor productivity.") They could help their workers acquire new skills through education or training. They could also buy new machines to perform routine tasks, freeing workers for tasks that add greater value.

While most people think productivity growth at individual plants and places of business is a major source of aggregate growth, it is only part of the story. For example, during the 1987–97 period, productivity changes for individual manufacturing plants explain about 40 percent of total changes in U.S. manufacturing productivity. What explains the other 60 percent?

The bulk of this 60 percent is explained by the changing mix of plants in operation—that is, when more-productive plants open or expand while less-productive ones close or contract, it affects aggregate productivity.

This *Economic Commentary* examines how the process of manufacturing plants' entry, expansion, and exit affects the productivity growth of an economy. Using microdata on U.S. manufacturing from the Census Bureau, we quantify the role of reallocations, entries, and exits in order to explain differences in manufacturing productivity growth across regions. We find that what matters more than individual plants' productivity growth in explaining regional productivity differences is how efficiently resources are reallocated across plants.

■ Sources of Productivity Growth

Some economic growth models explain the link between plant-level dynamics and aggregate productivity growth with an emphasis on the role of creative destruction. They maintain that as a new plant enters the market with new technology it competes with existing plants that are using conventional technology. As new innovations become successful, aggregate productivity evolves. Newer, more-productive plants drive out less-productive ones, and resources are reallocated from the incumbents to the new entrants. As a consequence, the economy's overall efficiency level rises. Economists call the combined results of entries and exits on productivity growth *net-entry* effects.

Net-entry effects would be the most important source of productivity growth if new technologies were adopted mainly by new plants. However, some incumbents actively retool their production facilities to incorporate new technology. In fact, young

The mix of companies in the economy is always changing. The more-productive ones expand, and the less-productive ones are driven out of the market, freeing resources such as labor and capital for new ventures. This reallocation contributes more to aggregate productivity growth than the productivity gains achieved by individual businesses. The efficiency with which the process takes place is a key factor affecting rates of productivity growth in different regions and explaining why they differ.

and old plants tend to adopt new technologies with about the same frequency, according to a 1994 study conducted by Tim Dunne, who explores this issue using microdata on manufacturing plants.

The fact that existing plants can improve their productivity as well as new plants means that aggregate productivity may increase through two channels: First, aggregate productivity may increase if the productivity at individual plants increases. For example, if all plants in the economy adopted an innovative technology that increased their productivity levels 3 percent, aggregate productivity would increase 3 percent. Because this particular effect on productivity comes from changes within plants, economists call it the *within* effect.

Second, aggregate productivity may increase if resources are shifted toward plants that use new technology to raise their productivity levels. Aggregate productivity improves as the more-efficient plants utilize a larger share of available resources. Because this effect on productivity results from changes in output shares across plants, economists call it the *between* effect. Note that the net-entry effect is an extreme case of the between effect, as an exiting plant's changes of output from a positive number to zero, while an entrant's share changes from zero to some positive number.

■ Labor Productivity
Growth across Regions

Differences in reallocation patterns affect productivity growth rates across regions in interesting ways. Figure 1 reports labor productivity growth in manufacturing for each of the four Census regions for two 10-year periods, 1977–87 and 1987–97. In the figure, total changes in aggregate productivity are broken down into productivity changes due to within effects, between effects, and net-entry effects. Note that between effects and net-entry effects together are called reallocation effects.

Average productivity growth rates at individual plants (within effects) did not vary greatly across the four regions between 1977 and 1987. After 1987, productivity soared in the West; consequently, productivity growth rates across regions diverged. Note that the fast productivity growth that occurred in the U.S. in the mid-1990s was not evenly distributed across all regions. Rather, the West had much higher productivity growth rates than the national average, and the Midwest's were relatively low.

Although differences in within effects across regions did affect productivity growth, what really shaped the fate of

each region was differences in reallocation effects. In the West, for example, manufacturing productivity grew at an average annual rate of 5.5 percent during the 1987–97 period. Plant productivity grew 1.8 percent, accounting for one-third of the region's total productivity growth. Reallocation effects boosted productivity growth rates by 3.7 percentage points, contributing the other two-thirds. The same ratio emerges in the South: manufacturing productivity grew at an average annual rate of 3.5 percent, and of that, one-third is explained by increases in plant productivity (1.0 percent) and two-thirds by reallocation effects (2.5 percent). The situation was a little different in the Midwest, where average annual productivity grew 2.5 percent. While the productivity growth of existing plants was not that low compared to other regions (1.2 percent), reallocation effects totaled only 1.3 percentage points.

Between 1987 and 1997, within effects contributed more in the Northeast and West than in other parts of the country. Breaking down reallocation effects into between effects and net-entry effects, we find that most of the differences in reallocation effects are based on differences in between effects—that is, reallocation across existing plants, rather than entering plants replacing exiting plants. While the emergence of new producers using innovations is an important source of productivity growth in the long run, new entrants are generally small at birth and take a long time to grow big enough to make a meaningful impact on the aggregate economy. (Microsoft had fewer than 50 employees when it started in 1975; it now has about 79,000.)

The West achieved faster-than-average productivity growth between 1987 and 1997, partly because its existing plants increased their productivity more than plants in other divisions. However, a

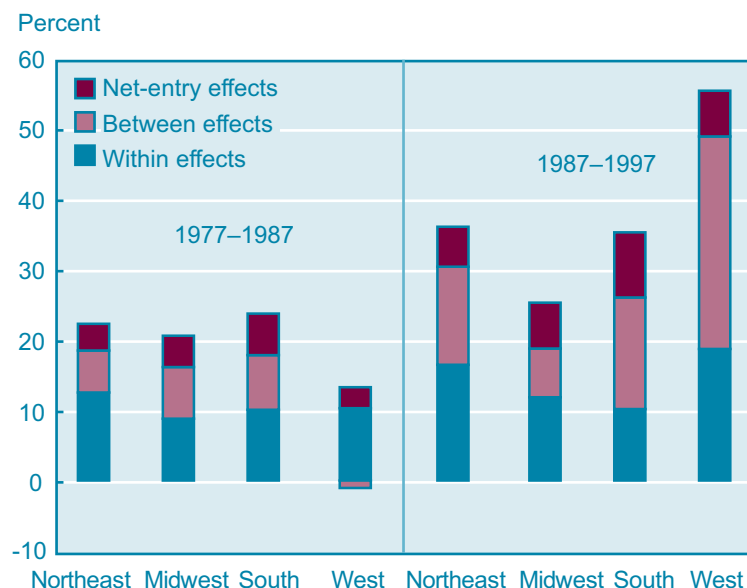
How Relocations
Across Plants Affect
Aggregate Productivity

Mathematically, aggregate productivity is a share-weighted average of the productivity of individual plants. As the share weights of more-productive plants increase, aggregate productivity rises. For simplicity, let us assume that there are only two plants in the economy: Plant A has newer technology and produces high-quality goods; Plant B, using conventional technology, produces low-quality goods. Plant A is more efficient than Plant B in the sense that its output per worker (2) is higher than Plant B's (1). Aggregate data for the two plants are the sums of their workers and outputs. Aggregate productivity (output per worker) is calculated as the weighted average of the two plants' productivities, in which the weight is the share of workers hired by each plant: $(\frac{1}{2} \times 2) + (\frac{1}{2} \times 1) = 1.5$. This is equal to output per worker based on aggregate output $(4 + 2 = 6)$ divided by the total number of workers $(2 + 2 = 4)$.

Let's assume that demand for Plant A's high-quality goods rises and the plant increases its output by hiring one more worker. Plant B, facing the fact that demand for its product is declining, fires a worker and reduces its output. Shifting a worker from the less-productive plant to the more-productive one increases the more-efficient plant's share of employment. In this example, Plant A's share of workers increases from $\frac{1}{2}$ to $\frac{3}{4}$, while Plant B's decreases from $\frac{1}{2}$ to $\frac{1}{4}$. As the share weight for the more efficient plant increases, aggregate productivity rises from 1.5 to 1.75: $(\frac{3}{4} \times 2) + (\frac{1}{4} \times 1)$. One interesting consequence is that aggregate productivity increased without any technological changes in the economy or productivity changes at the plant level.

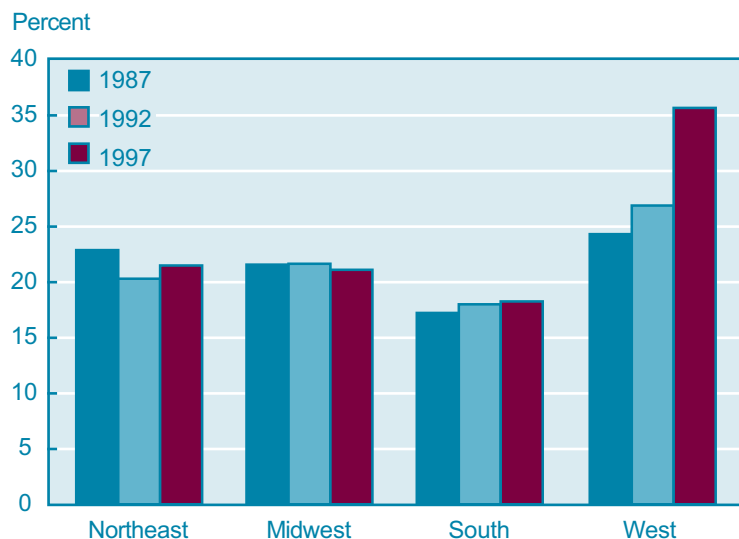
	Before reallocation			After reallocation		
	Worker	Output	Output per worker	Worker	Output	Output per worker
Plant A	2	4	2	3	6	2
Plant B	2	2	1	1	1	1
Aggregate	4	6	1.5	4	7	1.75

FIGURE 1 LABOR PRODUCTIVITY GROWTH BREAKDOWN, 1977–1987 AND 1987–1997



Source: U.S. Bureau of the Census.

FIGURE 2 SHARE OF HIGH-TECHNOLOGY INDUSTRIES IN MANUFACTURING (SIC 35 AND 36)



Note: SIC 35 comprises industrial machinery and equipment; SIC 36 comprises electronic and other electric equipment.

Source: U.S. Bureau of the Census.

more important factor in its remarkable growth was the substantial share of output that shifted from less- to more-productive plants. Reallocations between existing plants boosted annual

productivity growth rates by 3.1 percentage points on average, accounting for more than half of the West's productivity changes.

■ Productivity Growth and the Shift Toward IT Industries

Most economists think that information technology (IT) was the source of the 1990s productivity growth spurt. It probably also helped to create the cross-regional differences in productivity growth that emerged in the mid-1990s. To shed light on how IT growth affected each region, figure 2 shows changes in the output shares of IT-related industries. The IT industries shown are industrial machinery and equipment, which includes computers (these account for 25 percent of the output in this industry), and other electric equipment, which includes communications equipment and semiconductors (these account for about half of the output in this industry). Indeed, figure 2 shows that IT-related industries' shares increased in the West (33 percent) between 1992 and 1997.

IT-related capital investment during the 1990s boosted output growth for IT producers, increasing their output shares in some regions. Because of their higher levels of productivity, the shift in production toward high-tech plants enhanced productivity growth in those regions. This trend accounts for the stronger reallocation effects in the West, where IT's output share increased. However, such effects were relatively slight in other regions, where IT's share remained about the same.

■ Possible Sources of Regional Reallocation Differences

Why reallocation effects vary across regions remains a question for researchers. Some possible explanations for the differences observed in figures 1 and 2 do readily present themselves. IT plants in the West, benefiting from positive spillovers from nearby plants, may have been in a better position to grow than their counterparts. Alternatively, differences in policies, regulation, or the business environment may have enabled certain regions to be more flexible, helping resources flow easily across different plants and sectors. Understanding why some regions have done better at directing resources toward the most productive uses is the key to explaining variation in productivity growth across regions.

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■ **Recommended Reading**

“Plant Dynamics and Productivity Growth: A Review of Micro Evidence from OECD Countries,” by Sanghoon Ahn. 2001. OECD Economics Department, Working Paper 297.

“The Cleansing Effect of Recessions,” by Ricardo J. Caballero, and Mohamad L. Hammour. 1994. *American Economic Review*, vol. 84, 1350–68.

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