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EMPLOYMENT RESEARCH

The Decline of U.S. Manufacturing Employment—Automation and Trade

Susan N. Houseman

ARTICLE HIGHLIGHTS

- *U.S. manufacturing experienced unprecedented employment declines in the 2000s.*
- *Strong output and productivity growth in manufacturing are often cited as evidence that U.S. manufacturing is doing well and that automation is primarily responsible for the employment declines. A careful look at the evidence does not support this popular view.*

This article is based on "Understanding the Decline in Manufacturing Employment" (Houseman 2018).

The manufacturing sector experienced a precipitous and historically unprecedented decline in employment in the 2000s, which coincided with a surge in imports, weak growth in exports, and a yawning trade deficit. The sharp job losses in manufacturing significantly contributed to the weak employment growth and low labor force participation characterizing the U.S. economy for much of this period.

The plight of U.S. manufacturing featured prominently in the 2016 presidential election, with candidates Donald Trump and Bernie Sanders arguing that globalization had severely damaged U.S. factories and workers. That message resonated in many American communities and helped propel Trump to the presidency. Making good on campaign promises, the president pulled out of the Trans-Pacific Partnership agreement, has proposed renegotiating the North American Free Trade Agreement, and most recently has threatened high tariffs on Chinese imports, raising concerns about a trade war.

An alternative view, which many economists embrace, holds that automation, not globalization, largely explains manufacturing's relative employment declines and, in recent years, steep job losses. As evidence, proponents of this view point to statistics showing robust output growth and much higher productivity growth in manufacturing relative to the aggregate economy. This perspective often is presented as the consensus view among economists and taken as fact in media reports.

The view, however, reflects a misreading of the data. Although automation is occurring in manufacturing, as in other sectors of the economy, neither the descriptive nor the research evidence supports the view that automation was the leading cause of the relative and absolute decline in manufacturing employment in the 2000s.

The Collapse of Manufacturing Employment in the 2000s

Manufacturing employment trended upward in the years following World War II, peaking at over 19 million in 1979. From 1979 to 1989, the year of the next business cycle peak, manufacturing shed 1.4 million jobs, or 7.4 percent of its base, with job losses concentrated in the primary metals and textile and apparel industries. Employment in manufacturing was relatively stable in the 1990s.

Rapid productivity growth in the computer industry—and, by extension, the strong productivity growth in manufacturing—largely reflects improvements in high-tech products, not automation.

Manufacturing employment plunged in the 2000s. Between the business cycle peaks of 2000 and 2007, the sector's employment dropped by 3.4 million, or 20 percent. Although employment in manufacturing, a cyclically sensitive sector, often drops sharply during recessions, the early 2000s marked the first time that employment in the sector did not entirely or largely recover during the expansion. Manufacturing employment was hard-hit again during the Great Recession of 2008–2009, rebounding only slightly during the ensuing recovery. In total, since 2000, manufacturing employment has fallen by nearly 5 million, or over 28 percent. Unlike the declines experienced in the 1980s, the job losses have been broad-based, affecting all industries.

Widespread plant closures accompanied the employment declines. From 2000 to 2014,

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the number of manufacturing establishments dropped by more than 78,000, a 22 percent decline.

The Puzzle

Reflecting stable or declining employment in the manufacturing sector, the share of private sector employment in manufacturing has dropped steadily, and relative declines have been particularly prominent since the 1980s. Manufacturing employment as a share of private sector employment peaked at 35 percent in 1953; by 2016, that share had fallen to just under 10 percent. Manufacturing's share of private sector GDP has experienced a parallel decline: manufacturing's contribution to private sector GDP peaked at 33 percent in 1953, and by 2016 its share was just 13 percent.[1] The trends in these shares, depicted in the right scale of Figure 1, suggest that performance in the manufacturing sector has been weak relative to the rest of the economy.

Figure 1 also shows indices for the private sector and manufacturing real (inflation-adjusted) GDP on the left scale. Paradoxically, in view of manufacturing's declining employment and GDP shares, real GDP growth in manufacturing has largely kept pace with that of the private sector overall. Only since the Great Recession has real output growth been noticeably slower in manufacturing than in the aggregate economy.

Reconciling Manufacturing's Declining Shares with Robust Output Growth

How can these apparently contradictory trends be reconciled? If real GDP growth for manufacturing has kept pace with real GDP growth in the aggregate economy yet manufacturing's share of private sector GDP is falling, it must be the case that prices of manufactured goods have grown more slowly than the average growth in prices of goods and services in the economy.

Similarly, manufacturing's declining share of private sector employment results because manufacturing employment is growing more slowly than the average for the private sector.

The relationships between labor, GDP, and productivity growth may be expressed as a simple accounting identity, which shows that the difference in the growth rates of labor employed in the aggregate private sector and in manufacturing is equal to the difference in their real GDP growth rates less the difference in their labor productivity growth rates.[2]

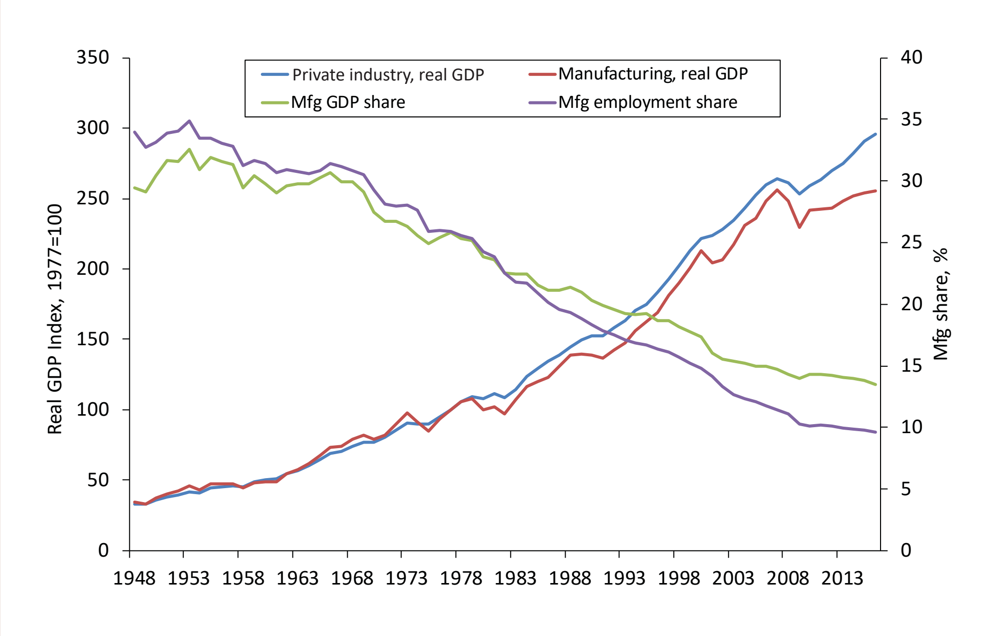
If manufacturing's real GDP growth rate is approximately the same as the average for the private sector, as indicated in Figure 1, then all, or virtually all, of manufacturing's declining employment share is accounted for by higher labor productivity growth. Many economists have taken the patterns shown in Figure 1, and related descriptive evidence, to infer that the higher productivity growth in manufacturing—implicitly or explicitly assumed to reflect automation—has largely caused the relative and absolute declines of manufacturing employment. Even when some role for trade is recognized, it is deemed small, and the decline is taken as inevitable.[3]

Broadly, there are two problems with this conclusion. First, the descriptive evidence is misleading and has been widely misinterpreted. The low growth in prices, strong real output growth, and high productivity growth in manufacturing are largely driven by one industry—computer and electronic products (hereafter computer industry)—and reflect the statistical adjustment of price deflators of computers and semiconductors for improvements in product quality.

Second, as researchers widely recognize, accounting identities and other descriptive evidence per se cannot be used to draw inferences about the causes of the relative and absolute decline in manufacturing employment. Productivity growth does not by itself cause employment reductions and may reflect many forces, including import competition and offshoring.

I discuss each problem in turn.

Figure 1: Manufacturing and Private Industry Real GDP; Manufacturing GDP and Employment Shares



SOURCE: Author's calculations using data from the Bureau of Economic Analysis.

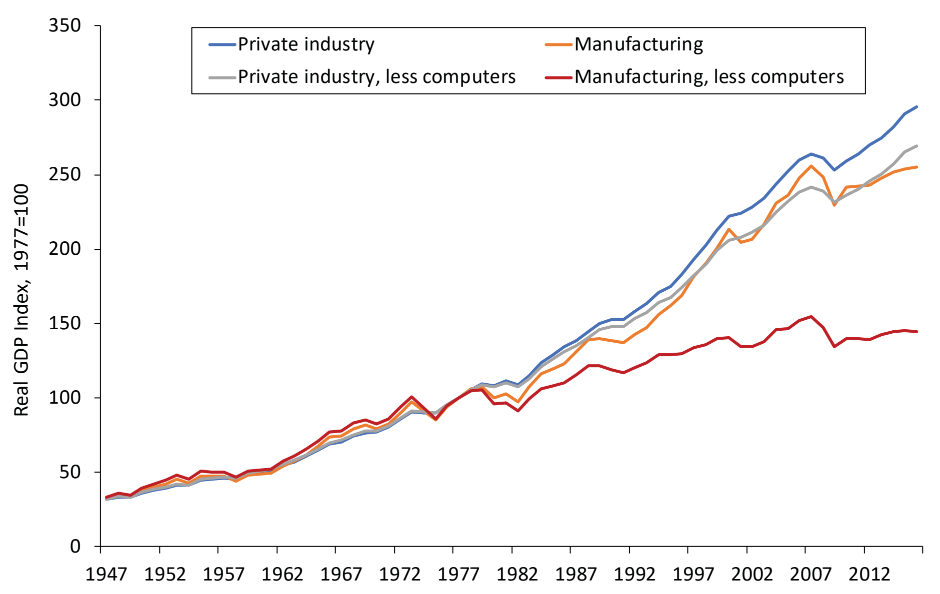
The Outsized Effect of the Computer Industry on Manufacturing Statistics

Many of the products produced in the computer industry have undergone substantial and rapid technical advances. The semiconductors embedded in our electronics, for example, are much more powerful today than they were a decade or even a year ago. Likewise, the computers and related devices that consumers and businesses buy today have much greater functionality than in the past. The statistical agencies account for the rapid improvements in product quality in the industry through adjustments to price deflators; for some products, adjusted prices have declined rapidly over time.

Adjusting product price deflators in the computer industry for improvements in product quality, in turn, has large effects on the industry's measured real GDP and productivity growth. Although the computer industry has always accounted for less than 15 percent of value-added in manufacturing, because of its extraordinary measured real GDP and productivity growth, it has an outsized effect on measured real output and productivity growth in the sector, skewing these statistics and giving a misleading impression of the health of American manufacturing.

Figure 2 displays indices of real GDP in the private sector and manufacturing, as published and omitting the computer industry. The computer industry has had large effects on measured real GDP growth in manufacturing since the 1980s. From 1979 to 2000, measured real GDP growth in manufacturing was 97 percent of the average for the private sector; when the computer industry is dropped from both series, manufacturing's real GDP growth rate is just 45 percent of the private sector average. Between 2000 and 2016, real GDP growth in manufacturing was 63 percent of the average private sector growth. Omitting the computer industry from each series, manufacturing's measured real output growth is only about 0.2 percent per year and just 12 percent of the average for the private sector in the 2000s. Without the computer industry, measured real output in manufacturing was lower in 2016 than in 2007 at the start of the Great Recession. In addition, without the computer industry, labor productivity growth was no higher or only somewhat higher in manufacturing than in the private sector overall (Houseman 2018).

Figure 2: Real GDP, Private Industry and Manufacturing, with and without Computer Industry



SOURCE: Author's calculations using data from the Bureau of Economic Analysis.

Once the anomalous effects of the computer industry are excluded, descriptive data no longer provide prima facie evidence that higher rates of automation were primarily responsible for the long-term decline in manufacturing's share of employment. Rather, they suggest that understanding the reasons for the slow output growth in manufacturing output is critical.

It is also important to recognize that the rapid productivity growth accompanying output growth in the computer industry has little to do with automation—production of computers and semiconductors has been automated for many years. Rather, rapid productivity growth in the industry—and, by extension, the strong productivity growth in manufacturing—largely reflects improvements in high-tech products. Nor is the rapid growth in measured computer and semiconductor output a good indicator of the international competitiveness of domestic manufacturing of these products. As detailed in Houseman, Bartik, and Sturgeon (2015), the locus of production of these products has been shifting to Asia, even as the industry was driving the apparent robust growth in the manufacturing sector.

Interpreting productivity growth

Labor productivity is measured as real GDP (the returns to capital and labor) divided by labor input (hours worked or employment). Labor productivity will increase if processes are automated—that is, if businesses invest in capital equipment and that equipment substitutes for workers in the production process. Measured growth in labor productivity, however, captures many factors besides automation. As just discussed, the strong productivity growth in the manufacturing sector has been driven by productivity growth in the computer industry, which largely stems from product improvements owing to research and development.

In addition, manufacturers have outsourced many activities previously done in-house, either to domestic or foreign suppliers, or have shifted their input sources to lower-cost, often foreign, providers. If the outsourced activities are primarily done by relatively low-paid workers, or if the outsourced labor is cheaper than the in-house labor, measured labor productivity will increase. Shifting to lower-cost input sources will raise measured productivity as well (Houseman et al. 2011).

International competition also may directly impact measured manufacturing productivity by affecting the composition of products produced and processes used in the United States. The industries and plants within industries most affected by increased competition from low-wage countries will likely be the most labor-intensive, raising measured labor productivity. For example, case study research on the impact of the wave of Asian furniture imports in the early 2000s shows that plant closures and employment declines were concentrated in the most labor-intensive furniture industries, and within industries less affected by imports, the most labor-intensive processes were offshored.[4]

Productivity growth surged in some manufacturing industries during the early 2000s, a period marked by a precipitous decline in manufacturing employment and factory closures. A superficial reading of the data might lead one to conclude that productivity in the form of automation caused the relative and absolute declines in manufacturing employment. Yet given the massive structural change occurring at the time, accelerated productivity growth may largely reflect changes in the composition of products produced and processes done in the United States, and may have largely been a consequence of international trade.

Discussion

The aggregate manufacturing output and productivity statistics, dominated by the computer industry, mask considerable weakness in most manufacturing industries, where real output growth has been much slower than in the private sector overall since the 1980s and has been anemic or declining since 2000. Because manufacturing has deep supply chains and accounts for a disproportionate share of R&D in the economy, the health of manufacturing industries has important implications for employment and output growth and innovation in the economy. Understanding the causes of the decline is necessary for developing sensible policy responses.

The prevailing view that automation largely caused the swift relative and absolute declines in U.S. manufacturing employment in the 2000s reflects a misinterpretation of the numbers. Moreover, the automation view is not backed by rigorous research. Studies have failed to find that automation was a significant cause of the precipitous decline in manufacturing employment in the 2000s. And while industrial robots may have the potential to displace many workers in the future, any effects on manufacturing employment to date are small.

A large and growing body of research has also examined the effects of trade on domestic manufacturing in the 2000s. No study captures all aspects of globalization and its effects on manufacturing and aggregate employment, and the limitations of any individual study need to be recognized. Collectively, however, the research points to sizable adverse effects from trade on employment, output, and investment.[5] The denial by many in both the Republican and Democrat parties of globalization's significant role in manufacturing's recent employment declines has inhibited much-needed, informed debate over trade policies.

NOTES

1. GDP, also called value added, reflects the contributions an industry or sector makes to output from its labor and capital.

2. Formally, $\dot{L_T} - \dot{L_M} = (\dot{GDP_T} - \dot{GDP_M}) - (\dot{Prd_T} - \dot{Prd_M})$, where the T and M subscripts indicate the total private and manufacturing sectors, and $\dot{L}$, $\dot{GDP}$, and $\dot{Prd}$ represent the growth rates in labor, GDP, and labor productivity, respectively.

3. See, for example, DeLong, Brad. 2017. "NAFTA and Other Trade Deals Have Not Gutted American Manufacturing—Period." Vox Media. I provide additional citations in Houseman (2018).

4. See Holmes, Thomas J. 2011. "The Case of the Disappearing Large-Employer Manufacturing Plants: Not Much of a Mystery After All." Economic Policy Paper 11-4. Minneapolis, MN: Federal Reserve Bank of Minneapolis.

5. I provide an overview and citations to studies on automation and trade in Houseman (2018).

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Pre-K Effectiveness at a Large Scale

Timothy J. Bartik and Brad Hershbein

ARTICLE HIGHLIGHTS

- *In states with high-quality programs, there is a significant gain of 2.8 percentiles on math tests.*
- *Pre-K programs can produce significant medium-term benefits, enough to pass a benefit-cost test, but this is more likely with high-quality programs or disadvantaged student populations.*

In the past 15 years, four-year-olds' enrollment in state-funded prekindergarten in the United States has more than doubled, with roughly one-third now enrolled. Advocates have pushed for further expansion; for example, New York City Mayor Bill de Blasio in 2014 implemented a universal pre-K program.

Although researchers have found that early childhood programs from decades ago had sizable benefits for students that lasted into adulthood, evidence from more recent (and less-expensive) programs has been mixed. Moreover, recent studies have focused on a modest number of programs, often high-quality ones, in a few states. It is unclear whether the effects of previously studied programs generalize to the cheaper programs more commonly implemented.

We perform the first national analysis of public pre-K's effects on standardized test scores, special education assignment, and grade retention, using data from thousands of school districts throughout the country. We estimate the impacts of typical public school pre-K programs, as well as how impacts vary for districts of different types.

Our analysis reveals the following:

1) The typical public pre-K program has no positive effects on 4th grade outcomes. We can rule out impacts from full pre-K adoption as small as 2 percentiles in math and reading test scores and 3 percentage points in special education assignment and grade retention.
2) However, for districts in states with high-quality programs (based on prior assessment by other experts), pre-K boosts 4th grade math test scores by 2.8 percentiles, twice the necessary threshold to pass a benefit-cost test in terms of predicted future earnings of students.
3) For districts with majority African American enrollment, pre-K program effects are even larger, with increases of 5.9 percentiles in math and 3.8 percentiles in reading. Among such districts in high-quality states, the increases are 6.6 and 7.4 percentiles, respectively.

Whereas many prior studies looking at high-quality programs analyzed what a pre-K program *could do* under the right circumstances, we look at what typical pre-K programs *have done* in practice over the past two decades. The typical public school pre-K program, which may have been of relatively poor quality, has done little for the average student. But these programs have substantively large benefits when they are either higher quality or operated in more disadvantaged school districts. Because much of the current policy debate is about the desirability of large-scale expansion of pre-K, these findings are highly policy relevant. For large-scale expansion of pre-K to make sense, policymakers must keep the quality up. If funds are more limited, pre-K should be targeted.

Analyzing Public School Pre-K across Thousands of Districts

To evaluate pre-K programs in public school districts, we need data on both pre-K enrollments and academic outcomes for many districts. We get both from the U.S. Department of Education. Pre-K enrollment is readily publicly available for almost every district every year. We create a scale measure by dividing a district's pre-K enrollment by its grade 1 enrollment. Since 1st grade enrollment is universal, this approximates the fraction of students in a district who were enrolled in pre-K each year.

In the early 1990s, the typical (or median) school district had no pre-K, but the top tenth of districts had at least one-quarter of each year's students in pre-K. By the 2007–2008 school year, the typical district had about one-fifth of its students attend pre-K, and the top tenth of districts had nearly 90 percent of their students attending pre-K.

Measuring academic outcomes at the district level is harder. We use confidential data from the National Assessment of Educational Progress (NAEP), also known as the Nation's Report Card, a nationally representative standardized test, with core subjects in math and reading for 4th graders. These data allow us to link average student outcomes at the school district level with the pre-K enrollment of the same districts five years earlier—when the tested 4th graders should have been of pre-K age. Although not every school district takes the NAEP every time it is administered, enough do that we have outcomes for math and reading test scores for more than 5,000 school districts from the late 1990s through 2013. (In the full paper,

This article is based on a working paper titled "Pre-K in the Public Schools: Evidence from within U.S. States." The paper is available at http://research.upjohn.org/up_workingpapers/285/.

we look at other available outcomes that pre-K may influence, particularly those that rely on socioemotional skills: the fraction of students in special education and the fraction who repeated a grade.)

The Effects of Public School Pre-K

We estimate the impact of pre-K by comparing changes in outcomes among districts that expanded pre-K with changes in outcomes for districts that did not expand pre-K. This strategy allows us to control for permanent differences across districts. We also statistically adjust for changing characteristics of districts, notably per-student spending, as well as of students, such as sex, race and ethnicity, participation in the federal assisted lunch program, and whether the student is an English-language learner. (The full paper provides details on methodology.)

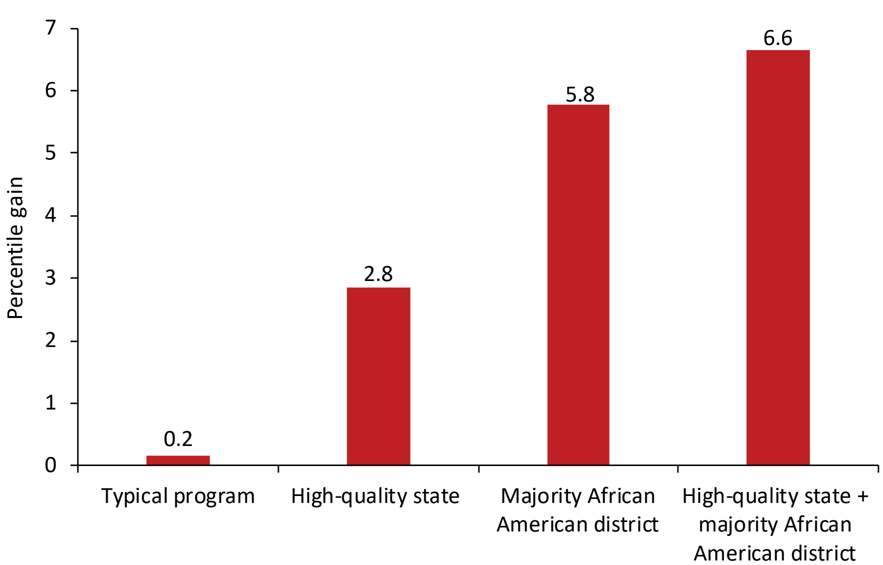
The first bar of Figure 1 shows the impact for a typical district of switching from no pre-K to full pre-K on math test score performance, measured in percentiles. The estimate of 0.2 means that moving from an environment in which none of a district's students attend public pre-K to one in which all the students attend pre-K is expected to raise math test scores by 0.2 percentiles—a tiny effect that is statistically indistinguishable from zero. What's more, although all statistical estimates come with a margin of error, the margin on this estimate is small enough that we can rule out effects as slight as 1.5 percentiles. As discussed below, this upper bound is just barely at the level needed to balance future social benefits (through higher future earnings of students) with program costs; it is also well below the benefit-cost ratio estimated for earlier, high-quality programs, such as Perry Preschool and the Chicago Child Parent Center.

However, states vary considerably in their funding and regulation of public pre-K programs, from per-pupil spending to necessary teacher credentials to teacher pay to curriculum. District implementation will vary within states, but is likely to be higher in states with stronger requirements. Drawing from expert opinion and findings from previous research, we identified—prior to our analysis—five states likely to have high-quality pre-K programs: Maryland, Massachusetts, New Jersey, North Carolina, and Oklahoma. The second bar in Figure 1 shows the impact of public school pre-K for districts in these five states. At 2.8 percentiles from switching from no pre-K to full pre-K, it is much larger than the impact for the typical district across all states and easily passes a benefit-cost test. Quality clearly matters for effectiveness.

Additionally, among previous studies of smaller-scale early childhood education programs, the largest effects have generally been found for those that target heavily disadvantaged students. In the last two columns, we show pre-K impacts among districts that are majority African American, overall and within high-quality states. These districts, whether they are urban or rural, often have high poverty rates: roughly three-quarters of students are eligible for free or reduced-price lunch in the typical district. Pre-K effects in these districts are substantively large, at 5.8 percentiles overall and 6.6 percentiles in districts in high-quality states. Although not shown in the figure, we also find large impacts on reading scores of 3.8 percentiles overall and 7.4 percentiles among districts in high-quality states. The magnitude of these effects is consistent with earlier studies of smaller programs; we show that similar effects are found for larger-scale public programs.

Overall, these pre-K impacts are consistent with a reasonable story. Pre-K in the average district for the typical student is of insufficiently high quality to create large positive benefits. However, pre-K is of sufficiently high quality on average to create benefits for some disadvantaged students—notably, for students in majority-black school

Figure 1 Pre-K Boosts 4th Grade Math Test Scores More When It's High-Quality and in Heavily African American Districts



NOTE: The figure shows the estimated gain in percentiles for 4th grade math test scores when a school district of the indicated type shifts from no pre-K enrollment to full pre-K enrollment for the cohort. Pre-K enrollment is measured five years prior to 4th grade test scores.
SOURCE: Authors' analysis of data from the National Assessment of Educational Progress and Common Core of Data. See the working paper for full details.

districts. Furthermore, in high-quality states, pre-K can create benefits for broader groups of students.

Factors to Keep in Mind When Evaluating Pre-K Programs

Only modest impacts are necessary for pre-K to have predicted long-term benefits greater than costs. The average state-funded pre-K program costs about $5,700 per student per year. Research shows that a 1-percentile increase in 4th grade test scores raises lifetime earnings by about $4,000. If pre-K boosts average test scores by just 1.4 percentiles, the expected future earnings gains are enough to pay for the cost of the program. Detecting these small effects requires a lot of data, as in the current analysis.

Pre-K effects can fade in middle grades before returning later in life. Many studies have found effects of pre-K immediately after the program, but that these effects partially fade out during the late elementary and middle school years. Older programs have shown positive effects returning in adulthood, such as greater earnings and less contact with the criminal justice system. These patterns may occur if pre-K has lasting impacts on hard-to-detect socioemotional skills, but test scores are highly dependent on curriculum, which converges for students regardless of pre-K exposure. Our analysis cannot speak to the possibility of the average public pre-K program having long-term effects; therefore, our analysis is conservative.

Children not attending public pre-K may be attending another early childhood education program. The well-publicized evaluation of the Head Start Impact Study found little net impact later in elementary school. Subsequent research, however, found that this was because many children not assigned to Head Start attended another program instead; Head Start effects were much greater relative to students who attended no program. In our context, it is likely that some children not attending public school pre-K were attending private preschool or a standalone Head Start center. In our analysis, we statistically control for the availability of Head Start and private preschool slots geographically close to each public school district; these controls do not change our findings.

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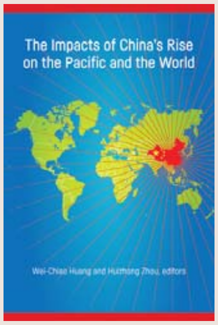
New from Upjohn Press

The Impacts of China's Rise on the Pacific and the World

Wei-Chiao Huang and Huizhong Zhou, Editors

China's economic growth over the past few decades is remarkable. On its current path,



projections are for it to surpass U.S. gross domestic product in the year 2028. Paralleling this economic growth is China's expanding geopolitical reach and influence. The combination of these two forces—economic and political— makes China, by many accounts, the most important diplomatic challenge facing its neighbors, the United States, and rest of the world's nations.

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