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Paths to Prosperity: Knowledge is Key for Fourth District States

by Paul W. Bauer and Mark E. Schweitzer

Since 1939, real U.S. per capita personal income has grown more than 400 percent—an average of 2.5 percent per year—greatly raising living standards. Each state has seen its per capita income rise dramatically (see figure 1), but not all states have grown at the same rate. Between 1939 and 2004, these differing growth rates have caused a substantial reduction in the income differences between high- and low-income states, a concept known as convergence.

For example, the highest-income state in 1939 (Delaware) had a per capita personal income that was four and a half times higher than that of the lowest-income state (Mississippi). Since the mid-1970s, per capita personal income in the highest-income states has typically been only slightly less than two times the income level of the lowest-income states. While these differences are clearly smaller than those in the 1930s, current income differences remain significant: Connecticut's 2004 top-ranked per capita personal income ($45,566) was almost double that of Mississippi's ($24,397) (see figure 2).

What are the sources of these remaining differences? Recent research by Bauer, Schweitzer, and Shane find that there are identifiable factors reliably associated with income differences in U.S. states. They find that a state's knowledge stocks—the innovativeness of its firms and the education and training of its workforce—are key determinants of its per capita personal income. In this *Economic Commentary*, we focus on the performance of Fourth District states in these areas. The results highlight issues that policymakers must face if they want to raise the income levels of Fourth District states.

How Are the Effects of Growth Factors Estimated?

Bauer, Schweitzer, and Shane apply a statistical model to identify factors that lead to persistent differences in state per capita personal incomes. The key features that help produce reliable estimates are as follows:

- Information on income levels over many years—65 years of state per capita income for the lower 48 states
- Information on how a wide variety of potential growth factors—educational attainment, patents, industry structure, taxes, infrastructure spending, banking deposits, and climate—differ between states
- A statistical model consistent with growth theory—the estimated model accounts for the income changes from the unobserved flows of capital and labor (see Barro and Sala-i-Martin, and Islam)
- A strategy ensuring that the factors are influencing income and not vice versa—the data on factors is five years prior to the income data

This last point requires more elaboration. When estimating the effects of these possible growth factors, it is necessary to carefully control for the possibility that per capita personal income might in turn influence the factors. For example, states with higher current incomes are likely to choose to spend more on education. The authors statistically verify that a five-year lag is enough to ensure that the factors' effects on income are captured, not current income's effect on the factors.

Even as per capita income has increased across the United States, differences among states' incomes remain. What are the sources of these remaining differences? This *Commentary* identifies and analyzes the key factors—patents, educational attainment, and industry structure—that influence income-growth rates and thus per capita incomes. It also explores where the Fourth District falls in relation to other states and the country as a whole.

The key identified factors turn out to be the knowledge stocks of patents and educational attainment, as well as a state's industry structure. Knowledge stocks are measured by three variables: The first measures the innovativeness of a state's firms. Data on patents issued to a state are used because they are highly correlated with research and development spending, but unlike these more direct measures, they are available at the state level further back in time (see Griliches). The patent factor is measured as a stock because the innovativeness that patents strive to proxy is likely to persist beyond their date of issuance. The patent stocks depreciate over time because the research and development that led to them are also likely to have a diminishing impact on incomes over time (this is not a critical assumption to Bauer, Schweitzer, and Shane's results, however).

The other two knowledge-stock variables measure educational attainment, or human capital in the form of education.

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FIGURE 1: INCOME GROWTH

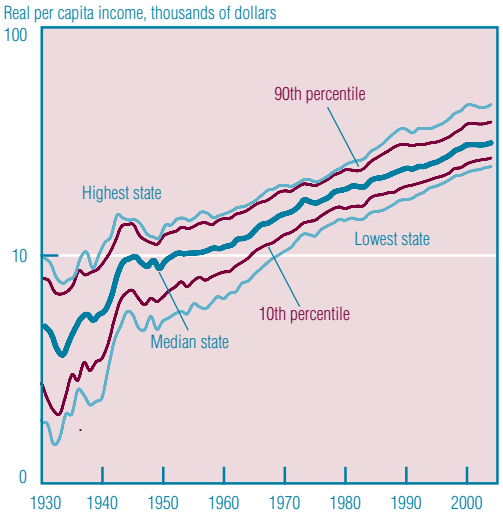
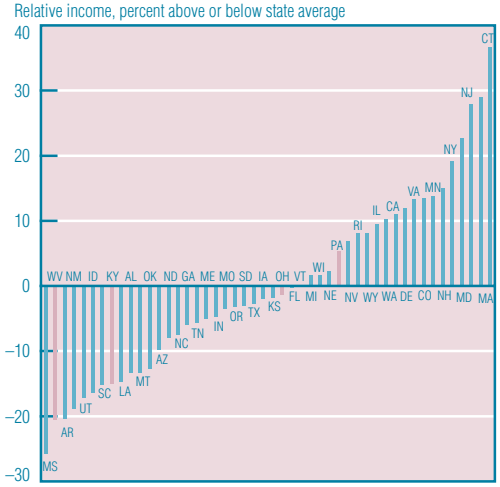


FIGURE 2: STATE RELATIVE INCOME, 2004



SOURCE: Authors' calculations.

One is the proportion of a state's population with at least a high school degree. The other is the proportion with at least a bachelor's degree. Each represents a fairly consistent measure of past investments in human capital that provides benefits over individuals' careers.

A state's industry structure also plays a significant role in its income growth. This factor—measured as a state's shares of personal income derived from manufacturing, farming, and mining relative to the nation—controls for a state's historical economic makeup, specifically the composition of its sector-specific capital and workers' human capital. Because adjustments in capital and labor cannot flow instantaneously from one sector to another, a state's current performance might be helped or hindered depending on whether its past industry structure turns out to be favorable. Implicitly, a state with low levels of manufacturing, farming, and mining will have a relatively large service sector. Despite the desire of some economic-development efforts to get the "right" mix of industries, the estimated industry-structure effects tend to be much smaller in magnitude than those for knowledge stocks.

The other factors—average tax rates, infrastructure spending, banking deposits, and climate—are also compared to the relevant national averages. While it may surprise some readers, these factors were not statistically significant, and their estimated effects were small.

■ Knowledge Matters

The cumulative effects of patent stocks, educational attainment, and industry structure from 1939 to 2004 on the Fourth District states and the average top- and bottom-quartile states are shown in figure 3. Effects accumulate because some of the boost (or drag) in per capita personal income in one period carries over into the next, so positive or negative factors have persistent effects just like any other historical source of income differences. For example, over the past 65 years, Kentucky has had a much lower-than-average patent stock, and as a result, the model predicts a lower per capita personal income (6.8 percent lower, to be specific). Kentucky's educational attainment has also lagged the average, which results in an estimated 7.8 percent lower level of per capita personal income. Its industry structure led to a further 4.9 percent lower level than would otherwise have been expected. The sum total of all the other factors (relative taxes, infrastructure spending, banking deposits, heating degree days, cooling degree days, and precipitation) lowered Kentucky's per capita personal incomes by 3.8 percent. All together, the model predicts that Kentucky's income will be 15.3 percent below average. The model does not account for everything, but for most states, the estimated effects match well with both the observed levels and the states' rankings.

Clearly, the performances of the top-quartile states are driven by the three identified factors. High levels of knowledge stocks promote the most income growth: Top-quartile states' relative patent stock is estimated to boost relative per capita personal incomes by 20.5 percent. The effect of educational attainment (high school and college) is smaller, but it is estimated to add another 8.0 percent. These top-performing states get a further 5.1 percent gain from their past industry structures. Other factors are small in magnitude, adding just 1.9 percent.

From the model's estimates, it is equally clear what drives low per capita personal incomes: low knowledge stocks. Relative per capita personal incomes of the lowest-quartile states are 6.3 percent lower due to their relatively low patent stocks, and they lose another 4.1 percent due to low relative educational attainments. Industry structure accounts for just a 1.9 percent additional decline. The effects of other explanatory variables in the model are relatively small (1.1 percent).

So how do Fourth District states stack up? Ohio and Pennsylvania are mid-pack performers and are remarkably similar to one another. Both have higher-than-average patent stocks that boost their per capita personal incomes: a 9.7 percent boost for Ohio and 9.2 percent for Pennsylvania. But they also both have just average levels of education and other factors. Somewhat surprisingly, given that they lie in the heart of the "rust belt," their past industry structure exerts only a modest drag—2.6 for Ohio and 1.6 percent for Pennsylvania.

Kentucky and West Virginia are also very similar to one another, both having significantly lower per capita personal incomes than Ohio and Pennsylvania as well as low stocks of knowledge factors. Patent stocks are predicted to reduce per capita personal incomes by 4.0 percent for West Virginia and 6.8 percent for Kentucky. Low educational attainments are expected to lower their personal incomes by an additional 11.4 and 7.8 percent, respectively. One difference between the two states is that while the effect of industry structure is negligible for West Virginia, Kentucky's relative per capita personal income is expected to be an additional 4.9 percent lower. Each benefit some from the total effect of all the other factors (3.8 for Kentucky and 2.7 percent West Virginia).

FIGURE 3: CUMULATIVE EFFECTS

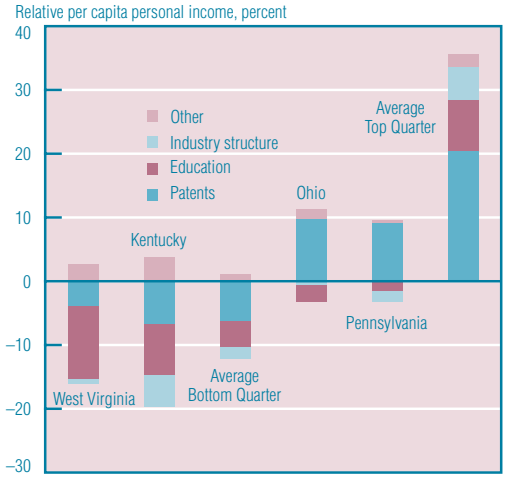


FIGURE 4: CHANGE IN ESTIMATED EFFECTS OF PATENTS ON INCOME, 1989–2004

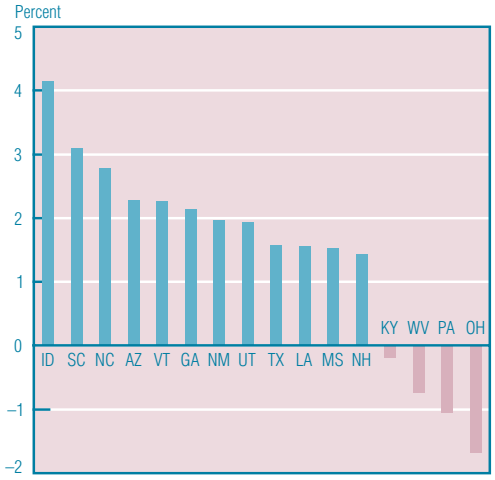


FIGURE 5: CHANGE IN ESTIMATED EFFECTS OF EDUCATION ON INCOME, 1989–2004

SOURCE: Authors' calculations.

Can States Change Their Growth Factors?

Are states simply stuck with their growth factors because of their geographic position or individual history, or can these factors be altered? Figures 4 and 5 suggest that they can. Figure 4 plots the change in the cumulative patent effects for Fourth District states and for the 12 states with the largest gains in this effect from 1989 to 2004. Fifteen years is a relatively short period of time for building up a research and development base, but it was long enough for some U.S. states to significantly improve their expected per capita personal incomes. Top performers' incomes increased 2.2 percent more than they otherwise would have because they found ways to improve their relative patent positions. For some of these states, the improvement came from going from an extremely low value to merely a low value. But Idaho, Vermont, and New Hampshire actually went from being below the national average to above.

While Ohio and Pennsylvania both currently have relatively high levels of per capita patent stocks (about 20 percent above the national average), each has seen its advantage erode over the past 25 years, so that their per capita incomes are lower than they otherwise would have been. Kentucky's and West Virginia's positions eroded less, but their relative per capita patent levels merely remained at low levels (approximately 60 percent below the national average).

Figure 5 plots the change in the cumulative education effects. Here, two Fourth District states made the top quartile (Kentucky and Pennsylvania). Many of the states that stand out in education gains achieved their status by going from extremely low high school attainment to the national average, and further gains from this source will be harder to achieve. But Rhode Island, New Jersey, Missouri, Pennsylvania, and especially Minnesota achieved their gains from a position already at or above the national average.

Although Kentucky's high school and college attainment remain among the lowest in the nation, the state has improved its relative performance. Kentucky led the nation in education gains, increasing its relative per capita personal income to 4.7 percent above what it would have otherwise been. It did this by making strong gains in both high school and college attainment. Pennsylvania also made strong gains in education, boosting its relative per capita income by 1.6 percent, mostly due to gains in high school attainment. All of West Virginia's improvement came from a higher level of high school attainment, as it actually lost ground relative to the nation in college attainment. Ohio was fairly close to the national average for education (slightly above for high school attainment, but slightly below for college) and essentially remained there.

What Can States Do?

Governments are heavily involved in providing and encouraging education, and the results reported here suggest that significant benefits accrue to states that are successful in boosting their relative education levels. Of course, with the mobile labor force of the United States, a state can either educate its own residents or attract educated workers from other regions. Colorado has a large positive education effect, gained partly by the highly educated migrants to that state. Alternatively, states that produce more graduates internally can also achieve higher attainment levels, although some "brain drain" has to be expected. A past *Economic Commentary* showed that, for Ohio, brain drain seems to reflect current economic conditions rather than a general overproduction of college graduates (see Yazback).

While specific policies for improving education levels are not identified in this research, we have singled out states that have been successful at raising their relative education levels for further study. In particular, Minnesota is a potentially interesting state to study because it had one of the biggest gains in its estimated education effect over the past fifteen years and currently has the second-largest estimated effect.

Innovation, as measured by state patent stocks, has an even larger estimated effect on income than does education, particularly for top-quartile states (see figure 3), so governments should also be interested in encouraging this activity. We do not think that it is literally the income generated by patents granted to entities of a state that matter because most estimates of profits accruing to firms that hold patents are not particularly high. Patents are more likely serving as a proxy for firms that are innovative in a far wider variety of ways. This broad characterization of

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what patents might proxy for suggests few policies directly, but the successes of some states over the past 15 years at least should invite research interest in what might underlie these trends.

Bauer, Schweitzer, and Shane's project revealed that large differences in state income levels are primarily associated with the variation in the states' knowledge-building activities of education and patenting. Yet economic development has long focused not on boosting these activities, but instead on recruiting (or retaining) companies (often with a preference for manufacturers) or on recommending infrastructure projects. Looked at case-by-case, some of these efforts have offered substantial benefits, but the research looked at in this *Commentary* suggests that having a larger manufacturing base has not reliably led to higher incomes. While this research does not identify specific policies for raising a state's per capita personal income, it does indicate that income growth at the state level tends to follow innovation and education.

For a detailed review of the evidence of state-income-level convergence, see:

Paul Bauer, Mark Schweitzer, and Scott Shane. 2006. "State Growth Empirics: The Long-Run Determinants of State Income Growth," Federal Reserve Bank of Cleveland, working paper, no. 06-06.

For analysis of migration patterns of college graduates that suggest reasons why Ohio's losses are not so extraordinary, see:

Shadya Yazback. 2004. "Losing Its Minds? Evaluating 'Brain Drain' in Ohio," Federal Reserve Bank of Cleveland, *Economic Commentary*. Jan. 1, 2005

Recommended Reading

R. Barro and X. Sala-i-Martin. 1991. "Convergence across States and Regions," *Brookings Papers on Economic Activity*, vol. 1: 107–82.

Nazrul Islam. 1995. "Growth Empirics: A Panel Data Approach," *Quarterly Journal of Economics*, vol. 110, no. 4.

Zvi Griliches. 1990. "Patent Statistics as Economic Indicators: A Survey," *Journal of Economic Literature*, vol. 28, no. 4: 1661–707.

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