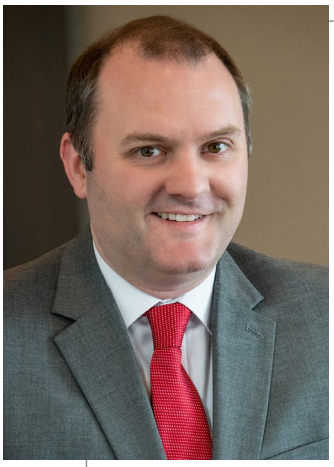
AMERICAN EXPERIMENT

Accounting for Growth

Measuring the sources of per capita economic growth at the state level

JOHN PHELAN



John Phelan is an economist at Center of the American Experiment. He is a graduate of Birkbeck College, University of London, where he earned a BSc in Economics, and of the London School of Economics where he earned an MSc. John worked in finance for ten years before becoming a professional economist. He worked at Capital Economics in London, where he wrote reports ranging from the impact of Brexit on the British economy to the effect of government regulation on cell phone coverage. John has written for newspapers and magazines in both Europe and the United States, including *The Wall Street Journal* and *National Review*, as well as contributing regularly to newspapers across Minnesota. He has also been published in the journal *Economic Affairs*.

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CONTENTS

Executive summary

Minnesota's relative growth slowdown

- What matters for economic well-being is income – or GDP – per capita and Minnesota's recent performance has been concerning.
- Minnesota's level of GDP per capita was $4,669 above that of the United States generally as recently as 2014. By the first half of 2024, that "premium" had disappeared.
- In every year since 2014, per capita GDP grew more slowly in Minnesota than in the United States generally. Only Wisconsin matches this record.
- Minnesota's decline relative to the United States was not driven by a few high-performing states. The state's average annual real growth rate of GDP per capita fell from a rank of 17th out of 50 states in 2008-2014 to 37th in 2014-2023.
- This decline occurred even though Minnesota's real per capita GDP growth rate rose from an annual average of 0.8 percent in 2008-2014 to 1.1 percent in 2014-2023. Other states did better.
- To identify the sources of Minnesota's relative slowdown, we use a technique called "growth accounting" to break down the observed rate of change in real per capita GDP into the shares derived from changes in human capital, physical capital, or Total Factor Productivity (TFP).

Per capita GDP growth

- Minnesota's mean rate of annual per capita GDP growth rose by 0.3 percentage points from the period 2008-2014 to 2014-2023.
- An increase in the (weighted) mean per capita human capital growth rate contributed 0.2 percentage points to this increase and a higher mean rate of per capita physical capital growth for the rest. A decline in the average annual growth rate of TFP acted as a drag.
- While Minnesota's ranking for mean annual TFP growth between the two periods rose from 30th to 20th, it fell for human capital growth — 4th to 42nd — and for physical capital growth — 24th to 37th.

Human capital growth

- From 2008 to 2023, per capita increases in human capital arising from education accounted for all of Minnesota's average annual per capita growth of human capital. Increases in the employment ratio and average annual hours worked contributed nothing, and a decline in the per capita human capital stock arising from experience acted as a drag.
- Minnesota's (unweighted) average annual growth rate of human capital per capita rose by 0.8 percentage points from 2008-2014 to 2014-2023, but this rate's ranking fell from 4th out of 50 states to 42nd.

Employment

- An increase in the mean annual growth rate of the employment ratio accounted for 0.2 percentage points of the (unweighted) increase in the overall human capital growth rate from 2008-2014 to 2014-2023.
- While Minnesota's performance improved on this measure, in relative terms, it fell from a ranking of 2nd to 43rd out of 50 states.
- Minnesota already had one of the highest employment ratios in the United States. Its average ratio from 2008 to 2014 ranked 7th out of 50 states at 51.7 percent, and from 2015 to 2023, its ratio ranked 3rd out of 50 at 52.3 percent. With employment ratios already high, there is less scope for driving faster per capita GDP growth by increasing them.
- There is some scope, however. Minnesota's employment ratio was 6.5 percentage points lower in 2023 than in 1998, with the rates down in the 16- to 24-years-of-age categories. If the employment ratios in these sections of the labor force could be boosted to 2000 levels, 37,000 more young Minnesotans would be employed, and GDP per capita would be higher.

Education

- The average annual per capita growth rate of human capital arising from education rose from 0.1 percent in 2008-2014 to 0.2 in 2014-2023, accounting for 0.1 percentage points of the increase in the (unweighted) rate of human capital growth between the two periods.
- While Minnesota's performance improved on this measure, in relative terms, it fell from a ranking of 3rd to 42nd out of 50 states.
- The average annual growth rates of employment and human capital arising from education per worker remained constant between the two periods, so this increase was

entirely down to a slowing of Minnesota's average population growth rate, from 0.7 percent annually to 0.5 percent.

- In 2023, 72.8 percent of Minnesota's workforce was educated beyond a regular high school diploma, GED, or alternative credential, the second highest share in the United States. Once again, with the workforce already so highly educated, there is limited scope for driving further per capita GDP growth by driving education levels up.

Experience

- The stock of human capital per capita arising from experience in Minnesota improved from a mean annual rate of decline of -0.4 percent in 2008-2014 to 0.0 percent in 2014-2023, accounting for 0.4 percentage points of the increase in the (unweighted) rate of human capital growth between the two periods.
- While Minnesota's performance improved on this measure, in relative terms, it fell from a ranking of 4th to 45th out of 50 states.
- This increased rate was split equally between an improvement in the average rate of change of human capital per worker from a decline of -0.3 percent annually in 2008-2014 to -0.1 percent in 2014-2023 and the decline in Minnesota's average population growth rate.
- We assume that a worker's human capital arising from experience rises until their mid-40s and falls thereafter as they get "set in their ways." From 1999 to 2018, the share of Minnesota's workforce aged 45 or over rose by 10.6 percentage points, to 45.4 percent, and human capital arising from experience per worker fell by 5.8 percent as a result. Since 2018, however, the share of Minnesota's workforce aged 45 or over fell to 41.7 percent and human capital arising from experience per worker rose by 0.9 percent. Since 2018, employment ratios have risen in every age group under 55 and fallen in those above it driving an improvement in this rate.

Physical capital growth

- The increase of 0.3 percentage points in the (unweighted) mean rate of growth of physical capital per capita from 2008-2014 to 2014-2023 was largely driven by an increase in the physical capital stock in the Real Estate and Rental and Leasing sector. This accounted for 44.1 percent of Minnesota's total physical capital stock in 2008, so the increase of 1.8 percentage points in the annual, per capita growth of physical capital here drove the increased growth rate for the state.
- Even so, Minnesota's mean annual growth rate of physical capital per capita fell from 24th out of 50 states in 2008-2014 to 37th in 2014-2023.
- Minnesota's fall in the rankings of growth was driven by the Manufacturing sector, which accounts for the second-largest share of the state's physical capital stock. The average annual growth rate of physical capital here fell by 2.7 percentage points from 2008-2014 to 2014-2023, falling by an average -0.2 percent annually in the latter period.

Introduction: Accounting for per capita growth

In American Experiment's 2021 report "The State of Minnesota's Economy: 2020 — A focus on economic growth," we wrote:

> What matters for economic welfare is per capita income. This is a general measure of welfare, telling us how much per person is available to be consumed, invested, or put to some other use.
>
> If we want to increase economic welfare, we should pursue policies that increase *per capita* incomes. A doubling of *total* [Gross Domestic Product] GDP, if it is matched by a doubling of the population, will leave the average member of the population no better off.[1]

Given its importance, Minnesota's recent record on per capita GDP growth is concerning. As Figure 1 shows, Minnesota has long been able to boast a per capita GDP above that of the United States generally, a "premium" for living in the state. In 2004, this premium was $4,973 per Minnesotan, and as recently as 2014, it was $4,669, or $18,676 for a family of four. Since 2014, however, this premium has fallen every year and was down to just $435 in 2023. In quarterly data, the premium disappeared completely in the first half of 2024.

Minnesota's advantage over the United States' average in per capita GDP has disappeared because in every year since 2014, its per capita GDP growth has been slower than that of the United States generally, as Figure 2 shows. While Minnesota's real per capita GDP growth rate was higher than that of the United States (highlighted in blue) in 10 of 17 years up to and including 2014, it has been below it (highlighted in red) in each of the nine years since. Only Wisconsin can match Minnesota's record of lagging the national growth rate of GDP per capita in every single year since 2014.

This didn't happen because Minnesota's average annual rate of per capita GDP growth fell. Minnesota's average rate of per capita GDP growth increased from 0.8 percent annually from 2008 to 2014 to 1.1 percent from 2014 to 2023. However, the rate for the United States increased from 0.6 percent to 1.9 percent, as Figure 3 shows (the reason for choosing these periods will become apparent). Looking at the longer periods 1997 to 2023 and 2008 to 2023, we see Minnesota's rate of per capita GDP growth lagging the national rate is nothing new, but the deficit in 2014-2023 is especially large: 0.8 percentage points annually. If this gap was maintained over 10 years of growth, it would mean total GDP per capita growth for the United States 2.5 times greater than for Minnesota.

Minnesota's decline relative to the United States isn't just driven by a handful of high-performing states. Figure 4 shows the ranking of Minnesota's mean, real per capita GDP growth among the 50 states in four time periods. In 2008-2014, Minnesota's rate ranked 17th out of 50 states, but this fell to 37th in 2014-2023, even as the rate itself rose.

Given its importance, Minnesota's recent record on per capita GDP growth is concerning.

The variation in rates of per capita GDP growth among the states can lead to significant differences over time. As Figure 5 shows, from 1997-2023, per capita GDP grew by 120.4 percent in real terms in North Dakota and 87.9 percent in California compared to 11.0 percent or less in Nevada, Delaware, and Alaska. Even over a shorter period, 2008-2023, we see that per capita GDP grew by 44.5 percent in real terms in North Dakota but shrunk by 9.7 percent in Wyoming.

What accounts for Minnesota's relative slowdown? What accounts for the relative successes in North Dakota and California and failures in Wisconsin, Nevada, Delaware, and Alaska? To answer this, we need to examine the components of real per capita GDP growth.

In our 2021 report, we wrote:

> Per capita economic growth comes from three sourc-

> es…These are an increase in the amount of labor provided by a given population…; growth of capital per worker (the tools those workers have to work with); and Total Factor Productivity ("The effectiveness with which factors of production are converted into output"), which is also known as Technology ("the way inputs to the production process are transformed into output").[2]

These three sources can be labelled "human capital" (*H*), "physical capital" (*K*), and "Total Factor Productivity" (*TFP*).

Determining how a country or state is performing with regard to these sources is vital for identifying policies that will boost real per capita GDP growth. Policies that increase employment or skills raise human capital; policies that stimulate increased capital investment elevate the amount of physical capital; and policies that spur increased innovation and entrepreneurship catalyze TFP growth.

Economists use a technique called "growth accounting" to break down the observed rate of change in real per capita GDP, such as those shown in Table 1, into the shares derived from changes in human capital, physical capital, or TFP.[3] These exercises are common at the national level, where estimates of human and physical capital are readily available, and the contribution of TFP can be calculated as the residual (the method will be described in more detail below).

However, in his book *Fully Grown: Why a Stagnant Economy is a Sign of Success*, in which he performs a growth accounting exercise for the United States, Dietrich Vollrath writes: "At the state level, I don't have enough data to calculate a residual productivity number, as detailed human capital and physical capital data is not available."[4] In this report, we will adapt Vollrath's growth accounting method and draw on the work of Makram El-Shagi and Steven Yamarik[5] to construct estimates of human and physical capital at the state level. This, in turn, will allow us to calculate TFP — the residual — and perform a growth accounting exercise for the 50 states.

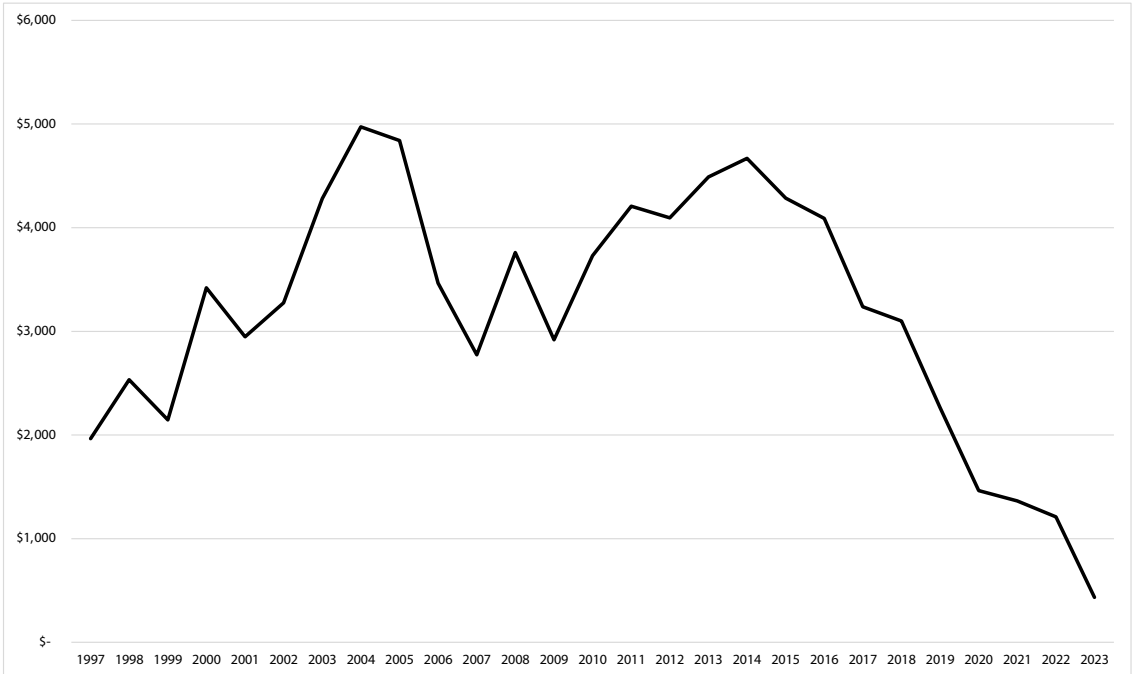
Section 1 looks at human and physical capital and TFP. We will examine what they are, how they relate to per capita economic growth, how we can quantify them, and, using these estimates, how they have changed in recent years. We will perform a growth accounting exercise to estimate TFP's contribution and that of human and physical capital to per capita GDP growth in each of the states.

Section 2 uses the results of our growth accounting exercise to examine Minnesota's relative growth slowdown. We will dig down into the ingredients of human capital — employment, education, and experience — and physical capital to understand why the state's per capita GDP growth rate has slipped down the rankings. This will serve as a model for how these estimates can be used by researchers in other states.

Section 3 briefly discusses the shortcomings of our analysis and ways in which we will seek to improve it in the future. This report will form the basis of the Center of the American Experiment United States Tables, modeled on the Penn World Tables, which will make all these estimates available to the public on our website at www.amexustables.org.

Figure 1

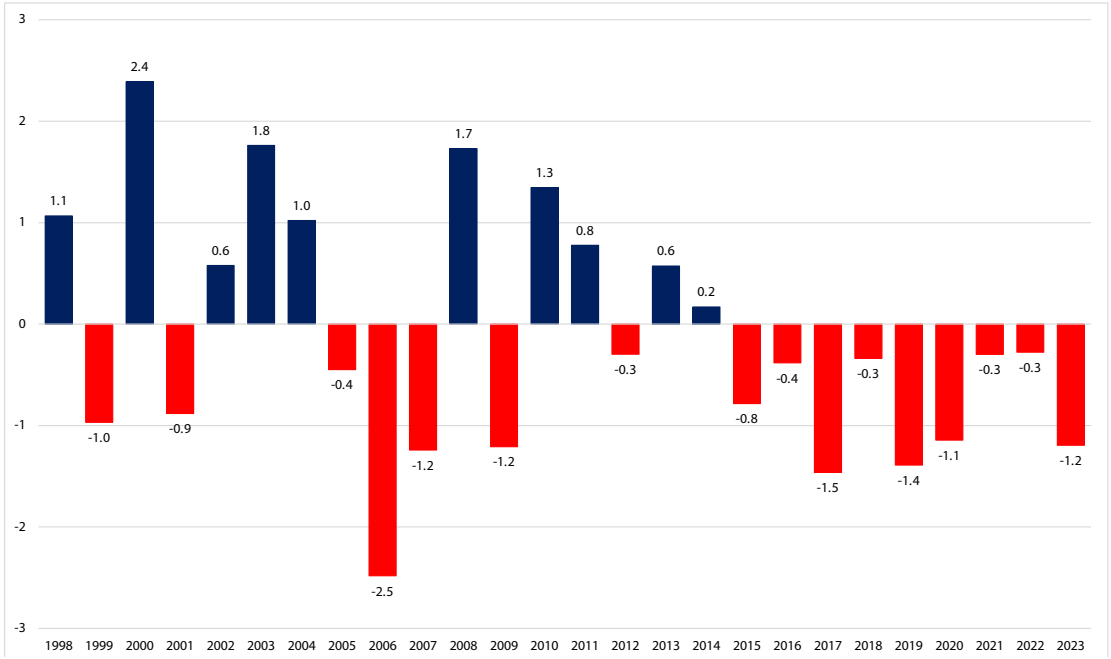
Minnesota's 'Premium' in Per Capita GDP Over the United States, $2017



Source: Bureau of Economic Analysis and Center of the American Experiment

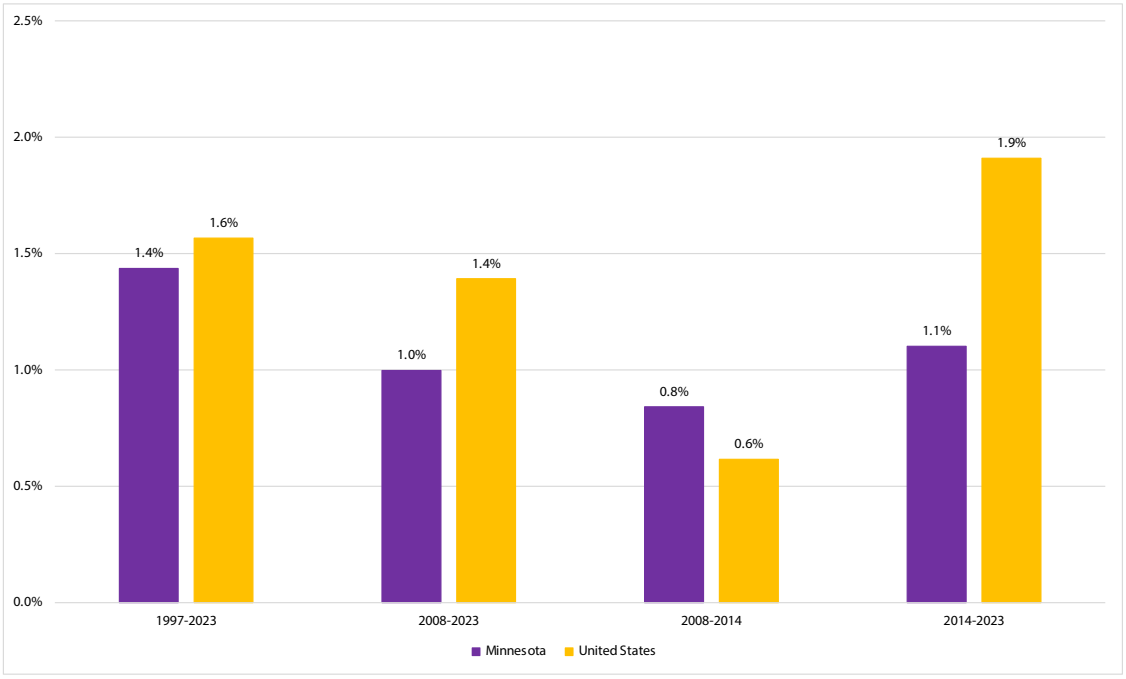
Figure 2

Growth of Real Per Capita GDP in Minnesota Minus Growth of Real Per Capita GDP for the United States, Percentage Points



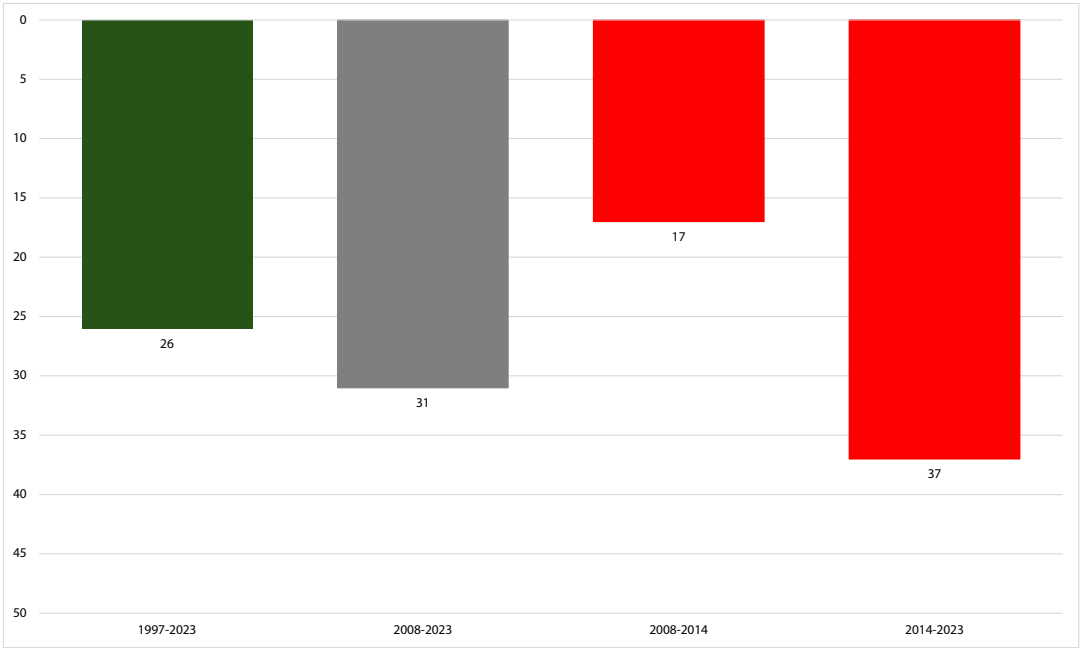
Source: Bureau of Economic Analysis and Center of the American Experiment

Figure 3
Average Real Growth Rate of GDP Per Capita



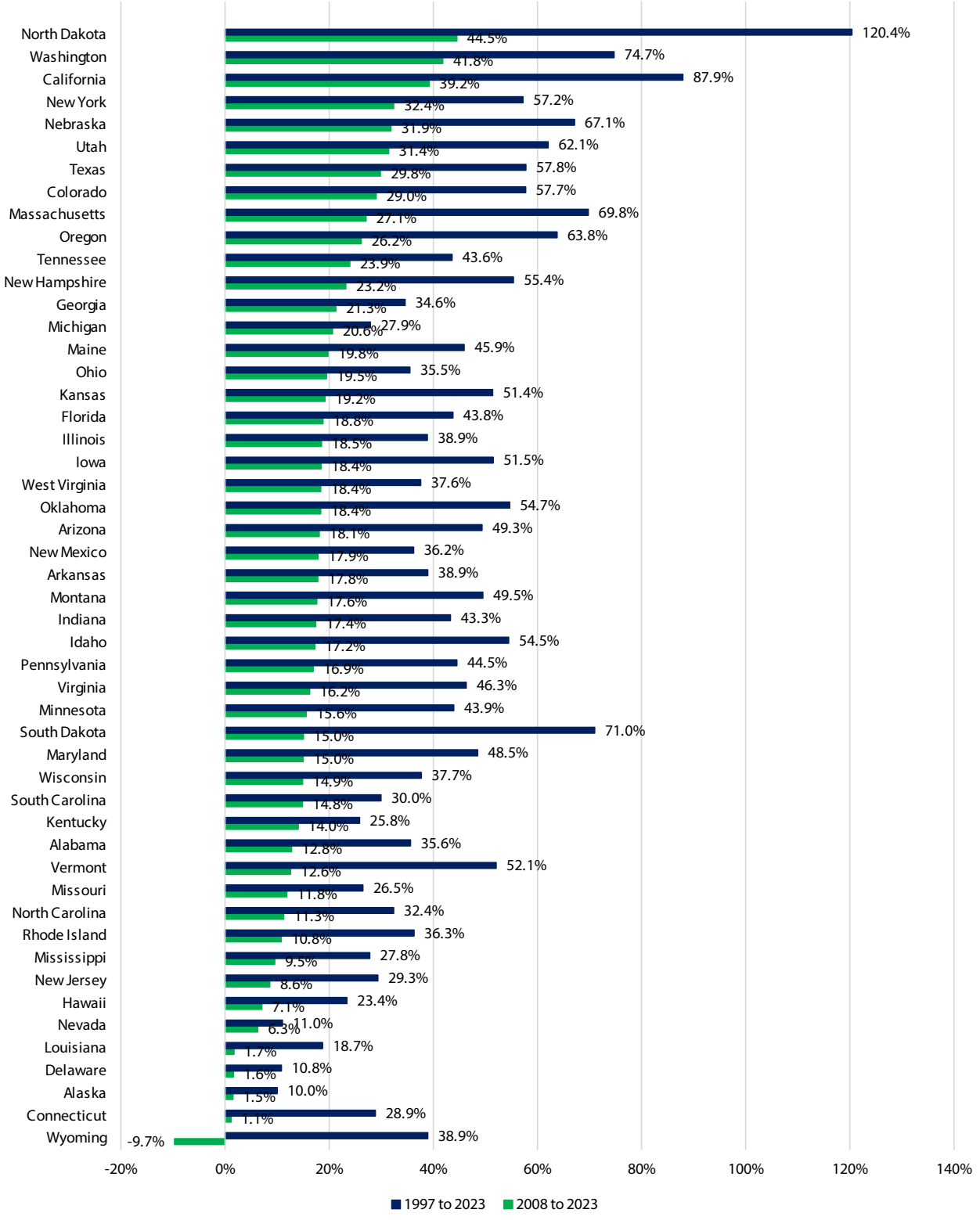
Source: Bureau of Economic Analysis and Center of the American Experiment

Figure 4
Ranking of Minnesota's Mean, Real Per Capita GDP Growth



Source: Bureau of Economic Analysis and Center of the American Experiment

Figure 5
Real Per Capita GDP Growth



Source: Bureau of Economic Analysis and Center of the American Experiment

Table 1
Change in Real Per Capita GDP

	Mean rates			Ranks		
	2008-2023	2008-2014	2014-2023	2008-2023	2008-2014	2014-2023
Alabama	0.8%	-0.1%	1.5%	37	39	24
Alaska	0.2%	0.0%	0.3%	48	34	48
Arizona	1.2%	-0.9%	2.5%	21	47	7
Arkansas	1.1%	0.6%	1.4%	26	22	25
California	2.3%	0.8%	3.2%	3	16	2
Colorado	1.7%	0.4%	2.6%	8	27	4
Connecticut	0.1%	-1.4%	1.1%	49	48	38
Delaware	0.2%	1.1%	-0.4%	46	8	49
Florida	1.2%	-0.8%	2.5%	17	46	6
Georgia	1.3%	0.2%	2.0%	13	30	11
Hawaii	0.5%	-0.3%	1.0%	44	41	39
Idaho	1.1%	-0.3%	2.0%	28	43	13
Illinois	1.2%	0.8%	1.4%	20	18	29
Indiana	1.1%	0.7%	1.4%	24	20	27
Iowa	1.2%	1.4%	1.0%	22	6	40
Kansas	1.2%	0.2%	1.9%	18	32	18
Kentucky	0.9%	0.4%	1.2%	36	28	33
Louisiana	0.2%	-0.3%	0.5%	47	42	46
Maine	1.2%	-0.1%	2.1%	16	38	9
Maryland	1.0%	0.6%	1.2%	32	24	35
Massachusetts	1.6%	0.9%	2.1%	9	15	8
Michigan	1.3%	0.9%	1.6%	14	14	21
Minnesota	1.0%	0.8%	1.1%	31	17	37
Mississippi	0.6%	-0.2%	1.2%	42	40	34
Missouri	0.8%	0.0%	1.3%	39	36	32
Montana	1.1%	0.8%	1.3%	27	19	30
Nebraska	1.9%	1.6%	2.0%	5	4	12
Nevada	0.5%	-1.7%	2.0%	45	49	15
New Hampshire	1.4%	1.0%	1.7%	12	10	20
New Jersey	0.6%	-0.6%	1.4%	43	45	28
New Mexico	1.1%	0.0%	1.9%	25	35	17
New York	1.9%	1.8%	2.0%	4	3	14
North Carolina	0.7%	-0.4%	1.5%	40	44	23
North Dakota	2.7%	7.4%	-0.4%	1	1	50
Ohio	1.2%	1.1%	1.3%	15	9	31
Oklahoma	1.2%	1.8%	0.7%	19	2	44
Oregon	1.6%	0.1%	2.6%	10	33	5
Pennsylvania	1.1%	1.0%	1.1%	29	11	36
Rhode Island	0.7%	0.5%	0.8%	41	26	43
South Carolina	1.0%	0.2%	1.4%	34	31	26
South Dakota	1.0%	1.3%	0.7%	33	7	45
Tennessee	1.5%	0.6%	2.1%	11	25	10
Texas	1.8%	1.5%	2.0%	7	5	16
Utah	1.9%	0.2%	2.9%	6	29	3
Vermont	0.8%	0.7%	0.9%	38	21	42
Virginia	1.0%	-0.1%	1.8%	30	37	19
Washington	2.4%	0.9%	3.4%	2	12	1
West Virginia	1.1%	0.6%	1.5%	23	23	22
Wisconsin	1.0%	0.9%	1.0%	35	13	41
Wyoming	-0.6%	-1.9%	0.3%	50	50	47

Source: Bureau of Economic Analysis and Center of the American Experiment

Sources of per capita economic growth

Human capital (H)

Our first source of real per capita GDP growth is human capital (*H*).[6]

We noted that increases in human capital can lead to "an increase in the amount of labor provided by a given population" and this can be expected to result in a greater output of goods and services — or GDP — to divide among that population, or growth in per capita GDP.

An employment ratio can only increase so far. Once the entire population is employed, there can be no further growth from that source.

To see how this works, imagine an economy with 100 people, 70 of whom are employed working an average of 1,500 hours annually and producing 10 units of output per hour (their average labor productivity). Total GDP in this economy is 1,050,000 units annually and per capita GDP is 10,500 units (Scenario 1 in Table 2). Now imagine that the employment ratio increases so that 80 people out of the 100 are employed. In this case, total GDP increases to 1,200,000 units and per capita GDP rises to 12,000 units (Scenario 2 in Table 2) as a result of a larger share of the population working, the *ex*tensive margin. Now imagine that these workers begin working longer hours — the *in*tensive margin — so that the average hours worked annually increases to 2,000. In this case, total GDP increases to 1,600,000 units and per capita GDP rises to 16,000 units (Scenario 3 in Table 2).

This illustrates how increases in the "raw" amount of labor provided in an economy can boost per capita GDP. But there are limits: An employment ratio can only increase so far. Once the entire population is employed, there can be no further growth from that source. The same applies to hours worked: there are only so many in a day. In addition, more hours worked means fewer hours doing something else we may enjoy more. Borjas notes that "the typical person employed in production worked 55 hours per week in 1900, 40 hours in 1940, and just under 34 hours in 2020" and argues that this is because, as wages have risen, the "income effect reduces hours of work" as workers can maintain their level of income while working for fewer hours, allowing them to purchase more leisure time.[7] The aim of policy is to maximize utility — "a measure of happiness or satisfaction"[8] — not GDP or even GDP per capita, which is a means to that end. With this in mind, analysis of average hours worked will be included only as necessary for the growth accounting exercise.

These limits do not hold with relation to other sources of human capital growth like increased skills, which make each unit of labor more productive. To see how this works, imagine that as a result of greater skills arising from more

Table 2

Effects of Increased Human Capital on Per Capita GDP

Scenario	Population (N)	Employed (E)	Average hours worked annually (hours)	Average output per hour (hEduc, hExp)	Annual output per worker (Y/E)	Total annual output (Y)	Annual output per capita (y)
1	100	70	1,500	10	15,000	1,050,000	10,500
2	100	80	1,500	10	15,000	1,200,000	12,000
3	100	80	2,000	10	20,000	1,600,000	16,000
4	100	80	2,000	20	40,000	3,200,000	32,000

Source: Center of the American Experiment

education or experience, the amount of output each worker is able to produce in an hour doubles to 20. In this case, total GDP increases to 3,200,000 units and per capita GDP rises to 32,000 units (Scenario 4 in Table 2) while the same number of workers work the same number of hours.

There is no reason to assume that there is some upper limit to the productivity of the skills we can possess. Because of this, beyond the limits imposed by the size of the labor force and length of the day, increased per capita economic growth from human capital must come from increased skills.

Increased per capita economic growth from human capital must come from increased skills.

We will look at each of these components of human capital — "raw" labor and skills — in turn.

Raw labor

To quantify the "raw" labor component of human capital at the national level, Vollrath multiplies "the number of workers" by "the average hours of a worker in a given year" to derive "the total hours of work"[9] in an economy. To repeat the exercise for the states, the Bureau of Labor Statistics' (BLS) Local Area Unemployment Statistics[10] provide estimates of the number of people in "Employment" in each state (*E*, which we use in place of Vollrath's "number of workers") and their State and Regional Labor Productivity[11] data provides figures for "Millions of hours" worked (*HOURS*, Vollrath's "total hours of work"). We can derive "the average hours of a worker in a given year" (*hours*) with the equation

$$hours = \frac{HOURS}{E} \qquad (1.1)$$

This allows us to identify what portion of changes in the amount of raw labor supplied arise from either the extensive or the intensive margin. We are limited by the fact that the data on "Millions of hours" worked only goes back to 2007.

Number of workers (E)

With our annual estimates we can calculate annual changes in employment. Table 3 shows the mean rates of employment change for three periods — 2008-2023, 2008-2014, and 2014-2023 — and the rankings of these means.

Average hours worked (hours)

As above, with our annual estimates we can calculate annual changes in average hours worked. Table 4 shows the mean rates of change for three periods — 2008-2023, 2008-2014, and 2014-2023 — and the rankings of these means.

Table 3
Change in Total Employed (*E*)

	Mean rates			Ranks		
	2008-2023	2008-2014	2014-2023	2008-2023	2008-2014	2014-2023
Alabama	0.7%	-0.2%	1.2%	21	37	16
Alaska	0.2%	0.4%	0.1%	40	16	48
Arizona	1.3%	0.0%	2.3%	5	27	3
Arkansas	0.3%	-0.4%	0.7%	34	46	27
California	0.6%	0.4%	0.8%	22	10	25
Colorado	1.3%	0.4%	1.8%	7	13	7
Connecticut	0.2%	-0.1%	0.4%	37	29	39
Delaware	0.9%	0.0%	1.5%	14	23	15
Florida	1.5%	0.6%	2.1%	4	4	5
Georgia	0.9%	-0.4%	1.8%	15	45	9
Hawaii	0.5%	0.6%	0.5%	27	6	36
Idaho	1.7%	0.5%	2.6%	3	7	2
Illinois	0.0%	-0.4%	0.2%	48	47	45
Indiana	0.5%	-0.1%	0.9%	25	28	22
Iowa	0.2%	0.2%	0.3%	39	20	44
Kansas	0.2%	0.0%	0.3%	38	24	41
Kentucky	0.1%	-0.2%	0.4%	42	40	40
Louisiana	0.1%	0.3%	0.0%	44	18	49
Maine	0.1%	-0.1%	0.2%	45	33	47
Maryland	0.5%	0.3%	0.7%	26	19	28
Massachusetts	0.7%	0.4%	0.9%	19	9	23
Michigan	0.5%	-0.3%	1.0%	29	41	20
Minnesota	0.6%	0.6%	0.6%	23	5	29
Mississippi	0.0%	-0.8%	0.4%	49	50	38
Missouri	0.3%	-0.1%	0.6%	31	34	30
Montana	0.9%	0.0%	1.5%	12	22	14
Nebraska	0.5%	0.4%	0.6%	28	11	31
Nevada	1.3%	-0.1%	2.2%	6	32	4
New Hampshire	0.3%	-0.1%	0.5%	33	30	34
New Jersey	0.6%	-0.2%	1.1%	24	39	18
New Mexico	0.3%	-0.4%	0.8%	32	44	26
New York	0.2%	-0.4%	0.5%	41	42	33
North Carolina	1.1%	0.5%	1.6%	9	8	11
North Dakota	0.9%	1.7%	0.3%	16	2	43
Ohio	0.0%	-0.7%	0.4%	46	49	37
Oklahoma	0.8%	0.4%	1.1%	17	12	17
Oregon	0.9%	0.0%	1.5%	13	26	12
Pennsylvania	0.2%	-0.2%	0.5%	35	38	32
Rhode Island	0.4%	-0.4%	0.9%	30	43	21
South Carolina	1.2%	0.7%	1.5%	8	3	13
South Dakota	0.7%	0.4%	0.9%	20	14	24
Tennessee	0.9%	-0.1%	1.6%	11	31	10
Texas	1.8%	1.8%	1.8%	2	1	8
Utah	1.8%	0.4%	2.8%	1	17	1
Vermont	0.1%	-0.2%	0.3%	43	35	42
Virginia	0.8%	0.4%	1.0%	18	15	19
Washington	1.1%	0.0%	1.8%	10	25	6
West Virginia	-0.1%	-0.5%	0.2%	50	48	46
Wisconsin	0.2%	-0.2%	0.5%	36	36	35
Wyoming	0.0%	0.1%	-0.1%	47	21	50

Source: Bureau of Labor Statistics and Center of the American Experiment

Table 4

Change in Average Hours Worked Annually (*hours*)

	Mean rates			Ranks		
	2008-2023	2008-2014	2014-2023	2008-2023	2008-2014	2014-2023
Alabama	-0.3%	-0.5%	-0.3%	44	42	38
Alaska	-0.3%	0.1%	-0.6%	43	23	47
Arizona	0.2%	-0.4%	0.6%	13	34	7
Arkansas	0.4%	-0.3%	0.9%	3	31	2
California	0.3%	0.2%	0.4%	9	17	11
Colorado	-0.3%	0.0%	-0.4%	39	26	44
Connecticut	-0.2%	-0.2%	-0.2%	36	30	33
Delaware	-0.4%	-0.5%	-0.3%	45	41	41
Florida	0.1%	-0.4%	0.4%	22	36	9
Georgia	0.3%	0.5%	0.2%	6	8	13
Hawaii	0.0%	0.1%	-0.1%	31	19	31
Idaho	0.0%	-0.9%	0.7%	26	47	6
Illinois	0.2%	0.5%	0.0%	14	9	27
Indiana	0.1%	0.3%	0.0%	19	14	23
Iowa	0.3%	0.7%	0.1%	8	6	19
Kansas	-0.3%	-0.4%	-0.3%	40	35	39
Kentucky	0.2%	-0.8%	0.9%	10	46	3
Louisiana	0.1%	0.4%	-0.2%	25	12	32
Maine	0.2%	-0.5%	0.7%	11	40	5
Maryland	-0.5%	-0.7%	-0.4%	49	45	43
Massachusetts	-0.1%	-0.1%	0.0%	32	29	24
Michigan	0.1%	0.7%	-0.2%	18	5	37
Minnesota	0.0%	0.0%	0.0%	27	27	20
Mississippi	0.1%	0.4%	0.0%	20	13	29
Missouri	-0.1%	-0.4%	0.0%	35	37	22
Montana	0.3%	0.2%	0.4%	7	15	10
Nebraska	-0.4%	-0.4%	-0.4%	47	38	45
Nevada	-0.1%	-2.1%	1.2%	34	50	1
New Hampshire	0.4%	0.5%	0.3%	4	7	12
New Jersey	-0.1%	-0.3%	0.0%	33	33	21
New Mexico	-0.4%	-1.0%	0.0%	46	48	28
New York	0.5%	1.0%	0.1%	2	2	15
North Carolina	0.2%	-0.3%	0.5%	15	32	8
North Dakota	0.9%	4.1%	-1.3%	1	1	50
Ohio	0.3%	0.8%	0.0%	5	3	25
Oklahoma	-0.3%	0.2%	-0.7%	42	16	48
Oregon	0.0%	0.1%	0.0%	28	24	26
Pennsylvania	0.1%	0.1%	0.1%	23	20	17
Rhode Island	-0.2%	-0.1%	-0.2%	37	28	36
South Carolina	0.0%	-1.1%	0.7%	30	49	4
South Dakota	0.2%	0.8%	-0.2%	12	4	35
Tennessee	0.1%	0.1%	0.2%	17	18	14
Texas	0.1%	0.1%	0.1%	24	22	18
Utah	0.0%	0.5%	-0.3%	29	10	40
Vermont	-0.5%	-0.6%	-0.4%	48	44	42
Virginia	-0.3%	-0.5%	-0.2%	41	43	34
Washington	0.1%	0.1%	0.1%	21	25	16
West Virginia	-0.2%	0.1%	-0.4%	38	21	46
Wisconsin	0.2%	0.5%	0.0%	16	11	30
Wyoming	-0.7%	-0.4%	-0.9%	50	39	49

Source: Bureau of Labor Statistics and Center of the American Experiment

Skills

Vollrath notes that "there isn't a clear and objective way to measure skills like there is to measure time." "In the absence of an obvious metric," he continues, "the most common way is to look at years of schooling, with the presumption that workers with higher levels of education possess more skills...in general we think that skills are correlated with education, if only because we see higher educated workers receive higher wages, an indication that they bring something extra to employers." Skills also come with experience. But, he argues, "at some point more experience might become a detriment to workers' human capital, perhaps if they tend to rely on their usual way of doing things rather than learning to adapt." Vollrath writes that "we can measure [experience] by the number of years a worker has been in the labor force."[12]

Education (hEduc)

To estimate the contribution of education to human capital (*hEduc*), we will follow Vollrath's method with adaptations.[13]

The Census Bureau provides data on Educational Attainment via its American Community Survey,[14] which allow us to break down the number of those aged 16 and over and employed in each state[15] — not the total population as we are trying to measure the amount of human capital actually *applied* to production, not that simply *available* — into the 24 groups (j) in Table 5, rather than Vollrath's six groups. Because the Census Bureau's estimates of the number of people employed in each state differ from those of the BLS, we continue using the BLS' numbers. We calculate the share of employment in each group in the Census Bureau's estimates and apportion the BLS' number of total employed (E) using those shares. For each of these groups, we assume each member has a single value for the years of schooling (s). Again, we are limited by the availability of data. Prior to 2008, the categories used by the Census Bureau to report Educational Attainment were not complete enough to allow us to apply our method. This confines us to the period after 2008.

Vollrath explains that "Each of the [24] groups j thus has years of schooling s_j," – shown in Table 5[16] – "and the amount of human capital coming from education for each individual in group j is

$$\ln h_j^{Educ} = 0.10 \times S_j \qquad (1.2)$$

which says that each additional year of schooling adds 10% to the stock of human capital of an individual."[17] Next, we simply multiply each individual's human capital from education () by the number of members of each group and sum these totals for each state in each year. This gives us the total stock of human capital derived from education in each state from 2008 to 2023. We divide that by the total population (N) to get per capita numbers (*hEduc*) from which we can calculate the annual change, the mean rates of change for three periods — 2008-2023, 2008-2014, and 2014-2023 — and the rankings of these means, shown in Table 6.

There is, obviously, a limit on how many years an individual can spend in education just as there is on how many hours they can work in a given day. When we say that such "limits do not hold with relation to other sources of human capital growth like increased skills" arising from education, what we mean is the productive power of the skills conveyed: Because of scientific progress, the knowledge possessed by someone graduating with a bachelor's degree in engineering today will allow for greater productivity than someone graduating with the same degree in 1925. To this point, Hanushek et al's argument that using years of schooling to quantify the human capital arising from education elevates the "quantity dimension" while neglecting the important "quality dimension" is well taken.[18] However, our adaptation of Vollrath's method goes someway to linking the two. First, it does not just award points for years of attendance but also for actual attainment, such as earning a high school diploma or bachelor's degree. Second, by going beyond Hanushek et al's use of NAEP test scores administered at grade level, we can measure a greater share of the human capital arising from education (See Appendix).

Table 5
Educational Attainment

Number	Groups (j)	Years of schooling (sj)
1	No schooling completed	0
	Nursery school, preschool	1
	Kindergarten	2
	Grade 1	3
	Grade 2	4
	Grade 3	5
	Grade 4	6
	Grade 5	7
	Grade 6	8
	Grade 7	9
	Grade 8	10
	Grade 9	11
	Grade 10	12
	Grade 11	13
	12th grade - no diploma	13
2	Regular high school diploma	14
	GED or alternative credential	14
3	Some college, but less than 1 year	14
	1 or more years of college credit, no degree	15
	Associate's degree	16
4	Bachelor's degree	18
5	Master's degree	20
	Professional degree beyond a bachelor's degree	20
	Doctorate degree	23

Source: Census Bureau and Center of the American Experiment

Table 6
Change in Human Capital Derived from Education (*hEduc*)

	Mean rates			Ranks		
	2008-2023	2008-2014	2014-2023	2008-2023	2008-2014	2014-2023
Alabama	0.3%	-0.6%	0.9%	13	33	11
Alaska	-0.2%	-0.7%	0.2%	48	37	44
Arizona	0.4%	-0.7%	1.2%	3	41	2
Arkansas	0.0%	-0.7%	0.5%	39	40	31
California	0.4%	-0.3%	0.9%	4	15	13
Colorado	0.3%	-0.9%	1.0%	16	45	4
Connecticut	0.2%	-0.2%	0.6%	19	11	29
Delaware	0.1%	-0.6%	0.5%	37	32	32
Florida	0.3%	-0.4%	0.8%	11	19	19
Georgia	0.1%	-1.2%	0.9%	38	49	12
Hawaii	0.2%	-0.5%	0.7%	25	31	24
Idaho	0.2%	-0.5%	0.7%	24	29	25
Illinois	0.3%	-0.5%	0.7%	18	25	20
Indiana	0.2%	-0.4%	0.6%	22	22	28
Iowa	-0.1%	-0.1%	0.0%	46	6	47
Kansas	0.0%	-0.5%	0.4%	41	28	38
Kentucky	0.0%	-0.5%	0.3%	45	27	40
Louisiana	0.1%	-0.2%	0.3%	30	7	39
Maine	0.0%	0.2%	-0.1%	42	2	50
Maryland	0.1%	-0.4%	0.4%	34	23	35
Massachusetts	0.4%	-0.2%	0.8%	5	12	17
Michigan	0.6%	-0.2%	1.0%	1	9	3
Minnesota	0.2%	0.1%	0.2%	26	3	42
Mississippi	0.1%	-0.8%	0.7%	32	42	21
Missouri	0.2%	-0.3%	0.4%	28	14	34
Montana	0.1%	-0.6%	0.6%	36	35	30
Nebraska	0.0%	-0.2%	0.2%	40	10	43
Nevada	0.2%	-0.9%	0.9%	27	47	9
New Hampshire	0.0%	-0.2%	0.1%	44	8	45
New Jersey	0.3%	-0.6%	1.0%	9	36	5
New Mexico	0.1%	-0.9%	0.8%	31	46	15
New York	0.2%	-0.8%	0.9%	20	44	8
North Carolina	0.4%	-0.2%	0.8%	6	13	18
North Dakota	-0.2%	-0.4%	0.0%	49	21	48
Ohio	0.0%	-0.7%	0.5%	43	39	33
Oklahoma	0.3%	-0.3%	0.7%	12	16	23
Oregon	0.3%	-0.7%	1.0%	10	38	6
Pennsylvania	0.2%	-0.4%	0.6%	21	20	27
Rhode Island	0.3%	-0.5%	0.9%	8	30	10
South Carolina	0.2%	-0.1%	0.4%	23	4	36
South Dakota	-0.1%	-0.5%	0.1%	47	26	46
Tennessee	0.3%	-0.6%	0.9%	17	34	14
Texas	0.5%	0.3%	0.6%	2	1	26
Utah	0.3%	-1.2%	1.3%	14	50	1
Vermont	0.1%	-0.1%	0.3%	33	5	41
Virginia	0.3%	-0.4%	0.7%	15	24	22
Washington	0.1%	-1.1%	1.0%	29	48	7
West Virginia	0.3%	-0.4%	0.8%	7	18	16
Wisconsin	0.1%	-0.3%	0.4%	35	17	37
Wyoming	-0.4%	-0.8%	-0.1%	50	43	49

Source: Census Bureau, Bureau of Labor Statistics, and Center of the American Experiment

Experience (hExp)

To estimate the contribution of experience to human capital (*hExp*) we will again follow Vollrath's method with adaptations.[19]

First, we use estimates from the BLS' Local Area Unemployment Statistics[20] on the number of people *employed* in each state, in each year, and in each age group rather than the *total population* in such groups because, again, we want to measure the amount of human capital actually *applied* to the production of goods and services, not the amount *available*. And, once again, because these data give different totals for the number of people employed in each state, we use them to calculate the share of employment in each group and apportion the total number employed (E) according to those shares.[21] Second, where Vollrath has nine age groups (j) we have seven. "For each of these groups j, [we] use the mid-point range and call that x_j," shown in Table 7.

Vollrath calculates an individual's "human capital from experience in a given group" with the equation

$$\ln h_j^{Exp} = 0.05 \times x_j - 0.0007 \times x_j^2 \quad (1.3)$$

"where the negative coefficient on the squared term means that the return on experience declines as people age."[22] As with human capital from education, we simply multiply each individual's human capital from experience ($\ln h_j^{Exp}$) by the number of members of each group and sum these group totals for each state in each year. This gives us the total stock of human capital derived from experience in each state from 2008 to 2023. We divide that by the total population (N) to get per capita numbers ($hExp$) from which we can calculate the annual change for each state, the mean rates of change for three periods — 2008-2023, 2008-2014, and 2014-2023 — and the rankings of these means in Table 8.

Table 7
Experience

Per worker human capital	Groups (j)	Experience (xj)
Increasing	Total, 16 to 19 years	17.5
	Total, 20 to 24 years	22.0
	Total, 25 to 34 years	29.5
	Total, 35 to 44 years	39.5
Decreasing	Total, 45 to 54 years	49.5
	Total, 55 to 64 years	59.5
	Total, 65 years and over	65.0

Source: Bureau of Labor Statistics and Center of the American Experiment

Table 8

Change in Human Capital Derived from Experience Per Capita (*hExp*)

	Mean rates			Ranks		
	2008-2023	2008-2014	2014-2023	2008-2023	2008-2014	2014-2023
Alabama	0.0%	-0.8%	0.6%	7	15	14
Alaska	-0.4%	-1.1%	0.1%	46	35	39
Arizona	0.1%	-1.2%	0.9%	3	40	2
Arkansas	-0.3%	-1.1%	0.2%	40	33	34
California	0.1%	-0.8%	0.6%	4	13	13
Colorado	-0.1%	-1.4%	0.7%	23	47	10
Connecticut	-0.1%	-0.6%	0.2%	19	5	33
Delaware	-0.4%	-1.4%	0.2%	47	46	36
Florida	-0.1%	-0.8%	0.4%	16	16	26
Georgia	-0.3%	-1.6%	0.6%	42	50	17
Hawaii	-0.3%	-1.1%	0.3%	37	30	32
Idaho	-0.1%	-0.9%	0.5%	13	25	20
Illinois	-0.2%	-1.1%	0.5%	30	31	22
Indiana	0.0%	-0.7%	0.4%	11	9	25
Iowa	-0.3%	-0.7%	-0.1%	44	7	46
Kansas	-0.2%	-0.9%	0.4%	31	27	30
Kentucky	-0.3%	-1.0%	0.1%	45	29	38
Louisiana	-0.3%	-0.8%	0.0%	43	12	44
Maine	-0.5%	-0.9%	-0.2%	49	18	49
Maryland	-0.2%	-0.9%	0.2%	35	21	37
Massachusetts	-0.1%	-0.9%	0.5%	14	24	21
Michigan	0.2%	-0.8%	0.8%	1	10	4
Minnesota	-0.2%	-0.4%	0.0%	32	4	45
Mississippi	-0.1%	-1.2%	0.6%	20	37	15
Missouri	-0.2%	-0.9%	0.3%	28	17	31
Montana	-0.1%	-1.1%	0.5%	27	36	19
Nebraska	-0.2%	-0.6%	0.0%	36	6	41
Nevada	-0.1%	-1.2%	0.5%	26	38	18
New Hampshire	-0.4%	-0.9%	-0.2%	48	19	48
New Jersey	-0.1%	-1.3%	0.8%	12	44	8
New Mexico	-0.2%	-1.5%	0.8%	29	49	6
New York	-0.1%	-1.3%	0.7%	21	43	12
North Carolina	-0.1%	-0.8%	0.4%	17	14	27
North Dakota	-0.2%	-0.4%	-0.1%	33	2	47
Ohio	-0.3%	-1.2%	0.4%	38	39	29
Oklahoma	0.0%	-0.8%	0.6%	8	11	16
Oregon	0.1%	-1.2%	0.9%	5	42	3
Pennsylvania	-0.1%	-0.9%	0.4%	18	22	23
Rhode Island	0.0%	-1.1%	0.8%	9	32	7
South Carolina	-0.1%	-0.4%	0.0%	25	3	42
South Dakota	-0.3%	-0.7%	0.0%	39	8	43
Tennessee	-0.1%	-1.2%	0.7%	15	41	11
Texas	0.1%	-0.2%	0.4%	2	1	28
Utah	0.0%	-1.4%	1.0%	6	45	1
Vermont	-0.3%	-0.9%	0.1%	41	26	40
Virginia	-0.1%	-1.0%	0.4%	24	28	24
Washington	-0.1%	-1.5%	0.8%	22	48	5
West Virginia	0.0%	-1.1%	0.7%	10	34	9
Wisconsin	-0.2%	-0.9%	0.2%	34	23	35
Wyoming	-0.5%	-0.9%	-0.3%	50	20	50

Source: Census Bureau, Bureau of Labor Statistics, and Center of the American Experiment

Adding it up (h)

Adapting Vollrath's method once again,[23] we can use our estimates for each state in a given year of the total number of people employed (*E*), average number of hours worked annually (*hours*), per capita skills arising from education (*hEduc*), and per capita skills arising from experience (*hExp*) to generate an estimate of the total human capital stock in each state in each year (*H*). "[B]ecause what we care about in the end is the production of real *GDP p*er cap*ita,"* Vollrath writes, "what really matters to us is the stock of human capital per capita," (*h*).[24] We find this with the equation

$$h = \frac{E \times hours \times h^{\text{Educ}} \times h^{\text{Exp}}}{N} \qquad (1.4)$$

where *N* is the total population.[25] This gives us the stock of human capital per capita in each state from 2008 to 2023 from which we can calculate the annual change for each state, the mean rates of change for three periods — 2008-2023, 2008-2014, and 2014-2023 — and the rankings of these means in Table 9.

Table 9
Change in Human Capital Stocks Per Capita (*h*)

	Mean rates			Ranks		
	2008-2023	2008-2014	2014-2023	2008-2023	2008-2014	2014-2023
Alabama	0.3%	-2.4%	2.1%	25	33	20
Alaska	-0.9%	-2.5%	0.1%	49	37	45
Arizona	1.1%	-3.0%	3.8%	4	44	2
Arkansas	0.1%	-2.8%	2.1%	32	40	21
California	1.3%	-1.1%	3.0%	2	10	7
Colorado	0.2%	-3.1%	2.3%	30	46	17
Connecticut	0.2%	-1.3%	1.2%	29	14	35
Delaware	-0.6%	-2.9%	1.0%	47	42	36
Florida	0.8%	-1.8%	2.5%	7	22	13
Georgia	0.2%	-3.4%	2.6%	27	47	10
Hawaii	0.6%	-1.9%	2.3%	16	25	18
Idaho	0.4%	-2.7%	2.4%	20	38	16
Illinois	0.6%	-1.6%	2.1%	15	16	23
Indiana	0.7%	-1.0%	1.8%	12	9	27
Iowa	-0.1%	-0.5%	0.1%	39	5	46
Kansas	-0.4%	-2.3%	0.8%	43	30	39
Kentucky	-0.2%	-2.9%	1.6%	40	41	30
Louisiana	0.1%	-0.9%	0.7%	35	7	40
Maine	-0.3%	-1.2%	0.3%	42	12	44
Maryland	-0.5%	-2.5%	0.8%	45	36	38
Massachusetts	0.7%	-1.6%	2.3%	10	18	19
Michigan	1.7%	-0.3%	3.1%	1	3	4
Minnesota	0.1%	-0.4%	0.4%	34	4	42
Mississippi	0.2%	-2.5%	2.0%	28	34	24
Missouri	0.0%	-1.9%	1.3%	37	23	34
Montana	0.3%	-2.1%	2.0%	22	27	25
Nebraska	-0.7%	-1.6%	-0.1%	48	21	48
Nevada	0.8%	-4.7%	4.4%	9	50	1
New Hampshire	0.0%	-0.8%	0.5%	38	6	41
New Jersey	0.6%	-3.0%	3.0%	14	43	5
New Mexico	-0.2%	-4.3%	2.5%	41	49	14
New York	1.0%	-2.1%	3.0%	5	28	6
North Carolina	0.8%	-1.6%	2.4%	6	17	15
North Dakota	0.4%	3.1%	-1.4%	21	1	50
Ohio	0.2%	-1.6%	1.3%	31	19	32
Oklahoma	0.3%	-1.2%	1.3%	24	13	33
Oregon	0.8%	-2.4%	2.9%	8	32	8
Pennsylvania	0.5%	-1.6%	1.9%	18	20	26
Rhode Island	0.7%	-2.3%	2.6%	13	29	11
South Carolina	0.3%	-1.5%	1.5%	23	15	31
South Dakota	-0.4%	-0.9%	-0.1%	44	8	47
Tennessee	0.6%	-2.4%	2.6%	17	31	12
Texas	1.2%	0.4%	1.8%	3	2	28
Utah	0.7%	-3.1%	3.2%	11	45	3
Vermont	-0.6%	-2.0%	0.4%	46	26	43
Virginia	0.0%	-2.5%	1.7%	36	35	29
Washington	0.3%	-3.6%	2.9%	26	48	9
West Virginia	0.5%	-1.9%	2.1%	19	24	22
Wisconsin	0.1%	-1.2%	1.0%	33	11	37
Wyoming	-1.9%	-2.8%	-1.3%	50	39	49

Source: Center of the American Experiment

Physical capital (K)

Our second source of real per capita GDP growth is physical capital (*K*).[26]

"Physical capital," Howitt and Weil write:

> …is made up of tools, machines, buildings, and infrastructure such as roads and ports. Its key characteristics are, first, that it is produced (via investment), and second that it is in turn used in producing output.[27]

Vollrath notes that physical capital "consists not only of the stock of physical assets like buildings and machines but also but also of intellectual property like software."[28]

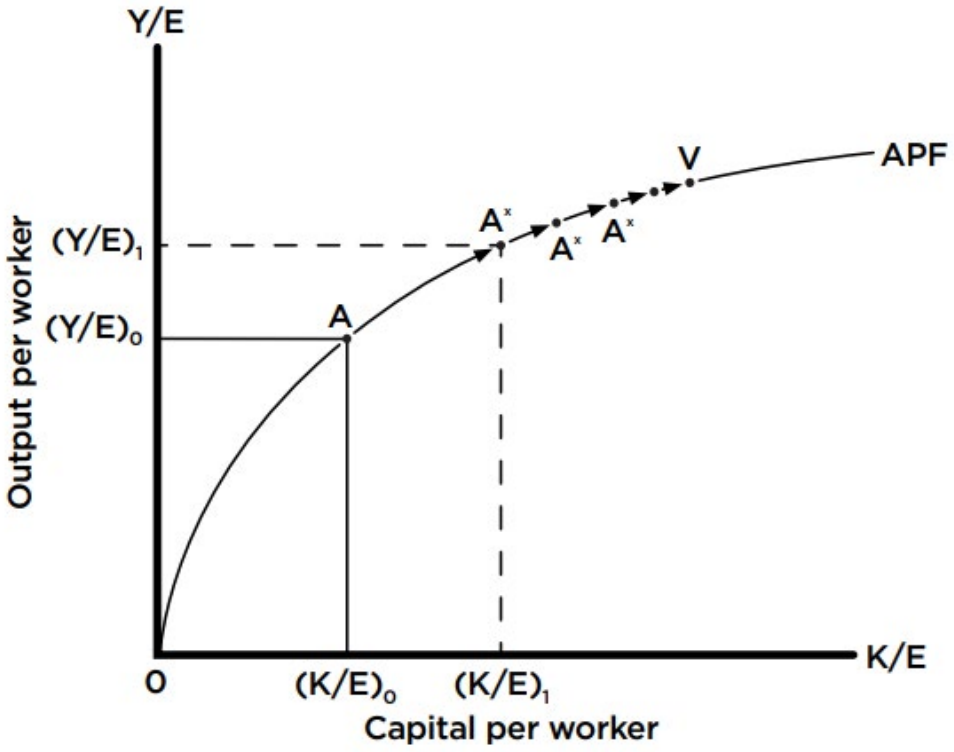
In the neoclassical model, capital deepening — an increase in the amount of capital per worker — is one of the drivers of economic growth. But, as with increases in the share of the population employed or the average hours worked, there are limits.

As Figure 6 illustrates, as the amount of capital per worker increases from $(K/E)_0$ to $(K/E)_1$, the amount of output per worker increases from $(Y/E)_0$ to $(Y/E)_1$.

To see how this works, imagine an economy with 100 people, 80 of whom are employed working an average of 2,000 hours annually, and producing 20 units of output per hour. Total GDP in this economy is 3,200,000 units annually, and per capita GDP is 32,000 units (Scenario 4 in Table 2 and Table 10). Now imagine that, thanks to an increased amount of capital, each worker can produce 30 units of output per hour. In this case, total GDP is 4,800,000 units annually and per capita GDP is 48,000 units (Scenario 5 in Table 10).

Figure 6

Economic Growth Through Capital Deepening



Source: Samuelson and Nordhaus

Table 10
Effects of Increased Physical Capital on Per Capita GDP

Scenario	Population (N)	Employed (E)	Average hours worked annually (hours)	Average output per hour (hEduc , hExp, k)	Annual output per worker (Y/E)	Total annual output (Y)	Annual output per capita (y)
4	100	80	2,000	20	40,000	3,200,000	32,000
5	100	80	2,000	30	60,000	4,800,000	48,000
6	100	80	2,000	35	70,000	5,600,000	56,000

Source: Center of the American Experiment

However, Samuelson and Nordhaus write:

> As capital deepens, diminishing returns set in, so the rate of return on capital and the real interest rate fall. (The slope of the curve in [Figure 6] is the marginal product of capital, which is seen to fall as capital deepening occurs.) Also, because each worker can work with more capital, workers' marginal productivities rise and the real wage also rises.

As the marginal product of capital declines so, too, do increases in capital per worker. A rise in capital per worker from A' to A'' or from A'' to A''' brings ever smaller increases in output per worker. In Table 10, imagine that for the same increase in capital per worker from Scenario 4 to Scenario 5, the average output per hour does not rise by the previous 10 units but only by five, from 30 to 35. Total GDP in this economy is 5,600,000 units annually and per capita GDP is 56,000 units (Scenario 6 in Table 10), but the same increase of capital per worker increased per capita output by 8,000 units from Scenario 5 to Scenario 6 as opposed to the increase of 16,000 units from Scenario 4 to Scenario 5. Eventually, at the point V in Figure 6, "the capital-labor ratio stops growing." "In the long run," Samuelson and Nordhaus write, "the economy will enter a steady state in which capital deepening ceases, real wages stop growing, and capital returns and real interest rates are constant." Nevertheless, Samuelson and Nordhaus write that "the capital-accumulation model is a first step on the road to understanding economic growth."[29]

There is no official data on capital stocks at the state level. The YES database provides estimates of state capital stocks from 1947 to 2021 in constant 2009 U.S. dollars,[30] but the Bureau of Economic Analysis (BEA) no longer publishes the estimates of net stocks and depreciation of private nonresidential fixed assets by industry which we would require to replicate El-Shagi and Yamarik's method and extend their estimates beyond 2021.

We can do something similar if we add together the BEA's estimates of the Historical-Cost Net Stocks of Private Equipment, Private Fixed Assets, IP Products, and Private Structures, adjusting each for inflation using the relevant Chain-Type Quantity Indexes,[31] to produce an estimate of the total capital stock by industry in each year ($K_i(t)$) (as the estimates are net stocks, we do not need to calculate a net investment rate). El-Shagi and Yamarik use each state's share of total United States earnings in each industry to apportion the national capital stock in that industry among the states. However, state earnings as a share of national earnings can be somewhat volatile. The Real Estate and Rental and Leasing sector, for example, accounted for an average of 43.4 percent of the total physical capital stock of the United States from 2008 to 2023 and Minnesota's share of the national earnings in this sector have a Coefficient of Variation over the period 1998 to 2023 three times higher (0.007) than that for the state's share of GDP in that sector (0.002). Given that investments in physical capital typically have some lead time, we use the more stable series, GDP, rather than earnings to apportion our estimate of the total capital stock by in-

As the marginal product of capital declines so, too, do increases in capital per worker.

dustry in each year between the states. Our method assumes a constant relationship between GDP and the physical capital stock across the states, but this seems less "heroic" than an assumption of a constant relationship between earnings and the capital stock (See Appendix).

To apportion the United States' total physical capital stock between the states, we use this equation adapted from El-Shagi and Yamarik

$$k_{i,j}(t) = \left[\frac{gdp_{i,j}(t)}{GDP_i(t)}\right] K_i(t) \qquad (1.5)$$

"where the subscript i represents the two-digit industry, j denotes the state, and t represents the year. The lowercase $[gdp]_{i,j}$ refers to state-level [GDP] in industry i, while the uppercase $[GDP]_i$ and K_i denote national [GDP] and capital in industry i, respectively."[32] We can sum the resulting estimates of the capital stock in each industry in each state in each year ($k_{i,j}(t)$) to derive the total capital stock in each state (K). Because we are investigating the impact of physical capital growth on *per capita* GDP growth, as with human capital, we divide our estimate of physical capital by state for each year by the population to generate an estimate of physical capital per capita (k) and their annual rates of change. Table 11 shows the mean rates of annual change for three periods — 2008-2023, 2008-2014, and 2014-2023 — and the ranks of these means.

Table 11
Change in Physical Capital Stocks Per Capita (*k*)

	Mean rates			Ranks		
	2008-2023	2008-2014	2014-2023	2008-2023	2008-2014	2014-2023
Alabama	1.4%	0.4%	2.0%	29	39	20
Alaska	-0.1%	1.0%	-0.9%	50	26	50
Arizona	1.8%	-0.4%	3.2%	16	46	4
Arkansas	1.4%	1.4%	1.4%	27	14	35
California	2.2%	1.0%	3.0%	7	25	5
Colorado	1.7%	0.7%	2.4%	18	34	12
Connecticut	0.3%	-1.4%	1.5%	48	49	32
Delaware	0.8%	-0.6%	1.8%	44	47	26
Florida	1.7%	-0.9%	3.3%	21	48	2
Georgia	1.8%	0.5%	2.6%	14	35	10
Hawaii	0.9%	0.4%	1.3%	41	40	36
Idaho	1.8%	0.9%	2.4%	17	27	16
Illinois	1.7%	1.3%	2.0%	20	19	19
Indiana	1.3%	1.2%	1.3%	33	20	38
Iowa	1.3%	1.7%	1.1%	31	11	40
Kansas	1.9%	0.5%	2.8%	11	37	6
Kentucky	1.5%	1.3%	1.6%	25	17	29
Louisiana	0.9%	1.4%	0.6%	42	15	45
Maine	1.8%	0.5%	2.7%	12	36	9
Maryland	0.9%	0.7%	1.1%	39	33	39
Massachusetts	1.8%	0.8%	2.4%	15	31	13
Michigan	1.7%	1.5%	1.9%	19	12	23
Minnesota	1.2%	1.0%	1.3%	34	24	37
Mississippi	1.6%	1.1%	1.9%	22	22	21
Missouri	1.1%	0.5%	1.5%	38	38	31
Montana	1.4%	2.0%	1.0%	26	6	41
Nebraska	2.4%	2.7%	2.2%	5	5	17
Nevada	0.6%	-1.7%	2.1%	47	50	18
New Hampshire	1.3%	0.8%	1.6%	32	28	28
New Jersey	0.7%	-0.4%	1.5%	45	45	34
New Mexico	1.6%	1.7%	1.5%	23	8	33
New York	2.1%	1.7%	2.4%	8	10	14
North Carolina	1.1%	0.1%	1.8%	37	42	25
North Dakota	4.2%	10.8%	-0.2%	1	1	48
Ohio	1.4%	1.1%	1.6%	28	23	30
Oklahoma	1.1%	3.7%	-0.6%	36	2	49
Oregon	1.5%	0.0%	2.6%	24	43	11
Pennsylvania	1.4%	1.8%	1.0%	30	7	42
Rhode Island	0.9%	0.8%	0.9%	43	29	44
South Carolina	1.9%	1.2%	2.4%	10	21	15
South Dakota	1.8%	1.7%	1.9%	13	9	24
Tennessee	1.9%	0.7%	2.7%	9	32	8
Texas	2.3%	2.9%	1.9%	6	4	22
Utah	2.6%	0.8%	3.8%	3	30	1
Vermont	0.7%	1.3%	0.2%	46	18	46
Virginia	0.9%	-0.1%	1.7%	40	44	27
Washington	2.5%	1.4%	3.2%	4	13	3
West Virginia	3.0%	3.3%	2.8%	2	3	7
Wisconsin	1.2%	1.3%	1.0%	35	16	43
Wyoming	0.2%	0.2%	0.2%	49	41	47

Source: Bureau of Economic Analysis and Center of the American Experiment

Total Factor Productivity (TFP)

Our third source of real per capita GDP growth is Total Factor Productivity (*TFP*).[33]

What is TFP?

Jones and Vollrath write:

> …in the Solow model [Figure 6]…sustained growth occurs only in the presence of technological progress. Without technological progress, capital accumulation runs into diminishing returns. With technological progress, however, improvements in technology continually offset the diminishing returns to capital accumulation. Labor productivity grows as a result, both directly because of the improvements in technology and indirectly because of the additional capital accumulation these improvements make possible.[34]

This is captured in Figure 7. "In this diagram," Samuelson and Nordhaus write:

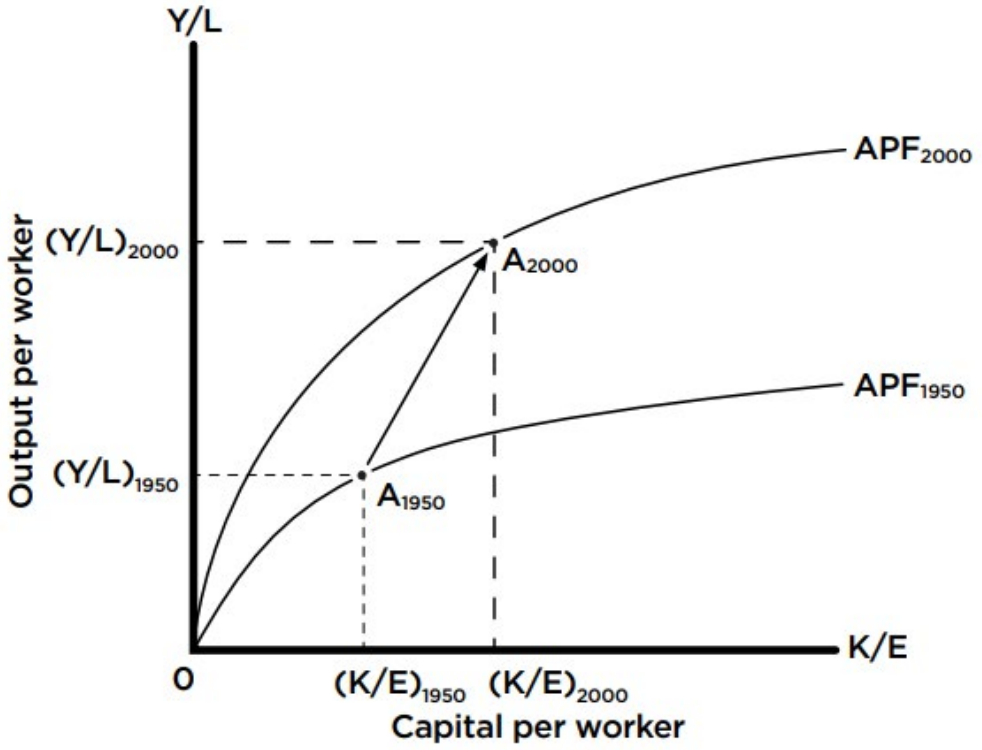
> …we show the aggregate production function for both 1950 and 2000. Because of technological change, the aggregate production function has shifted upward from APF_{1950} to APF_{2000}. This upward shift shows the advances in productivity that are generated by the vast array of new processes and products like electronics, Internet commerce, advances in metallurgy, improved medical technologies and so forth.[35]

The phrases "technological progress" and "technology" should not be misunderstood. "In the economics of growth and development," Jones and Vollrath write, "the term 'technology' has a very specific meaning: *technology* is the way inputs to the production process are turned into output." "Ideas improve the technology of production," they write, offering the example of the changing use of tin through history, from its use in "weapons, armor, and household items like plates and cups" in the Bronze Age to its use today in the production of "the touch screen on smartphones." But "[i]deas are by no means limited to feats of engineering," they note, "Sam Walton's creation of the Wal-Mart approach to retailing is no less an idea than advances in semiconductor technology."[36] As Comin explains:

> Total factor productivity (TFP) is the portion of output not explained by the amount of inputs used in production. As such, its level is determined by how efficiently and intensely the inputs are utilized in production.[37]

In Figure 7, the increase in capital per worker from $(K/E)_{1950}$ to $(K/E)_{2000}$ is not responsible for the entire increase in output per worker from $(Y/E)_{1950}$ to $(Y/E)_{2000}$. There is some source of the observed changes in per capita incomes seen in Table 1 besides the accumulation of inputs like labor and capital seen in Tables 9 and 11. This is Total Factor Productivity.

Figure 7
Economic Growth Through Technological Progress



Source: Samuelson and Nordhaus

Growth accounting

While we can measure more or less directly the number of people employed or the stock of physical capital, we cannot do so with TFP. Economists use a technique called "growth accounting" to measure it indirectly. This technique, Caselli writes:

> …consists of a set of calculations resulting in a measure of output growth, a measure of input growth, and their difference, most commonly referred to as total factor productivity (TFP) growth.[38]

"To identify the growth of total factor productivity in a short time interval," Metcalfe writes, "one need only subtract from the growth of output the growth in total factor input, itself a factor-price-weighted sum of the growth rates of the individual inputs."[39] The following equation adapted from Vollrath captures this

$$g_y^{Tfp} = g_y - g_y^{Cap} = g_y - \varepsilon_K g_k - \varepsilon_H g_h \quad (1.6)$$

where the growth rate of TFP (g_y^{TFP}) equals the growth in per capita GDP (g_y seen in Table 1) minus the per capita growth rate of the weighted sum of human and physical capital inputs (g_y^{Cap}). This, in turn, equals the elasticity of real GDP with respect to physical capital (ε_K) multiplied by the real per capita growth in physical capital (g_k, shown in Table 11) minus the elasticity of real GDP with respect to human capital (ε_H) multiplied by the real per capita growth in human capital (g_h, shown in Table 9).[40]

The next question is what numbers we will use for elasticities of real GDP with respect to human and physical capital. Where *constant* returns to scale are assumed, so that if all the inputs are doubled output will exactly double, these sum to 1.[41] But whereas a unit of labor or physical capital is *rivalrous* in

that your employment of it precludes mine, this is not the case for ideas. "The fact that Toyota takes advantage of just-in-time inventory methods does not preclude GM from taking advantage of the same technique," Jones and Vollrath write: "ideas are *nonrivalrous*." From this we get *increasing* returns to scale, where a doubling of all inputs increases output by *more than* double. "For example," Jones and Vollrath write:

Some share of national income must be paid to the generators of ideas besides that paid to the owners of human or physical capital.

> …once Steve Jobs and Steve Wozniak invented the plans for assembling personal computers, those plans ("the idea") did not need to be invented again. To double the production of personal computers, Jobs and Wozniak needed only to double the number of integrated circuits, semiconductors, and so on, and find a larger garage. That is, the production function exhibits constant returns to scale with respect to the capital and labor inputs, and therefore must exhibit increasing returns with respect to all three inputs: if you double capital, labor, and the stock of ideas, then you will more than double output.[42]

Generating ideas has a cost, and a return is required to cover that cost. Because of this, some share of national income must be paid to the generators of ideas besides that paid to the owners of human or physical capital. As a result, the elasticities of human and physical capital must sum to <1. Estimates of these elasticities vary, but we will use 0.325 as the elasticity of real GDP with respect to physical capital (ε_K) and 0.3 for the elasticity of real GDP with respect to human capital (ε_H).[43]

The results of our growth accounting exercise are shown in Table 12. Having calculated annual rates of change, we see the mean rates of change for three periods — 2008-2023, 2008-2014, and 2014-2023 — and the rankings of these means.

We now have estimates of the contributions to real per capita GDP growth from the three sources identified previously — human capital, physical capital, and TFP — for all 50 states for the 15-year period from 2008 to 2023. We can use these estimates to investigate why some states have performed relatively well and others relatively poorly.

Table 12
Change in Total Factor Productivity (*TFP*)

	Mean rates			Ranks		
	2008-2023	2008-2014	2014-2023	2008-2023	2008-2014	2014-2023
Alabama	0.3%	0.4%	0.2%	36	35	37
Alaska	0.5%	0.4%	0.5%	29	34	22
Arizona	0.3%	0.2%	0.3%	37	42	29
Arkansas	0.6%	1.0%	0.3%	23	13	31
California	1.2%	0.9%	1.4%	4	22	2
Colorado	1.1%	1.1%	1.1%	5	8	5
Connecticut	-0.1%	-0.5%	0.2%	48	48	34
Delaware	0.1%	2.2%	-1.3%	43	2	50
Florida	0.4%	0.0%	0.7%	33	47	13
Georgia	0.7%	1.1%	0.4%	21	11	27
Hawaii	0.0%	0.2%	-0.1%	46	40	48
Idaho	0.4%	0.2%	0.6%	34	41	19
Illinois	0.4%	0.9%	0.1%	32	18	40
Indiana	0.5%	0.6%	0.5%	27	31	23
Iowa	0.8%	1.0%	0.6%	12	14	16
Kansas	0.7%	0.7%	0.7%	16	29	10
Kentucky	0.5%	0.8%	0.2%	31	25	35
Louisiana	-0.2%	-0.5%	0.1%	50	49	41
Maine	0.7%	0.0%	1.2%	14	45	4
Maryland	0.8%	1.1%	0.6%	11	7	18
Massachusetts	0.8%	1.1%	0.7%	9	9	14
Michigan	0.2%	0.5%	0.0%	39	32	43
Minnesota	0.6%	0.6%	0.5%	24	30	20
Mississippi	0.0%	0.1%	0.0%	47	43	46
Missouri	0.4%	0.4%	0.4%	35	37	24
Montana	0.5%	0.7%	0.4%	26	26	26
Nebraska	1.3%	1.2%	1.4%	2	5	3
Nevada	0.1%	0.3%	-0.1%	44	39	47
New Hampshire	1.0%	1.0%	1.0%	6	16	6
New Jersey	0.2%	0.4%	0.0%	41	36	44
New Mexico	0.7%	0.7%	0.7%	20	27	15
New York	0.9%	1.9%	0.3%	7	3	32
North Carolina	0.1%	0.0%	0.2%	42	46	38
North Dakota	1.2%	3.0%	0.1%	3	1	42
Ohio	0.7%	1.2%	0.4%	15	6	28
Oklahoma	0.7%	1.0%	0.5%	17	15	21
Oregon	0.9%	0.9%	0.8%	8	20	7
Pennsylvania	0.5%	0.9%	0.2%	30	21	33
Rhode Island	0.2%	0.9%	-0.2%	40	17	49
South Carolina	0.2%	0.3%	0.2%	38	38	36
South Dakota	0.5%	1.1%	0.1%	28	12	39
Tennessee	0.7%	1.1%	0.4%	19	10	25
Texas	0.7%	0.5%	0.8%	22	33	8
Utah	0.8%	0.9%	0.8%	10	19	9
Vermont	0.8%	0.9%	0.7%	13	23	11
Virginia	0.7%	0.7%	0.7%	18	28	12
Washington	1.5%	1.5%	1.5%	1	4	1
West Virginia	0.0%	0.1%	0.0%	45	44	45
Wisconsin	0.5%	0.8%	0.3%	25	24	30
Wyoming	-0.1%	-1.2%	0.6%	49	50	17

Source: Center of the American Experiment

Using the numbers: Explaining Minnesota's relative slowdown

With our estimates of the components of per capita GDP growth for the 50 states from 2008 to 2023, we can investigate why Minnesota's mean per capita GDP growth rate rose from 0.8 percent annually in 2008-2014 to 1.1 percent in 2014-2023 while falling from a ranking of 17th fastest to 37th out of 50 states, eroding the "premium" for living in the state which we saw in Figure 1.

Table 13 shows the results of our growth accounting exercise for Minnesota for three periods: 2008-2023, 2008-2014, and 2014-2023. For comparison, it also contains Vollrath's estimates for the United States for the overlapping period 2006-2016.[44] It shows the mean growth rates of per capita GDP growth taken from Table 1 in Column 1; the mean rates of per capita human capital growth taken from Table 9 and weighted by 0.3 in Column 2; the mean rate of per capita physical capital growth taken from Table 11 and weighted by 0.325 in Column 3; and the mean rate of per capita TFP growth taken from Table 12 in Column 4.[45] Columns 5, 6, 7, and 8 show how Minnesota's rates rank among the 50 states.

The ranking of Minnesota's mean per capita GDP growth fell from 17th in 2008-2014 to 37th in 2014-2023.

The first row shows us that over the period 2008 to 2023, increases in human capital accounted for just 3.4 percent of Minnesota's average annual per capita GDP growth, increases in physical capital accounted for 39.1 percent, and TFP 57.5 percent.

Looking at the two shorter periods, Column 1 shows the increase in the mean per capita GDP growth rate from 0.8 percent annually in 2008-2014 to 1.1 percent in 2014-2023 as seen in Figure 3, an improvement of 0.3 percentage points. This increase was driven by improvements in the per capita growth rates of human capital — from a mean rate of decline of -0.1 percent annually to growth of 0.1 percent shown in Column 2, contributing 0.2 percentage points — and physical capital — from a mean rate of growth of 0.3 percent annually to 0.4 percent, shown in Column 3, contributing 0.1 percentage points. As Column 4 shows, the mean annual growth rate of TFP fell between our two periods, reducing the mean per capita rate of GDP growth in 2014-2023 by 0.1 percentage points.

But, as we have seen, even with this increase in the mean per capita GDP growth rate, Figure 4 and Column 5 show that the ranking of Minnesota's mean per capita GDP growth fell from 17th in 2008-2014 to 37th in 2014-2023. To understand Minnesota's *relative* slowdown, we need to compare it to other states. As Column 8 in Table 13 shows, while Minnesota's mean per capita TFP growth declined slightly, its ranking rose from 30th to 20th out of 50 states. For both human (Column 6) and physical (Column 7) capital, however, while the rates of growth increased, the rankings fell from 4th to 42nd and 24th to 37th, respectively.

Table 13
Growth Accounting for Minnesota

Columns	1	2	3	4	5	6	7	8
	Mean rates, %				Mean rates, rank			
Time period	GDP (Table 1)	Human capital (Table 9, weighted)	Physical capital (Table 11, weighted)	Total Factor Productivity (Table 12)	GDP (Table 1)	Human capital (Table 9)	Physical capital (Table 11)	Total Factor Productivity (Table 12)
2008-2023	1.0	0.0	0.4	0.6	31	34	34	24
2008-2014	0.8	-0.1	0.3	0.6	17	4	24	30
2014-2023	1.1	0.1	0.4	0.5	37	42	37	20
2006-2016	0.6	-0.2	0.1	0.6	-	-	-	-

Source: Center of the American Experiment

What explains these changes in rates and rankings? We can use the data that underpin our estimates of human and physical capital to examine more closely the causes of the decline in Minnesota's relative performance in real per capita GDP growth.

Human capital

Using the numbers in Tables 4, 6, and 8, as well as the ratio of the total employed to the population (*E*/*N*), Table 14 breaks down the *unweighted* mean rates of per capita human capital growth (g_h) in the three periods (Table 9) into the shares derived from each component using the equation (adapted from Vollrath)

$$g_h = g_{E/N} + g_{hours} + g_{Educ} + g_{Exp} \quad (2.1)$$

where $g_{E/N}$ is the growth rate of the share of the population employed, g_{hours} is the growth rate of the average annual hours worked, g_{Educ} is the growth rate of human capital arising from education, and g_{Exp} is the growth rate of human capital arising from experience.[46]

The first row shows us that over the long period 2008 to 2023, per capita increases in human capital arising from education accounted for all of Minnesota's average annual growth of per capita human capital while that arising from experience declined, slowing the rate of growth. Looking at the two shorter periods, Column 1 shows that the mean annual per capita growth rate of human capital increased by 0.8 percentage points, from -0.4 percent decline in 2008-2014 to 0.4 percent growth in 2014-2023. Column 6 shows that, at the same time, this rate's ranking fell from 4th out of 50 states to 42nd.

Employment

Column 2 shows that an increase in the mean annual rate of change of the share of Minnesota's population employed — the employment ratio — from -0.1 percent in the period 2008-2014 to 0.1 percent in the period 2014-2023 contributed 0.2 percentage points to the increase of 0.5 percentage points in the mean rate of growth of human capital overall. Column 7 shows, however, that while the employment ratio fell on average in Minnesota in 2008-2014, it still fared better than most states, ranking 2nd out of 50 states, while the better performance in 2014-2023 only scored a rank of 43rd.

The steepest falls in employment ratios among age groups since 2000 are found among those aged 16-19 and 20-24.

This may be largely due to the fact that Minnesota already has a relatively large share of its population employed. As Figure 8 shows, Minnesota has one of the highest employment ratios in the United States. Its average ratio across the years 2008 to 2014 — 51.7 percent — ranked 7th out of 50 states and across the years 2015 to 2023, its ratio — 52.3 percent — ranked 3rd out of 50. This has long been the case. Figure 9 shows the employment ratio in Minnesota, calculated both as above, using the entire population, and using the civilian non-institutional population, which is "Persons 16

Table 14
Growth Accounting for Minnesota, Human Capital

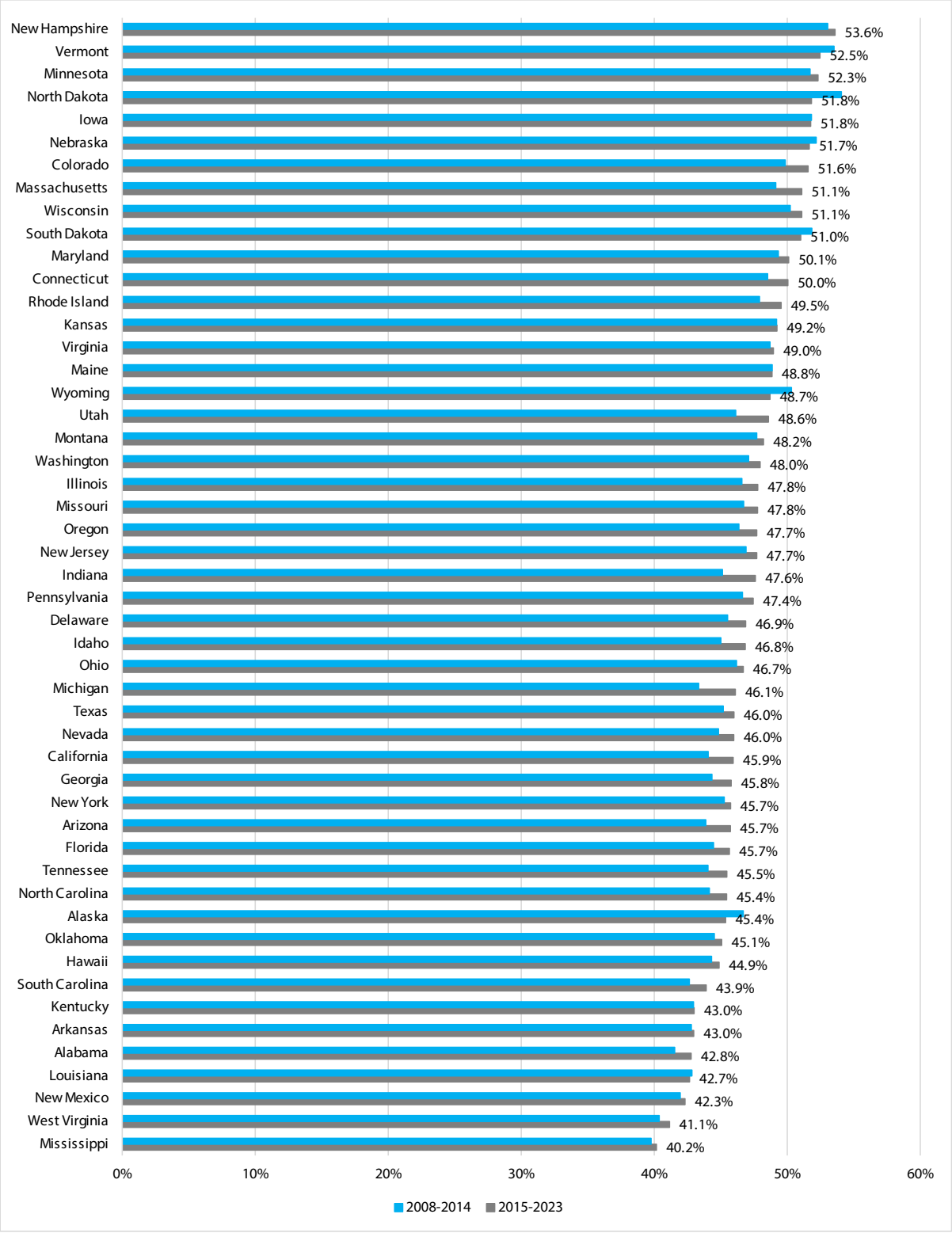
Columns	1	2	3	4	5	6	7	8	9	10
	Mean rates, %					Mean rates, rank				
Time period	Human capital (Table 9)	Employment / Population	Hours (Table 4)	Education (Table 6)	Experience (Table 8)	Human capital (Table 9)	Employment / Population	Hours (Table 4)	Education (Table 6)	Experience (Table 8)
2008-2023	0.1	0.0	0.0	0.2	-0.2	34	27	27	26	32
2008-2014	-0.4	-0.1	0.0	0.1	-0.4	4	2	27	3	4
2014-2023	0.4	0.1	0.0	0.2	0.0	42	43	20	42	45

Source: Center of the American Experiment

years of age and older residing in the 50 states and the District of Columbia, who are not inmates of institutions (e.g., penal and mental facilities, homes for the aged), and who are not on active duty in the Armed Forces."[47] It also includes the rank of the latter among the 50 states going back to 1976. Minnesota's employment ratio has ranked in the top 10 every year since 1977. Given its relatively high employment ratio, there is less potential for Minnesota to generate faster per capita GDP growth from this source than in most other states, so a relatively low ranking is unsurprising.

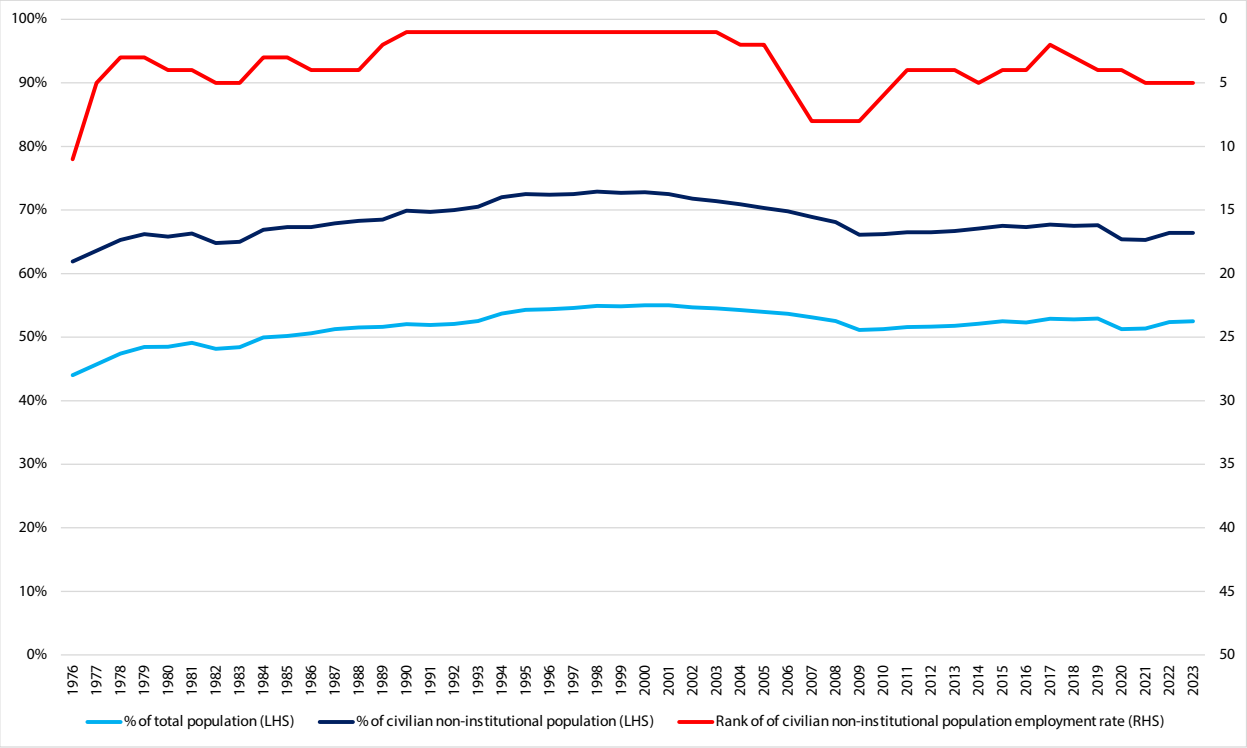
This is not to say that there is no scope at all, however. Figure 9 shows that, as a share of the civilian non-institutional population, Minnesota's employment ratio peaked at 72.9 percent in 1998 but had fallen by 6.5 percentage points to 66.4 percent in 2023. While this is often attributed to the aging of the workforce, Figure 10 shows that the steepest falls in employment ratios among age groups since 2000 (the solid bars) are found among those aged 16-19 and 20-24, down 5.3 and 6.0 percentage points respectively. If the employment ratios among these younger groups could be raised back to their levels of 2000, 37,000 more young Minnesotans would be employed, and per capita GDP would be higher.

Figure 8
Average Employment Ratios



Source: Bureau of Labor Statistics, Census Bureau, and Center of the American Experiment

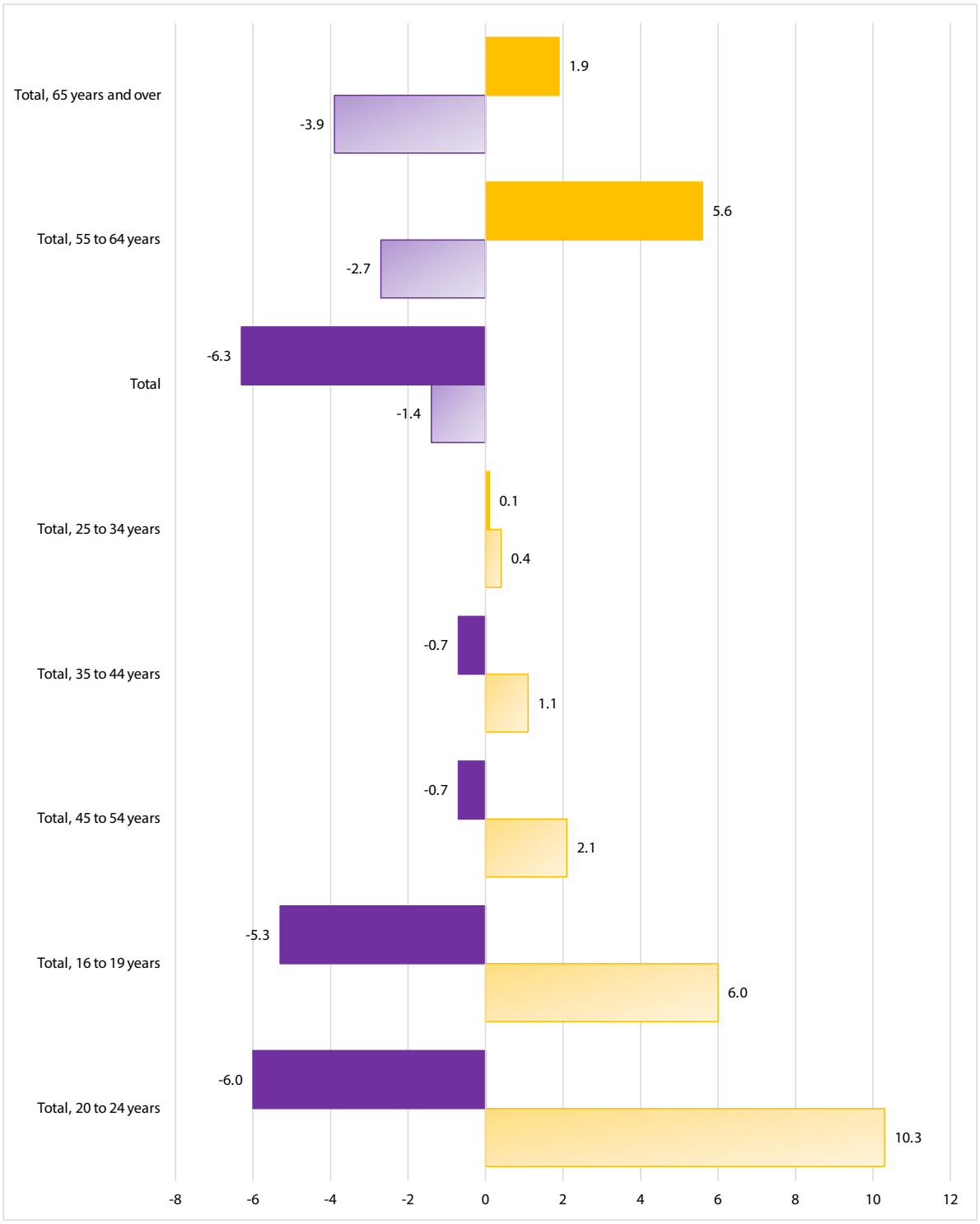
Figure 9
Minnesota's Employment Ratios and Rank



Source: Bureau of Labor Statistics, Census Bureau, and Center of the American Experiment

Figure 10

Change in Employment Ratios in Minnesota, 1999 to 2023 (solid) and 2018 to 2023 (shaded)



Source: Bureau of Labor Statistics, Census Bureau, and Center of the American Experiment

Skills

Per capita levels of human capital applied to the production of goods and services arising from either education or experience can increase for two reasons: First, if the share of the population working increases, assuming the new workers have *some* level of education or experience; second, if the average level of skills arising from education or experience which *each worker* possesses increases. While we are primarily concerned with per capita numbers in this report as that is the standard measure of economic welfare, the importance of *per worker* numbers should not be forgotten. As Krugman writes:

> Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker.[48]

Once again, the data underlying our estimates of the human capital arising from education and experience allow us to dig deeper for the sources of Minnesota's relative growth slowdown.

Education

Table 15 breaks down the mean annual growth rates of the per capita stock of human capital arising from education in Minnesota (g_{Educ}) into the shares arising from either a change in the number of people employed (g_E), a change in each individual worker's average human capital arising from education ($g_{Educ/E}$), or a change in the population () using the equation

$$g_{Educ} = g_E + g_{Educ/E} - g_N \qquad (2.2)$$

We see that over the long period 2008-2023, Minnesota's per capita stock of human capital derived from education increased by 0.2 percent annually, on average. Both population and employment increased at the same average annual rate over this period — 0.6 percent — so all that growth came from increases in the stock *per worker*. The average annual growth rate of both employment and *per worker* human capital arising from education held steady over all three periods, at 0.6 percent and 0.2 percent respectively. This means that the increase in the *per capita* growth rate of human capital from 2008-2014 to 2014-2023 was driven entirely by a decline in the rate of population growth.

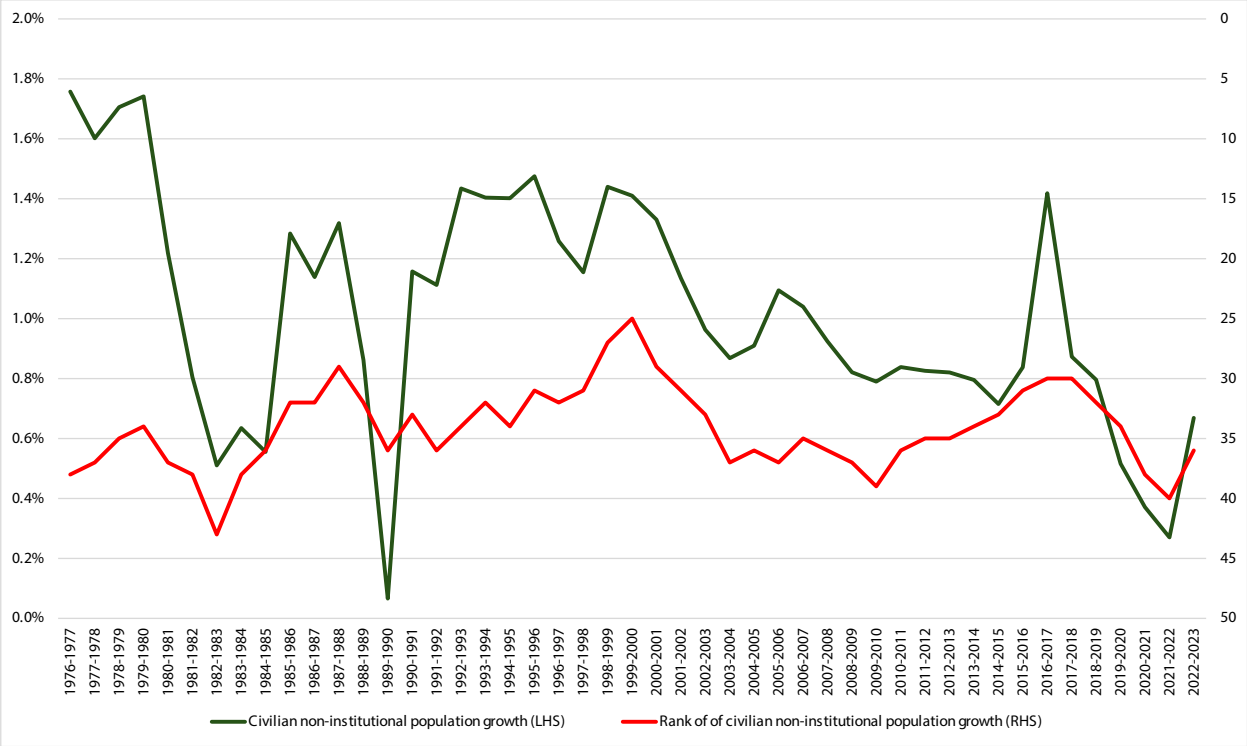
While the rate of employment growth may not have varied, its ranking did. Column 6 shows that Minnesota's average annual rate of employment growth fell from 5th out of 50 states in 2008-2014 to 29th in 2014-2023. Given what we have seen about high employment ratios, this must mean that the growth rate of the civilian non-institutional population — the labor force — must have been similarly slow. Indeed, Figure 11 shows that Minnesota's rate of labor force growth slowed at the turn of the century, from an annual average of 1.2 percent for the period 1976 to 1998 to 0.9 percent since. This, however, is a nationwide phenomenon and the ranking of Minnesota's labor force growth rate has changed little from the period before 2000 — when it peaked for the United States — to that after it.

Table 15
Growth Accounting for Minnesota, Human Capital from Education

Columns	1	2	3	4	5	6	7	8
	Mean rates, %				Mean rates, rank			
Time period	Human capital from education per capita (Tables 6, 14)	Employment (Table 3)	Human capital from education per worker	Population (N)	Human capital from education per capita (Tables 6, 14)	Employment (Table 3)	Human capital from education per worker	Population (N)
2008-2023	0.2	0.6	0.2	0.6	23	23	30	21
2008-2014	0.1	0.6	0.2	0.7	4	5	28	28
2014-2023	0.2	0.6	0.2	0.5	28	29	30	18

Source: Center of the American Experiment

Figure 11
Labor Force Growth in Minnesota



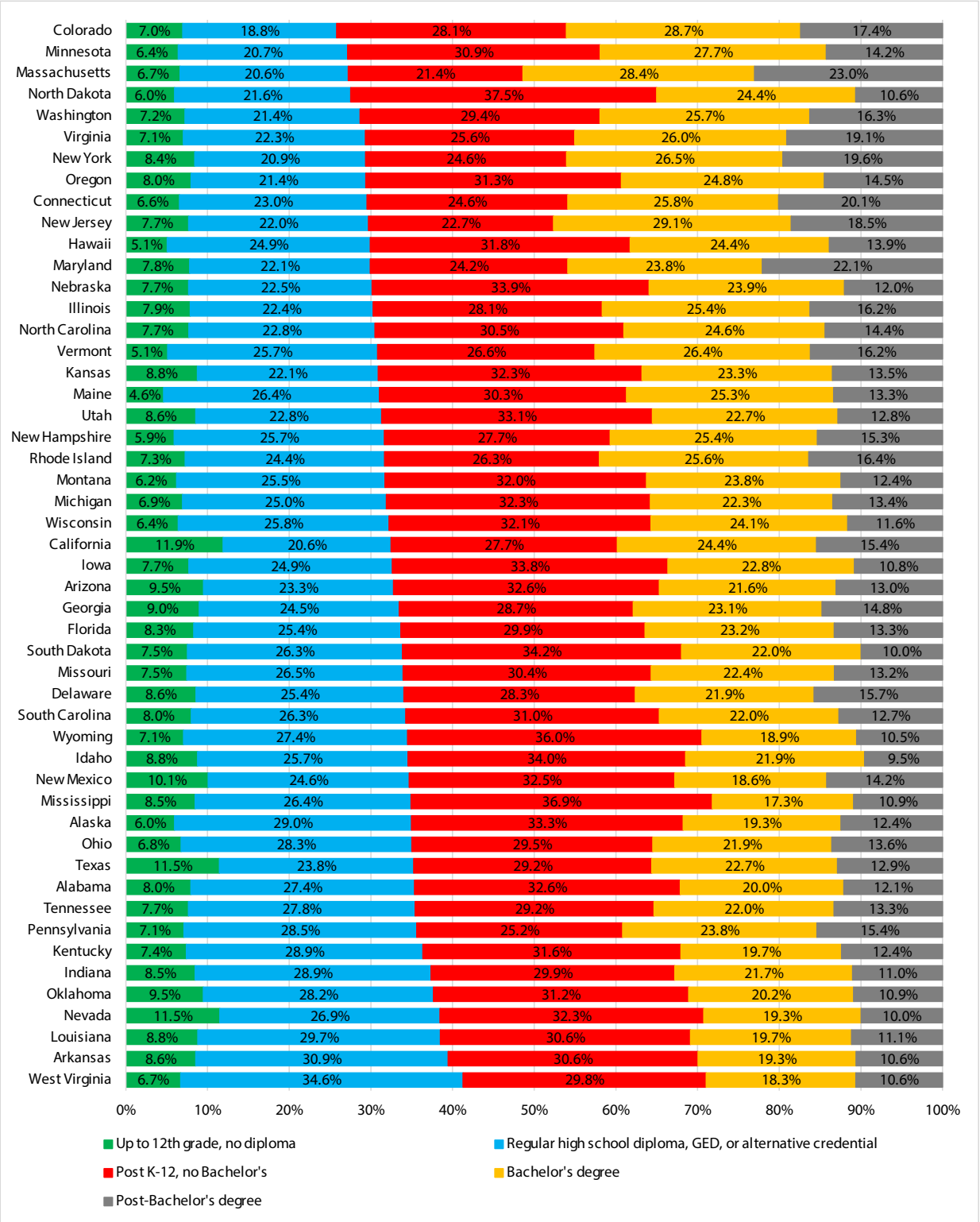
Source: Bureau of Labor Statistics, Census Bureau, and Center of the American Experiment

Column 7 shows that the ranking of the rate of growth of human capital arising from education *per worker* changed little between the two short periods. The ranking for population growth, on the other hand, improved from 28th to 18th, despite the rate slowing.

The ranking of Minnesota's labor force growth rate has changed little from the period before 2000 — when it peaked for the United States.

We noted above that our method might fail to record increases in the human capital arising from education beyond a certain level. In 2023, for example, 72.8 percent of Minnesota's workforce was educated beyond a regular high school diploma, GED, or alternative credential (Numbers 3, 4, and 5 in Table 5), the second highest share in the United States as Figure 12 shows. It might not be possible to increase this much further. The key question is whether the 20.7 percent of Minnesota's 2023 workforce which had a regular high school diploma, GED, or alternative credential (Number 2 in Table 5), for example, are more skilled than the 22.2 percent of the state's 2014 workforce who were similarly educated. This, again, raises the need for a qualitative element.

Figure 12
Workforce by Educational Attainment, 2023



Source: Census Bureau and Center of the American Experiment

Experience

Table 16 breaks down the mean annual growth rates of the per capita stock of human capital arising from experience in Minnesota (g_{Exp}) into the shares arising from either a change in the number of people employed (g_E), a change in the amount of human capital arising from experience which each individual worker possesses ($g_{Exp/E}$), and a change in the total population () using the equation

$$g_{Educ} = g_E + g_{Educ/E} - g_N \quad (2.3)$$

Table 16 shows, again, that total employment grew at an average annual rate of 0.6 percent in Minnesota over our three periods. Over the long period 2008-2023, this matched the average annual growth rate of the population so all the change in the *per capita* stock of human capital arising from experience came from changes in the *per worker* stock. The average annual growth rate of human capital arising from experience per capita improved by 0.4 percentage points from 2008-2014 to 2014-2023, rising from a decline of -0.4 percent to no change at all. This was split equally between a 0.2 percentage point improvement in the average annual growth rate of human capital *per worker* — from a decline of -0.3 percent to -0.1 percent — and a decline in the average annual rate of population growth, from 0.7 percent to 0.5 percent.[49]

Why might *per worker* human capital arising from experience fall and why might that fall either slow, as in Minnesota, or rise? As we noted above, our measure of human capital *per worker* has it increasing in each of the four categories in Table 7 up to and including "Total, 35 to 44 years;" after that, it declines in each category as workers get set in their ways and their experience becomes a negative. An increasing share of the workforce aged over 45 would lead to a lower average level of human capital arising from experience.

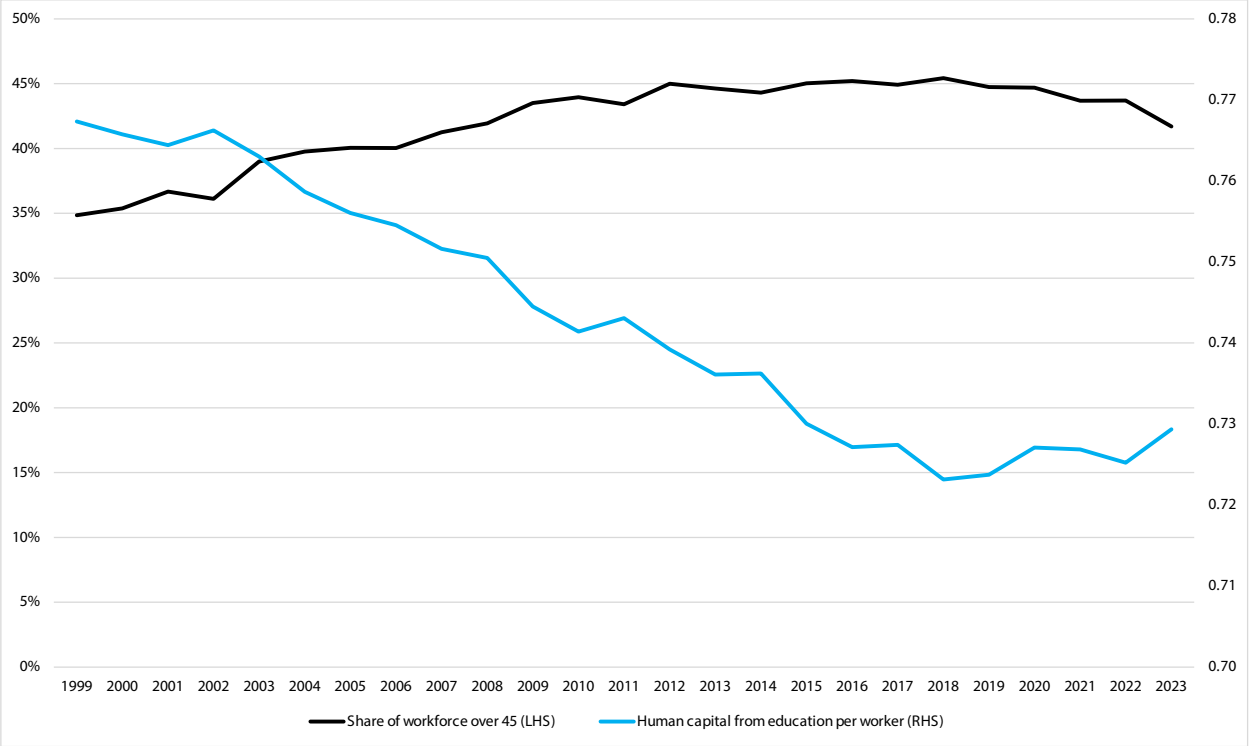
This is what we see in Figure 13. From 1999 to 2018, the share of Minnesota's workforce aged 45 or over rose by 10.6 percentage points, from 34.8 percent to 45.4 percent, and human capital arising from experience *per worker* fell by 5.8 percent as a result. Since 2018, however, the share of Minnesota's workforce aged 45 or over fell to 41.7 percent and human capital arising from experience *per worker* rose by 0.9 percent. Minnesota's improved rate of change for human capital arising from experience is a result of its workforce getting younger, on average, since 2018, thanks to increases in the employment ratios of age groups under 55 and declines in those above, seen in the shaded bars in Figure 10.

Table 16
Growth Accounting for Minnesota, Human Capital from Experience

Columns	1	2	3	4	5	6	7	8
	Mean rates, %				Mean rates, rank			
Time period	Human capital from experience per capita (Tables 8, 14)	Employment (Table 3)	Human capital from experience per worker	Population (N)	Human capital from experience per capita (Tables 8, 14)	Employment (Table 3)	Human capital from experience per worker	Population (N)
2008-2023	-0.2	0.6	-0.2	0.6	32	23	34	21
2008-2014	-0.4	0.6	-0.3	0.7	4	5	26	28
2014-2023	0.0	0.6	-0.1	0.5	45	29	31	18

Source: Center of the American Experiment

Figure 13
Employment and Human Capital Arising from Experience in Minnesota



Source: Bureau of Labor Statistics, Census Bureau, and Center of the American Experiment

Physical capital

Table 11 shows that the (unweighted) average per capita growth for physical capital in Minnesota rose from 1.0 percent annually in 2008-2014 to 1.3 percent in 2014-2023. What accounts for this?

As our measure of human capital has four components, growth in our measure of physical capital () can be broken down between the 19 NAICS two□digit industries using the equation

$$g_k = \sum_{i=1}^{19} gk_{i,j}(t) \qquad (2.4)$$

where *i* represents the 19 NAICS two-digit industries. Figure 14 shows the per capita growth in Minnesota's physical capital stock from 2008 to 2014 ($10,307) and for 2014 to 2023 ($21,662) broken down into that arising from each of the 19 NAICS two-digit industries. We see that growth in the per capita physical capital stock in the Real Estate and Rental and Leasing sector was $314 from 2008 to 2014 and $12,707 between 2014 and 2023. While it accounted for 3.0 percent of total growth in Minnesota's per capita physical capital stock in the former period, this rose to 58.7 percent in the latter.

This, the Bureau of Labor Statistics explains, "is part of the financial activities supersector:"

> The Real Estate and Rental and Leasing sector comprises establishments primarily engaged in renting, leasing, or otherwise allowing the use of tangible or intangible assets, and establishments providing related services. The major portion of this sector comprises establishments that rent, lease, or otherwise allow the use of their own assets by others. The assets may be tangible, as is the case of real estate

and equipment, or intangible, as is the case with patents and trademarks.

This sector also includes establishments primarily engaged in managing real estate for others, selling, renting and/or buying real estate for others, and appraising real estate. These activities are closely related to this sector's main activity, and it was felt that from a production basis they would best be included here. In addition, a substantial proportion of property management is self-performed by lessors.

The main components of this sector are the real estate lessors industries (including equity real estate investment trusts (REITs)); equipment lessors industries (including motor vehicles, computers, and consumer goods); and lessors of nonfinancial intangible assets (except copyrighted works).[50]

The increase in the mean rate of growth in this sector — by 1.8 percentage points from 2008-2014 to 2014-2023 — is not the largest, but this sector accounts for by far the greatest share of Minnesota's physical capital stock: 44.1 percent in 2008 and 41.7 percent in 2014. This is not unusual. In the years 2008 to 2023, this sector accounted for an average of 43.4 percent of the total physical capital stock of the United States. This increased growth rate in such a major sector was the primary driver of the increased overall growth rate in Minnesota's per capita stock of physical capital between the two periods 2008-2014 and 2014-2023.

But Table 11 also shows that the ranking of Minnesota's per capita physical capital growth fell from 24th out of 50 states in 2008-2014 to 37th in 2014-2023. What accounts for this?

Table 17 shows that the ranking of the growth rate in Minnesota's per capita stock of physical capital fell in 12 of the 19 NAICS industries between the periods 2008-2014 and 2014-2023, including Manufacturing, Information, Health Care and Social Assistance, Utilities, and Finance and Insurance – which accounted for the 2nd, 3rd, 4th, 5th, and 6th largest average shares of the state's total capital stock between 2008 and 2023 between them. In seven of these industries, their growth rankings fell while their rate of growth accelerated: Here it is the case that per capita growth rates of physical capital improved in Minnesota, but not by as much as in other states. In four industries, both the ranking and the rate of growth declined. One of these was Manufacturing, in which the average annual rate of growth of per capita physical capital fell by 2.7 percentage points, from 2.5 percent in 2008-2014 to a decline of -0.2 percent in 2014-2023. Manufacturing accounts for the second largest share of Minnesota's total physical capital stock, an average of 13.7 percent in 2008-2023. To understand how important the decline in the growth of physical capital in this sector is, Table 17 multiplies the percentage point change in each industry's growth rates by the average share of Minnesota's total capital physical capital stock. For Manufacturing, this "index" is -0.4, the largest in magnitude after Real Estate and Rental and Leasing and the main drag on the state's rate of per capita physical capital growth between the two periods.

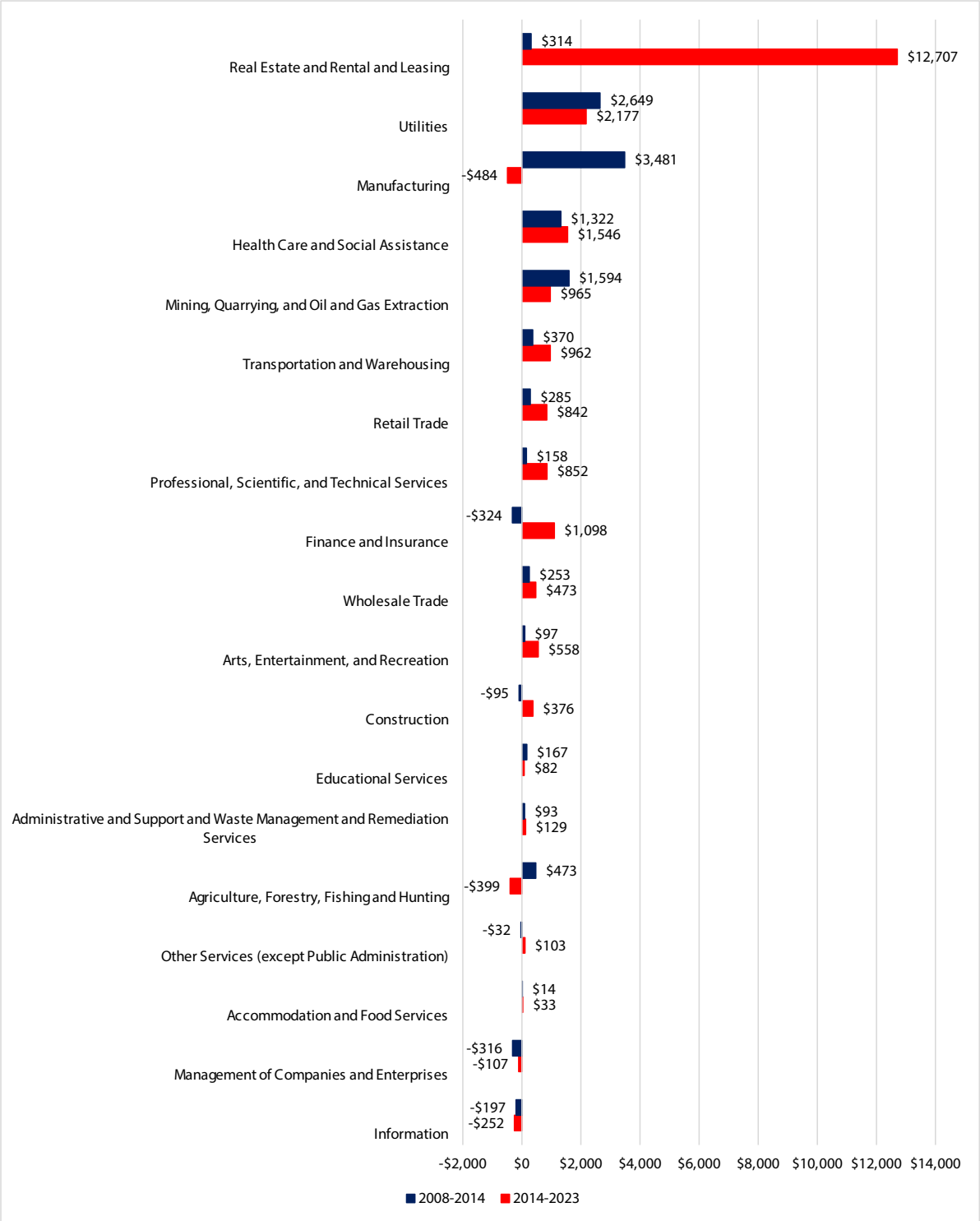
Our method of calculating the physical capital stocks in each state uses the GDP of each industry in each state as a share of the GDP of the industry for the United States as a whole to apportion the overall physical capital stock of the United States in each industry to each industry in each state. It follows that a decline in Minnesota's per capita physical capital stock in the Manufacturing sector could come from either a decline in the per capita physical capital stock in that sector for the United States generally or a decline in Minnesota's share of national output in that sector.

The decline of Minnesota's per capita physical capital stock in the Manufacturing sector was not the result of a decline at the national level. Figure 15 shows the average annual growth rate of the per capita physical capital stock in Manufacturing in three periods for both Minnesota and the United States. We see that the national rate was largely unchanged between the two periods 2008-2014 and 2014-2023 — 1.5 percent and 1.6 percent respectively — but that in Minnesota it slumped from a rate of 2.5 percent annual growth in 2008-2014 to an annual rate of decline of -0.2 percent in 2014-2023.

This must mean that the per capita decline in Minnesota's stock of physical capital in the Manufacturing sector in 2014-2023 was driven by a decline in the state's share of the United States' output in that industry. Figure 16 shows that this was the case. The state's share of national Manufacturing

Figure 14

Change in Minnesota's Per Capita Physical Capital Stock by Industry, 2017$



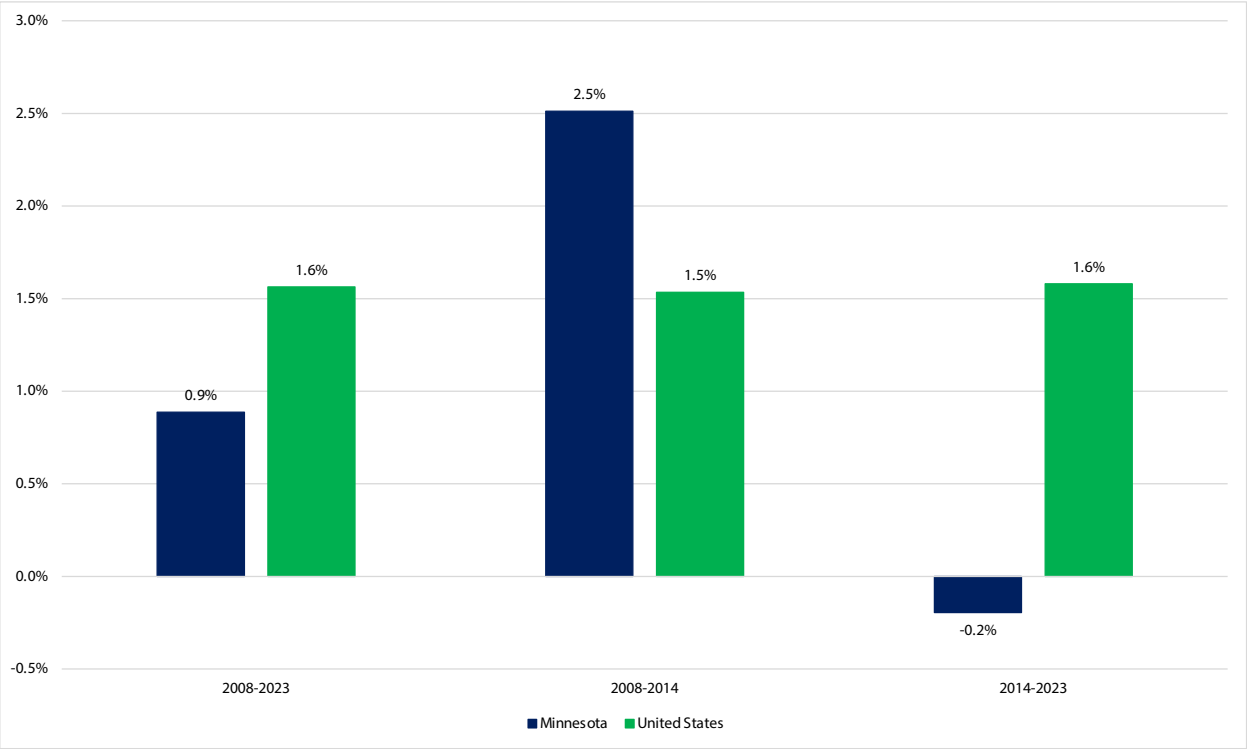
Source: Bureau of Economic Analysis and Center of the American Experiment

Table 17
Physical Capital Stocks in Minnesota

ode	NAICS industry	Average share of physical capital stock, 2008 to 2023	Change in rankings of per capita physical capital stock growth, 2008-2014 to 2014-2023	Change in rates of per capita physical capital stock growth, 2008-2014 to 2014-2023	Change in rates of per capita physical capital stock growth weighted by average share of physical capital stock
53	Real Estate and Rental and Leasing	42.2%	7	1.8	0.8
52	Finance and Insurance	4.5%	-17	2.2	0.1
54	Professional, Scientific, and Technical Services	2.1%	-21	1.7	0.0
23	Construction	1.0%	-2	3.0	0.0
48-49	Transportation and Warehousing	3.3%	0	0.7	0.0
71	Arts, Entertainment, and Recreation	0.9%	0	2.5	0.0
44-45	Retail Trade	3.2%	-35	0.7	0.0
55	Management of Companies and Enterprises	1.3%	23	1.7	0.0
81	Other Services (except Public Administration)	1.5%	-3	0.6	0.0
42	Wholesale Trade	2.3%	-31	0.2	0.0
51	Information	5.4%	-9	0.1	0.0
72	Accommodation and Food Services	1.3%	-5	0.1	0.0
56	Administrative and Support and Waste Management and Remediation Services	0.7%	1	-0.2	0.0
61	Educational Services	1.1%	-3	-1.1	0.0
21	Mining, Quarrying, and Oil and Gas Extraction	1.6%	1	-2.2	0.0
62	Health Care and Social Assistance	5.4%	-10	-0.9	0.0
11	Agriculture, Forestry, Fishing and Hunting	3.1%	11	-2.3	-0.1
22	Utilities	5.2%	-25	-3.5	-0.2
31-33	Manufacturing	13.7%	-35	-2.7	-0.4

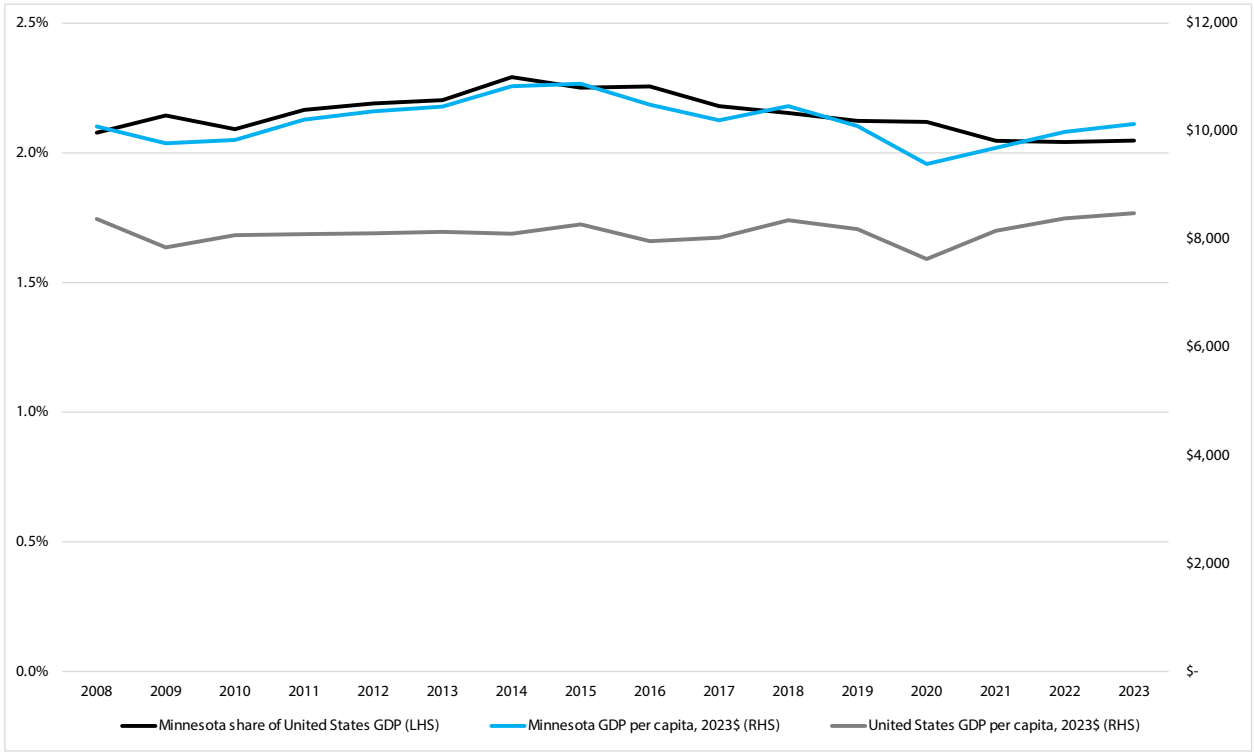
Source: Bureau of Economic Analysis and Center of the American Experiment

Figure 15
Average Annual Growth Rate of Per Capita Physical Capital Stock in the Manufacturing Sector



Source: Bureau of Economic Analysis and Center of the American Experiment

Figure 16
Manufacturing Sector GDP



Source: Bureau of Economic Analysis and Center of the American Experiment

GDP reached a post-1998 peak of 2.3 percent in 2014 but has since dropped to 2.0 percent in 2023. Neither was it the case that Minnesota's share fell because of growth in the United States' Manufacturing output. Figure 16 also shows that while Manufacturing output per capita for the United States increased by 4.7 percent from 2014 to 2023, in Minnesota, it declined by 6.5 percent.

Conclusion

Minnesota's average annual rate of per capita GDP growth was 0.3 percentage points higher in 2014-2023 than in 2008-2014. Even so, this rate's ranking fell from 17th out of 50 states to 37th.

An increased, weighted per capita average growth rate of human capital accounted for 0.2 percentage points of the increased average rate of per capita GDP growth. This, in turn, was driven by increases in the rate of growth of the employment ratio and the human capital arising from both education and experience per capita. The former was driven entirely by a decline in the rate of Minnesota's average annual population growth and the latter by, in equal parts, that decline in the rate of average annual population growth plus a fall in the rate at which human capital arising from education *per worker* was declining. For all, though, the rate of growth slipped, from a ranking of 2nd out of 50 states to 43rd for the employment ratio, 3rd to 42nd for education per capita, and 4th to 45th for experience per capita.

The employment ratio ranking reflects the fact that Minnesota has long ranked highly on this measure, so the scope for boosting per capita GDP growth by increasing this growth rate is small but not non-existent given the fall in employment ratios among younger Minnesotans. There are signs that this is reversing, however, and has driven the increase in the growth rate of human capital per worker arising from experience. If we assume that experience is something of a negative beyond a certain point as workers get "set in their

Table 18
Growth Accounting for the States

	Average per capita growth rates, 2008-2023				Ranks of per capita growth rates, 2008-2023			
	GDP	Human Capital (weighted)	Physical capital (weighted)	TFP	GDP	Human Capital	Physical capital	TFP
Alabama	0.8%	0.1%	0.4%	0.3%	37	25	29	36
Alaska	0.2%	-0.3%	0.0%	0.5%	48	49	50	29
Arizona	1.2%	0.3%	0.6%	0.3%	21	4	16	37
Arkansas	1.1%	0.0%	0.5%	0.6%	26	32	27	23
California	2.3%	0.4%	0.7%	1.2%	3	2	7	4
Colorado	1.7%	0.1%	0.6%	1.1%	8	30	18	5
Connecticut	0.1%	0.1%	0.1%	-0.1%	49	29	48	48
Delaware	0.2%	-0.2%	0.3%	0.1%	46	47	44	43
Florida	1.2%	0.2%	0.5%	0.4%	17	7	21	33
Georgia	1.3%	0.1%	0.6%	0.7%	13	27	14	21
Hawaii	0.5%	0.2%	0.3%	0.0%	44	16	41	46
Idaho	1.1%	0.1%	0.6%	0.4%	28	20	17	34
Illinois	1.2%	0.2%	0.6%	0.4%	20	15	20	32
Indiana	1.1%	0.2%	0.4%	0.5%	24	12	33	27
Iowa	1.2%	0.0%	0.4%	0.8%	22	39	31	12
Kansas	1.2%	-0.1%	0.6%	0.7%	18	43	11	16
Kentucky	0.9%	0.0%	0.5%	0.5%	36	40	25	31
Louisiana	0.2%	0.0%	0.3%	-0.2%	47	35	42	50
Maine	1.2%	-0.1%	0.6%	0.7%	16	42	12	14
Maryland	1.0%	-0.1%	0.3%	0.8%	32	45	39	11
Massachusetts	1.6%	0.2%	0.6%	0.8%	9	10	15	9
Michigan	1.3%	0.5%	0.6%	0.2%	14	1	19	39
Minnesota	1.0%	0.0%	0.4%	0.6%	31	34	34	24
Mississippi	0.6%	0.1%	0.5%	0.0%	42	28	22	47
Missouri	0.8%	0.0%	0.4%	0.4%	39	37	38	35
Montana	1.1%	0.1%	0.5%	0.5%	27	22	26	26
Nebraska	1.9%	-0.2%	0.8%	1.3%	5	48	5	2
Nevada	0.5%	0.2%	0.2%	0.1%	45	9	47	44
New Hampshire	1.4%	0.0%	0.4%	1.0%	12	38	32	6
New Jersey	0.6%	0.2%	0.2%	0.2%	43	14	45	41
New Mexico	1.1%	-0.1%	0.5%	0.7%	25	41	23	20
New York	1.9%	0.3%	0.7%	0.9%	4	5	8	7
North Carolina	0.7%	0.2%	0.4%	0.1%	40	6	37	42
North Dakota	2.7%	0.1%	1.4%	1.2%	1	21	1	3
Ohio	1.2%	0.0%	0.5%	0.7%	15	31	28	15
Oklahoma	1.2%	0.1%	0.4%	0.7%	19	24	36	17
Oregon	1.6%	0.2%	0.5%	0.9%	10	8	24	8
Pennsylvania	1.1%	0.1%	0.4%	0.5%	29	18	30	30
Rhode Island	0.7%	0.2%	0.3%	0.2%	41	13	43	40
South Carolina	1.0%	0.1%	0.6%	0.2%	34	23	10	38
South Dakota	1.0%	-0.1%	0.6%	0.5%	33	44	13	28
Tennessee	1.5%	0.2%	0.6%	0.7%	11	17	9	19
Texas	1.8%	0.4%	0.7%	0.7%	7	3	6	22
Utah	1.9%	0.2%	0.9%	0.8%	6	11	3	10
Vermont	0.8%	-0.2%	0.2%	0.8%	38	46	46	13
Virginia	1.0%	0.0%	0.3%	0.7%	30	36	40	18
Washington	2.4%	0.1%	0.8%	1.5%	2	26	4	1
West Virginia	1.1%	0.1%	1.0%	0.0%	23	19	2	45
Wisconsin	1.0%	0.0%	0.4%	0.5%	35	33	35	25
Wyoming	-0.6%	-0.6%	0.1%	-0.1%	50	50	49	49

Source: Center of the American Experiment

ways," then a declining share of older workers will, paradoxically, boost this measure. We have seen this in Minnesota since 2018. Nevertheless, the decline in the ranking suggests that other states have done a better job here.

An increase in the weighted average per capita annual growth rate of Minnesota's physical capital added a further 0.1 percentage points to the average annual growth rate of per capita GDP in the period 2014-2023. This was largely driven by an increase in the stock in the Real Estate and Rental and Leasing sector. Even so, Minnesota's growth rate fell from 24th out of 50 states in 2008-2014 to 37th in 2014-2023. The per capita decline in the physical capital stock in the Manufacturing sector — which accounts for the second largest share of the state's overall physical capital stock — was the main drag. This decline was driven by a fall in Minnesota's per capita output in this sector between 2014 and 2023.

The growth rate of TFP declined slightly between our two periods. It acted as a slight drag on the increased rate of per capita GDP growth in Minnesota from 2008-2014 to 2014-2023.

Table 18 allows us to perform a similar analysis for each of the 50 states.

Next steps

Acemoglu notes that human capital, physical capital, and TFP "are only *proximate causes* of economic growth and economic success:"

> It would not be entirely satisfactory to explain the process of economic growth and cross-country differences with technology, physical capital and human capital, since presumably there are reasons for why technology, physical capital and human capital differ across countries. In particular, if these factors are so important in generating large cross country income differences and causing the takeoff into modern economic growth, why do certain societies fail to improve their technologies, invest more in physical capital, and accumulate more human capital?[51]

The same is true for differences in rates of economic growth and levels of income, shown in Figure 17, among the states. Indeed, Hanushek et al write that:

> There are reasons to believe that the cross-state application of development accounting is more appropriate than the international application. A concern with cross-country analysis is the difficulty of applying consistent economic models across extremely diverse economies, where comparisons are made between economies that have incomes differing by a factor of 30 such as between the United States and Uganda. It is much more plausible that US states operate under a common aggregate production function. Further, the common cultural and institutional milieu across the United States eliminates major structural factors that are generally unmeasured and likely to distort cross-country analyses. Relatedly, issues of data quality across diverse countries add to these concerns. On the other hand, free movement of workers, capital, and technologies, among others, and the resulting smaller income differences within a country suggest difficulties in extracting the influence of underlying input differences from other factors entering into state income determination.[52]

Likewise, El-Shagi and Yamarik note that "U.S. states provide a ready-made setting to test macroeconomic theories of production, growth, and factor use because they possess similar institutional backgrounds, which reduces potential omitted variable bias."[53] In addition, Liu et al observe that "The United States provides a rich environment to study economic dynamics and the impact of economic policy. The diversity of statewide and regional factors and policies allows for many interesting interactions and comparisons. In addition, the commonality of national factors, along with federal fiscal and monetary policy, can potentially allow for a clear isolation of sources of difference."[54]

Our report is a contribution to this literature. Our next steps are to investigate the *ultimate causes* of these differences in rates of economic growth and levels of income among the states. In future papers, we will use our estimates of human and physical capital and TFP at the state level to measure the impact of state policies on the components of real per capita GDP growth to identify those that either boost or restrain it.

Furthermore, in the spirit of producing a "public good," Center of the American Experiment will host on its website (www.amexustables.org) a spreadsheet containing all estimates contained in this report, together with notes on sources and methodology. Modeled on the Penn World Tables, we will update these "C.A.E. United States Tables" annually as the necessary data becomes available.

As we update our estimates, we hope to improve them. Our estimates begin in the 2008-2009 financial crisis and contain the COVID-19 recession which might obscure long term trends. So, we are particularly keen to extend our estimates further into the past. We can already do this with employment and physical capital, but we do not yet have the data on hours or educational attainment which would enable us to extend our more sophisticated analysis.

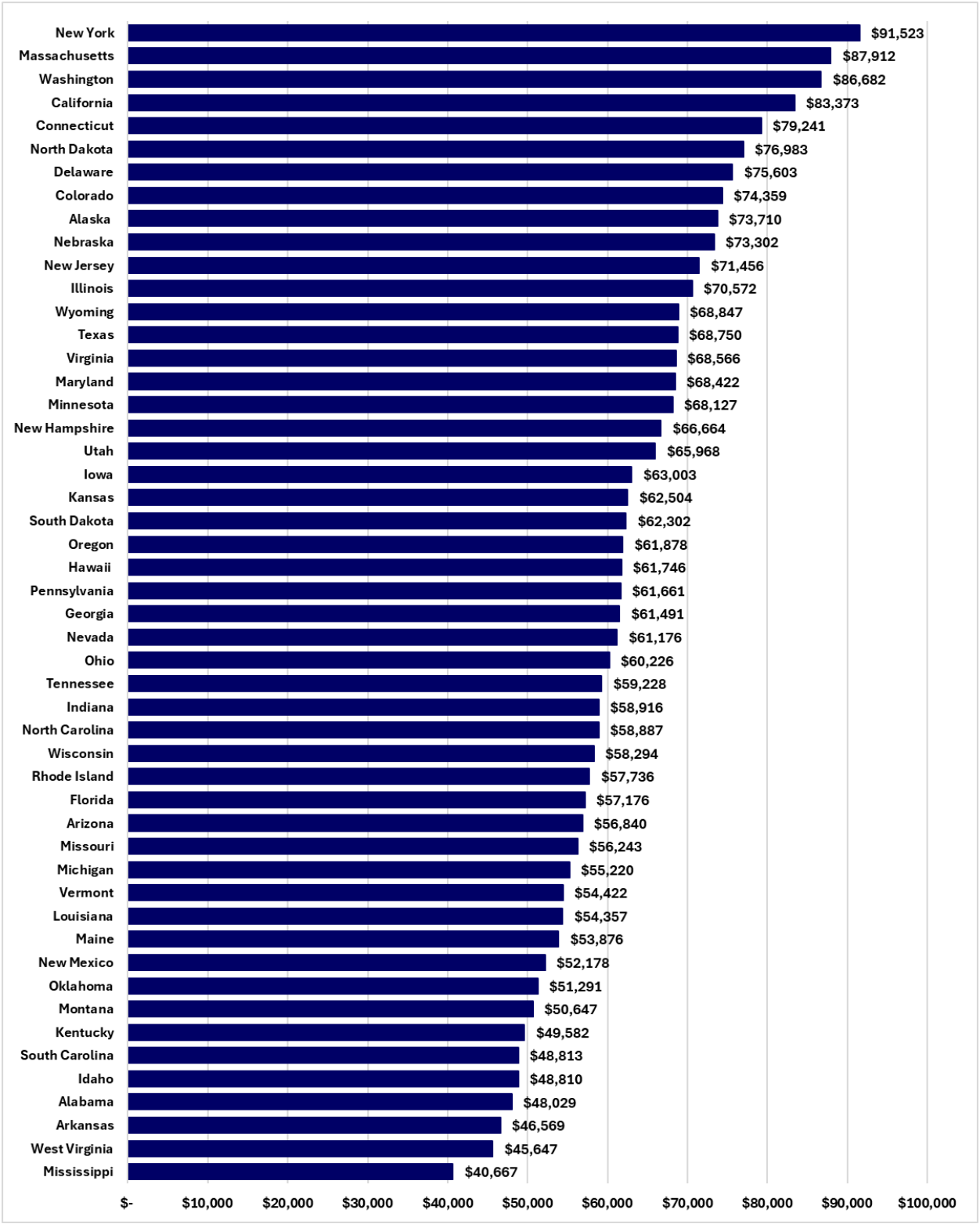
We also want to improve the estimates we have. Our measures of the human capital arising from education and experience — those components of human capital growth not subject to the constraints of diminishing returns — are themselves constrained. Once everyone has a PhD, for example, our method could not record further growth in the human capital arising from education. Likewise, the population cannot grow older in perpetuity. So at some point, our method's capacity to capture growth in human capital arising from experience will cease. The relevant questions are not, in those cases, how many PhDs or 50-year-olds are in the workforce in a given year, but whether current PhDs and 50-year-olds possess more productive knowledge than the PhDs and 50-year-olds of yesteryear. Ultimately, Hanushek et al's focus on educational quality over quantity is surely correct.

Reflecting on the differing economic growth rates between countries, such as those seen in Figure 5, and the resulting differences in income levels seen in Figure 17, Lucas wrote:

> I do not see how one can look at figures like these without seeing them as representing possibilities. Is there some action a government of India could take that would lead the Indian economy to grow like Indonesia's or Egypt's? If so, what, exactly? If not, what is it about the nature of India that makes it so? The consequences for human welfare involved in questions like these are simply staggering: Once one starts to think about them, it is hard to think about anything else.[55]

In this spirit, our work will continue. ■

Figure 17
GDP Per Capita, 2023, 2017$



Source: Bureau of Economic Analysis and Center of the American Experiment

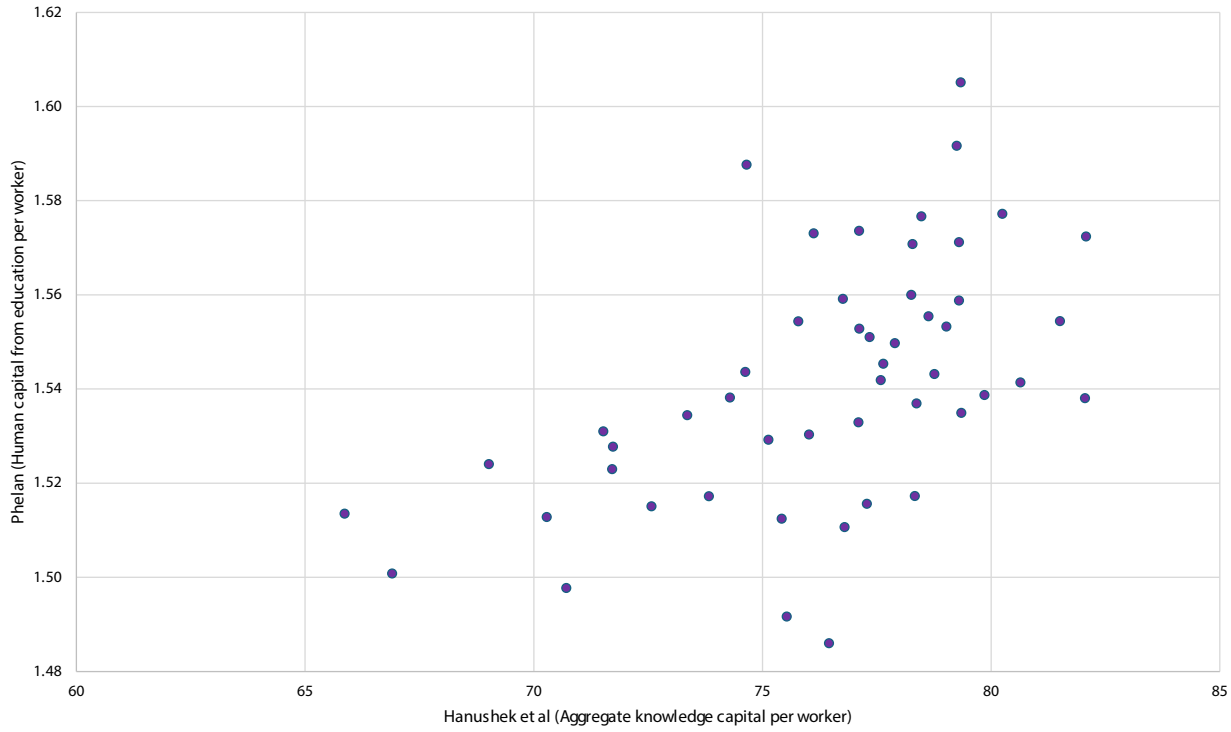
Appendix

How well do our estimates of the human capital arising from education and physical capital per capita align with previous attempts by Hanushek at al and Yamarik and E—Shagi to measure the same things?

Hanushek et al estimate "aggregate knowledge capital per worker" for each state in 2007. Figure 18 shows the relationship between this and our estimates of the human capital arising from education per worker in 2008. The correlation coefficient of 54.7 percent indicates a modest correlation between the two methods.

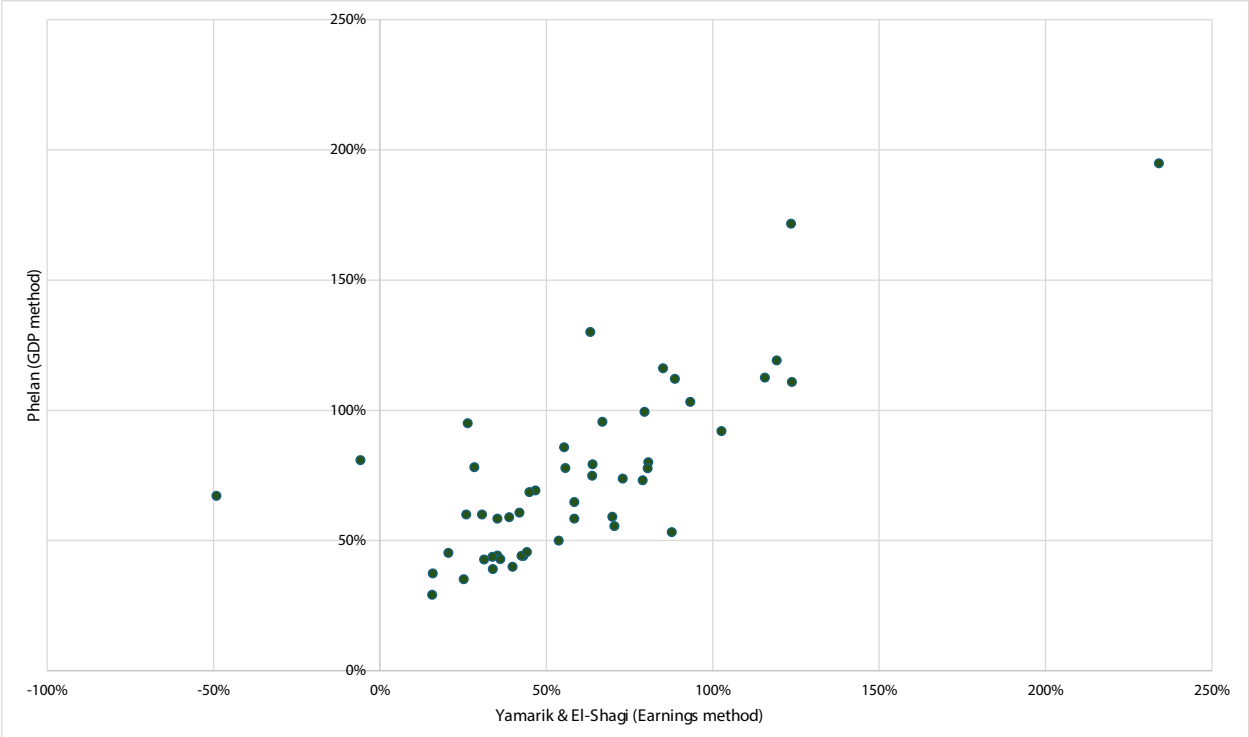
Figure 19 compares the estimates of per capita physical capital growth using Yamarik and El-Shagi's earnings method and our GDP method. The correlation coefficient of 75.6 percent indicates a strong correlation between the two methods.

Figure 18
Aggregate Knowledge Capital Per Worker, 2007, and Human Capital from Education Per Worker, 2008



Source: Center of the American Experiment

Figure 19
Real Per Capita Physical Capital Growth, 1998-2021



Source: Center of the American Experiment

Endnotes

1 Martha Njolomole and John Phelan, *The State of Minnesota's Economy: 2020: A focus on economic growth* (Center of the American Experiment, 2021): p. 3.
2 Martha Njolomole and John Phelan, *The State of Minnesota's Economy: 2020: A focus on economic growth* (Center of the American Experiment, 2021): p. 16.
3 *See* Robert J. Barro, *Notes on Growth Accounting* (National Bureau of Economic Research, 1998).
4 Dietrich Vollrath, *Fully Grown: Why a Stagnant Economy Is a Sign of Success* (University of Chicago Press, 2020): p. 157.
5 Makram El-Shagi and Steven Yamarik, "State-level capital and investment: Refinements and update," *Growth and Change*, No. 50 (2019): pp. 1411-1422.
6 David N. Weil, *Economic Growth* (Pearson, 2005): pp. 153-180.
7 George J. Borjas, *Labor Economics* (McGraw Hill Education, 2020): pp. 19-75.
8 N. Gregory Mankiw, *Principles of Microeconomics* (South-Western Cengage Learning, 2009): p. 508.
9 Dietrich Vollrath, *Fully Grown: Why a Stagnant Economy Is a Sign of Success* (University of Chicago Press, 2020): p. 30.
10 Bureau of Labor Statistics, Local Area Unemployment Statistics, Civilian Noninstitutional Population and Associated Rate and Ratio Measures for Model-Based Areas, Statewide Data, Annual Average Series, available at: https://www.bls.gov/lau/rdscnp16.htm.
11 Bureau of Labor Statistics, State and Regional Labor Productivity, available at: https://www.bls.gov/productivity/tables/.
12 Dietrich Vollrath, *Fully Grown: Why a Stagnant Economy Is a Sign of Success* (University of Chicago Press, 2020): pp. 28-30.
13 Dietrich Vollrath, *Fully Grown: Why a Stagnant Economy Is a Sign of Success* (University of Chicago Press, 2020): p. 221.
14 U.S. Census Bureau, American Community Survey, S1501 Educational Attainment, available at: https://data.census.gov/table/ACSST1Y2010.S1501?q=S1501&g=010XX00US$0400000 For all years we use the ACS 1-Year Estimates except for 2020 for which we use the ACS 5-Year Estimates.
15 Civilian employed, at work; Civilian employed, with a job but not at work; Armed forces, At Work; and Armed Forces, With a Job But Not At Work.
16 We assume that reaching 12th grade but not getting a diploma is equivalent to an 11th grade education; that a GED or alternative credential or less than one year of college is equivalent to a high school diploma; that an Associate's degree takes two years; a Bachelor's degree takes four years; a Master's degree takes two years; a Professional degree beyond a bachelor's degree takes two years; a Doctorate degree takes five years including the two years of a Master's.
17 Dietrich Vollrath, *Fully Grown: Why a Stagnant Economy Is a Sign of Success* (University of Chicago Press, 2020): p. 221.
18 Eric A. Hanushek, Jens Ruhose, and Ludger Woessmann, "Knowledge Capital and Aggregate Income Differences: Development Accounting for US States," *American Economic Journal: Macroeconomics*, Vol. 9, no. 4 (2017): pp. 184-224.
19 Dietrich Vollrath, *Fully Grown: Why a Stagnant Economy Is a Sign of Success* (University of Chicago Press, 2020): pp. 221-222.
20 Bureau of Labor Statistics, Local Area Unemployment Statistics, Expanded State Employment Status Demographic Data, available at: https://www.bls.gov/lau/ex14tables.htm.
21 Where there is one missing value for employment in one age group in the data, we simply subtract the sum of the other age groups from the total. Where there are values missing for more than one age group we perform the same calculation as before and apportion the difference to the groups based on the figures for previous and succeeding years.
22 Dietrich Vollrath, *Fully Grown: Why a Stagnant Economy Is a Sign of Success* (University of Chicago Press, 2020): pp. 221-222.
23 Dietrich Vollrath, *Fully Grown: Why a Stagnant Economy Is a Sign of Success* (University of Chicago Press, 2020): pp. 222-223.
24 Dietrich Vollrath, *Fully Grown: Why a Stagnant Economy Is a Sign of Success* (University of Chicago Press, 2020): p. 31.
25 Census Bureau estimates downloaded from the Bureau of Economic Analysis
26 David N. Weil, *Economic Growth* (Pearson, 2005): pp. 48-82.
27 Peter Howitt and David N. Weil, "economic growth," ed. Steven N. Durlauf and Lawrence E. Blume, *Economic Growth*, (Basingstoke: Palgrave, 2008): p. 40.
28 Dietrich Vollrath, *Fully Grown: Why a Stagnant Economy Is a Sign of Success* (University of Chicago Press, 2020): p. 2.
29 William D. Nordhaus and Paul A. Samuelson, *Economics* (McGraw Hill, 2010): pp. 509-510. See also Charles I. Jones and Dietrich Vollrath, *Introduction to Economic Growth* (Norton, 2013): pp. 20-36.
30 YES-Capital-Data, available at: https://cfds.henuecon.education/index.php/data/yes-capital-data.
31 Bureau of Economic Analysis, National Data, Fixed Assets Accounts Tables, Section 3 — Private Fixed Assets by Industry, available at: https://apps.bea.gov/iTable/?ReqID=10&step=2&_gl=1*f0l37h*_ga*MTY2MzcxOTQxNC4xNzI2NTE4Njcx*_ga_J4698JNNFT*MTczMzUwNzY3Mi40MC4xLjE3MzM1MDc4MjUuMzYuMC4w.
32 Makram El-Shagi and Steven Yamarik, "State-level capital and investment: Refinements and update," *Growth and Change*, No. 50 (2019): pp. 1411-1422. I am indebted to Prof. Yamarik for this suggestion.
33 David N. Weil, *Economic Growth* (Pearson, 2005): pp. 181-330.
34 Charles I. Jones and Dietrich Vollrath, *Introduction to Economic Growth* (Norton, 2013): pp. 44-45.
35 William D. Nordhaus and Paul A. Samuelson, *Economics* (McGraw Hill, 2010): pp. 510-511.
36 Charles I. Jones and Dietrich Vollrath, *Introduction to Economic Growth* (Norton, 2013): pp. 80-81.
37 Diego Comin, "total factor productivity," ed. Steven N. Durlauf and Lawrence E. Blume, *Economic Growth*, (Basingstoke: Palgrave, 2008): p. 260.
38 Francesco Caselli, "growth accounting," ed. Steven N. Durlauf and Lawrence E. Blume, *Economic Growth*, (Basingstoke: Palgrave, 2008): p. 91.
39 S. Metcalfe, "technical change," ed. Steven N. Durlauf and Lawrence E. Blume, *Economic Growth*, (Basingstoke: Palgrave, 2008): p. 245.
40 Dietrich Vollrath, *Fully Grown: Why a Stagnant Economy Is a Sign of Success* (University of Chicago Press, 2020): pp. 224-228.
41 Dietrich Vollrath, *Fully Grown: Why a Stagnant Economy Is a Sign of Success* (University of Chicago Press, 2020): pp. 42.45.
42 Charles I. Jones and Dietrich Vollrath, *Introduction to Economic Growth* (Norton, 2013): pp. 81-87, 98-100.
43 Mulholland et al. note that "input accumulation accounts for most of output growth, between three-fifths and three-quarters." See Chad Turner, Robert Tamura, and Sean E. Mulholland, "How important are human capital, physical capital and total factor productivity for determining state economic growth in the United States, 1840-2000?" *Journal of Economic Growth*, Vol. 18, no. 4 (December 2013): pp. 319-371.
44 Dietrich Vollrath, *Fully Grown: Why a Stagnant Economy Is a Sign of Success* (University of Chicago Press, 2020): p. 48.
45 Because of rounding, the sum of the values in columns 2, 3, and 4 may not exactly equal to Column 1. The same applies to Tables 14, 15, and 16.
46 Dietrich Vollrath, *Fully Grown: Why a Stagnant Economy Is a Sign of Success* (University of Chicago Press, 2020): p. 231.

47 Bureau of Labor Statistics, Current Population Survey, Methods, Concepts and Definitions (CPS), Civilian Noninstitutional Population, available at: https://webapps.dol.gov/dolfaq/go-dol-faq.asp?faqid=111&topicid=6.
48 Paul Krugman, *The Age of Diminishing Expectations* (MIT Press, 1994): p. 9.
49 The points made about employment and population regarding human capital arising from education apply here, too.
50 Bureau of Labor Statistics, Industries at a Glance, Industries by Supersector and NAICS Code, Real Estate and Rental and Leasing (NAICS 53), available at: https://www.bls.gov/iag/tgs/iag53.htm.
51 Daron Acemoglu, *Introduction to Modern Economic Growth* (Massachusetts Institute of Technology, 2007): p. 26.
52 Eric A. Hanushek, Jens Ruhose, and Ludger Woessmann, "Knowledge Capital and Aggregate Income Differences: Development Accounting for US States," *American Economic Journal: Macroeconomics*, Vol. 9, no. 4 (2017): pp. 184-224.
53 Makram El-Shagi and Steven Yamarik, "State-level capital and investment: Refinements and update," *Growth and Change*, No. 50 (2019): p. 1411.
54 Chang Liu, Joel McMurry, and Noah Williams, *Growth Accounting for the States*, (Working Paper, 2024).
55 Robert E. Lucas, "On the Mechanics of Economic Development," *Journal of Monetary Economics*, Vol. 22 (1988): pp. 3-42.

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12600 Whitewater Dr. ★ Suite 150
Minnetonka, MN 55343

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