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ENGINEERS, COMPUTER SCIENTISTS AND DATA SCIENTISTS AS DRIVERS OF ECONOMIC GROWTH

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ABOUT HEARTLAND FORWARD

Heartland Forward is a think-and-do tank dedicated to being a resource for states and local communities in the middle of the country. We do this by studying broad economic trends and building data-driven and community-tested partnerships, programs and policies to address the needs of the heartland - all while helping to change the narrative about the middle of the country and kick-starting economic growth.

The views expressed in this report are solely those of Heartland Forward.

EXECUTIVE SUMMARY

It is not surprising to acknowledge that investing in science, technology, engineering and mathematics (STEM) is important to economic growth, but it is novel to demonstrate that **doubling** the number of graduates and research at the University of Arkansas-Fayetteville, College of Engineering over the next 15 years could add $3.9 billion to Arkansas' economy. In fact, increasing engineering and computer science's share of the labor force by just 1.1 percentage points—from 2.3% to 3.4%—along with a commensurate rise in intellectual property that can be commercialized, could boost the state's gross domestic product by 1.6 percentage points and create an additional 19,000 jobs by 2038.

- These long-term economic impacts are 15 times greater than just the operations of the college.
- GDP per job added is $203,000.
- The ratio of annual GDP per job added to the cost per student is a remarkable 2.9, a rate within acceptable range for any company CEO or board of directors would gladly accept.
- Even a 50% increase in graduates and research output would generate $2.4 billion and 12,000 jobs by 2038.

The biggest annual technological and economic contributions to Arkansas begin accruing at the graduation ceremony of its universities. The diverse forms of university education are all of value, but the number of STEM (science, technology, engineering and math) graduates with bachelor's, master's or doctorate degrees, have a disproportionate contribution to economic growth across the nation and in Arkansas.

This study evaluates the channels through which the UA-F College of Engineering enhances long-term economic growth in Arkansas. Training graduates exposes them to the boundaries of advances in applied engineering and is a critical mechanism by which businesses absorb knowledge—if graduates remain in Arkansas. Research and commercialization are important components of the UA College of Engineering, but they need to be imbued into private industry to yield an economic return on the investment. Additionally, engineers often start their own business based upon discoveries in the lab.

Engineering is the most applied of all the sciences. Engineers tackle real-world challenges that provide public societal and private economic rewards. Engineers and computer scientists are analytical thinkers and problem solvers who utilize advanced quantitative decision-making methods. Engineers foster innovation and are highly creative, applying their skills in diverse occupations across multiple industries.

We developed a nationwide economic model where GDP per worker over 10 years—from 2012 to 2021—is explained by changes in the share of engineers and computer scientists in the labor force, Ph.D.s conferred in engineering/computer science per worker, university research and development per worker, and other related measures. This yielded a high degree of explanatory power (98.8% of the variation in GDP per worker) across the U.S. and Arkansas.

Data for Arkansas show that GDP per worker rose from $86,500 in 2012 to $111,600 in 2021. Activities attributable to engineering colleges represent 27.7%—or $7,000—of the total $30,100 increase in GDP per worker over our 10-year period.

- The rate of patents rose from one per 8,200 workers to one per 3,300, which is associated with an increase of $2,400 GDP per worker.
- The rate of new Ph.D.s in engineering and computer science rose from one per 36,000 workers to one per 21,300, which is associated with an additional $300 in GDP per worker.
- The engineering share of the workforce rose from 1.6% to 2.5%, which is associated with an additional $3,200 in GDP per worker.
- University research and development rose from $200 per worker to $260 per worker, which is associated with an additional $1,100 in GDP per worker.

Estimates of the individual effects of the UA-F College of Engineering were deployed through a counterfactual approach—removing the college's production from state statistics and calculating the difference in GDP per worker. The college made significant contributions to Arkansas' GDP growth by increasing the number of graduates and research funding. The three-year rolling average of bachelor's degrees awarded grew from 275 in 2011 to 623 in 2023. Research expenditures grew from $20.7 million in 2014 to $43.9 million in 2023.

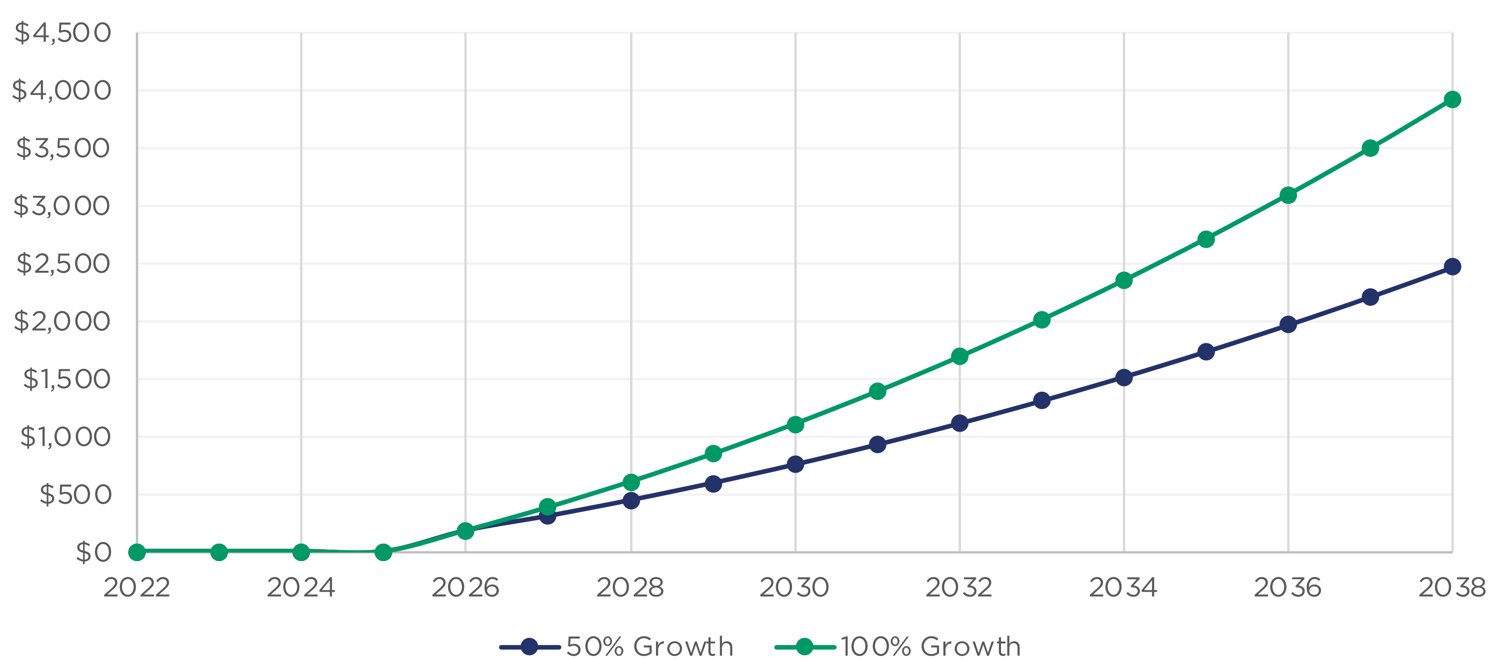
Projections

To estimate the incremental economic impact of increasing investment in the college over the next 15 years, we assume the Ph.D.s, additional graduates, R&D spending and patents of all other schools in the state continue their recent trends. We then calculate what each independent variable would be—and therefore the state GDP per worker—if the College of Engineering has:

1. All outputs fixed at 2022 levels.
2. A 50% increase in graduates, R&D spending and patents from 2024 to 2035.
3. A 100% increase in graduates, R&D spending and patents from 2024 to 2035.

This analysis provides an overwhelmingly strong rationale for why public, private and philanthropic investment in the University of Arkansas-Fayetteville, College of Engineering would yield enormous economic and financial returns to the state's economy and its residents. Several decades ago, Utah developed a comprehensive economic-development plan where investment in engineering education and research was instrumental. Utah's economy now is among the most dynamic and vibrant in the nation.

ADDITIONAL GDP PER YEAR WITH EXPANDED UA - FAYETTEVILLE COLLEGE OF ENGINEERING (MILLIONS OF DOLLARS)



INTRODUCTION

The presence of a research university can boost an area's economy—businesses thrive as students and faculty frequent nearby shops, restaurants, and services. Students frequently remain in the area after graduation and establish households, increasing the local number of highly skilled workers.

Colleges also create additional economic value through increased human capital that other similarly sized employers cannot. It is well documented that a solid route to economic development is to grow the quality and quantity of academic degrees and credentials within the local population and labor force.[1,2] The increased productivity allows incomes and GDP to grow steadily. In the modern economy, where technical advancements and innovations are ever increasing, STEM graduates have among the highest returns on investment (ROI) and economic growth.

Colleges employ faculty and staff and spend money locally for the facilities, supplies and services needed to operate the college. These are direct economic effects of a local college. The faculty and staff buy houses, go to restaurants, see physicians and shop in the local community. This faculty/staff spending bolsters the local economy and creates job opportunities in construction and utilities, hospitality, medical services, and retailers. The combination of these direct and indirect effects represents the immediate economic impact.[3]

The influence of the indirect effect relative to direct spending varies depending on characteristics of the local economy. Tax rates, consumer spending/saving patterns and local availability of desired goods all influence how much economic activity eventually comes from local expenditures by the college and its employees. Economists have derived models that measure the indirect effects that are unique to each industry and every metropolitan area and state. We use these multipliers to estimate the immediate impact of a college.

While the immediate impact is important, the greater effects accumulate over time because of the educational mission and creation of knowledge as students earn degrees. Valero and Van Reenen (2019) measured long-term GDP growth resulting from growth in the number of universities in a region.[4] Engineering and computer science graduates have strong analytical, problem-solving, and quantitative decision-making skills. They work in diverse occupations across many industries, where they are trained to foster innovation and encouraged to develop and apply a creative mindset that finds solutions to unresolved problems. Work by DeVol[5] discusses in more detail how universities influence regional economies.

Applying engineering and computer science principles improves efficiency and productivity across all sectors of the economy. Automation, optimization algorithms and streamlined processes improve efficiency in ways that other types of training and innovation do not. As we train more engineers and computer scientists, our ability to innovate grows. These skills are needed in all types of new businesses. The University of Arkansas, located in Fayetteville consists of 10 colleges and is classified as a highly active research university (R1) by the Carnegie Foundation. Its College of Engineering offers 10 bachelor's and 14 master's degree programs, as well as Ph.D.s in 10 specialties. Computer science and data sciences are included in the College of Engineering curriculum, and approximately 12% of UA – Fayetteville students are enrolled in its degree programs.

The University of Arkansas is in the Fayetteville-Springdale-Rogers metropolitan area in the northwest corner of the state, which includes Bentonville and all of Washington and Benton counties. This metro area also is home to the corporate offices for Walmart, Tyson Foods, and J.B. Hunt Transport Services. This region of the state has experienced rapid growth for the past 15 years because of growth in the major economic drivers, as well as an intentional effort by local leaders to make the region a welcoming and attractive place to live, work and raise a family.

UA - Fayetteville is one of several major economic drivers of the region, and the College of Engineering is one of 10 colleges within the university. As such, the economic impact of the college, while significant, is small relative to the regional economy. We calculated the immediate impact of the engineering college by taking the operating expenses and applying the unique multipliers for the industry and region.

Operating expenses of the college are broken down into two categories: educational operations and research/development. We apply the impact multipliers for junior colleges, colleges, and universities to the educational expenditures, and the multiplier for scientific R&D to the research expenditures. These multipliers come from the Bureau of Economic Analysis inside the U.S. Department of Commerce and are used to estimate the immediate effect of GDP, earnings, and jobs.

When we apply the multipliers for the entire metro area, we find a total effect of the College of Engineering is $107,580,158 in GDP, $40,032,460 in earnings and 851 jobs. While significant, this represents less than one-third of 1 percent of GDP, earnings, and employment in the robust and diversified local economy.

TABLE 1: IMPACT OF COLLEGE OF ENGINEERING ON LOCAL ECONOMY

	IMPACT FROM COLLEGE OF ENGINEERING	TOTAL METRO AREA	PERCENT
GDP	$107,580,158	$36,059,095,000	0.30%
EARNINGS	$40,032,460	$21,256,150,000	0.19%
INDIRECT JOBS	851	279,830	0.30%

TABLE 2: IMPACT FROM COLLEGE OF ENGINEERING ON STATE ECONOMY

	IMPACT FROM COLLEGE OF ENGINEERING	ARKANSAS	PERCENT
GDP	$125,608,787	$165,220,600,000	0.08%
EARNINGS	$45,173,984	$90,851,151,000	0.05%
INDIRECT JOBS	953	1,382,078	0.07%

Most of the college's economic impact occurs locally, although some reaches into other parts of the state. Some employees may live outside the metro area, or faculty may spend weekends exploring other locations in the state. Since economic activity that leaves the metro area does not necessarily leave the state, our multipliers for industries are larger for the state than the metro area. When we apply the state-level multipliers to the expenditures of the College of Engineering, we estimate the college contributes $125,608,787 to the state GDP; $45,173,984 to state earnings; and 953 jobs.

Table 2 represents the contemporaneous, or immediate, effects on the regional economies because the college is in Fayetteville rather than another part of the state or surrounding area. Obviously, the more students who attend, the more faculty and facilities are needed, the larger the immediate economic impact. A college with greater expenditures and more faculty would have a proportionally larger economic impact both locally and regionally. We intentionally calculated the lower bound of the effect for a college with less than 5,000 students within a larger university and excluded extracurricular activities.

A 2019 study estimated the economic impact of the University of Washington at $15.7 billion for the state of Washington.[6] UW has more than 40,000 students, and the report included the effects of athletics and the incomes of graduates who stay in the state after graduation. Another study measured the impact of all 14 public universities in Ohio and found an effect of $68.9 billion when considering a wider variety of paths by which the universities influence the state.[7]

The overall activities of an engineering college are less varied than a university. There are no athletic teams, dorms, performing-arts centers, or cafeterias. Activities focus on recruiting, educating, and retaining students in engineering and computer sciences, as well as and conducting research on the technology frontier.

Engineering faculty conduct research in labs to make breakthrough discoveries or enhance understanding. Once they have documented and confirmed their theories, their work frequently inspires ideas of how new knowledge can be used to create new products, improve existing ones, or allow goods to be produced at lower cost, or with lower risk.

Applications of new knowledge frequently happen in firms rather than university labs. It might be shared with or acquired by an existing company, or a new firm may emerge to capture the commercial potential. These expanded or newly created firms need a variety of occupations, including engineers and business managers. While these innovations are not guaranteed to be commercially successful, some produce rapid growth and substantial profits. Recent work by Feldman[8] measures how well U.S. universities apply technological information to the business community and economy.

Economists have used growth accounting models to try to measure productivity contributions resulting from research. Although the direct relationship of research to productivity has been difficult to isolate, there exists a well-documented positive rate of ROI for basic research, as measured by economic growth. The rate of return to private entities has been measured from 9% to 56%, and the social rate of return from 10% to 160% for privately funded R&D spending.[9] The overall rates of return for publicly funded R&D range from 20% to 67%.[10]

Research at the UA – Fayetteville College of Engineering has contributed to knowledge creation and economic activity beyond the expenditures of school and faculty. A research team led by Dr. Min Zou in mechanical engineering won awards for developing technology that inspired the founding of two startup companies that use those methods in a range of energy applications. Current research at the college involves robotic arms constructed with 3D printing to aid in poultry processing, high-tech methods to improve wound healing and improved imaging that makes breast cancer surgery more precise.

CatalyzeH2O is a chemical-engineering firm created by a UA professor and Ph.D. student who were awarded a Department of Defense grant to develop and use new techniques for removing explosives from water.[11] SurfTec, LLC is part of the university's Technology Development Foundation—it has received $225,000 from the National Science Foundation[12] and $1.2 million from the Department of Energy[13] to further hone technologies born out of UA research. SIEV Technologies is yet another Fayetteville-based company that owes its existence to College of Engineering research that has received funding from the National Science Foundation to further develop new technologies.[14]

Interdisciplinary projects often require an engineering or computer science expert to meet the team's technical needs. Namida Labs in Fayetteville was launched from research done by a team that included biochemistry and biomedical engineering experts. These types of research accelerate regional economic growth and tangible improvements to human lives. Entry-level poultry processing jobs are replaced with robotic-installation and maintenance positions. New technologies allow products to be better and more efficient. For instance, more women will beat breast cancer with a single, less invasive surgery.

To the degree that earnings often reflect the productivity of a worker, those trained in engineering and computer science are among the most productive in our economy. Nationally, engineering and computer science degree holders earn a lifetime average of $1 million more than social science or life science graduates and $2 million more than the average high school graduate[15] (Nietzel, 2021). Engineering students who also take courses in economics and management are more likely to start new firms early in their careers (Colombo and Piva, 2020).[16]

Since these longer-term, innovation-driven effects are believed to influence regional income, GDP, and employment more greatly, we have estimated a model to measure the impact on a state's economy of a college offering engineering and computer science degrees.

METHODOLOGY

We estimate the accumulated economic impact of a college of engineering on its home state as accurately as possible, given the limited amount of data that is readily available for all states.

We estimate state-level GDP per worker as a function of:

- Year fixed effects.
- State fixed effects.
- Ph.D.s conferred in engineering and computer science (CS) per worker.
- University R&D per worker (thousands of nominal dollars.)
- Share of labor force with a degree in computer science or engineering and employed in an occupation utilizing their education.
- Number of patents issued per worker.

This model has an r-squared of .988 (a high degree of explanatory power) when estimated on 10 years of GDP data (2012-21) for the 50 states and Washington, D.C.

We used a global search algorithm on a variety of models to determine the best lag structure with the limited time series data. We know that GDP does not increase simultaneously, as it takes time for the research discoveries to be confirmed and receive funding for commercial applications. New graduates also take time to find jobs and become highly productive. We made no assumptions about the time needed for the activity to show up in GDP but let a search algorithm find the lag that best fit the data. The top two models were lags of three and five years. There were no meaningful differences between them, so we estimated the models lagging each independent variable three years to maximize the number of observations from our sample.
Examining GDP per worker isolates the specific effects we wish to identify without the need for detailed demographic controls each year. Allowing a unique effect for each calendar year (year fixed effects) should incorporate overall macroeconomic conditions that influence GDP in all states similarly from year to year. The calendar year effects will also reflect annual price changes due to inflation, so we do not need to adjust R&D spending or GDP to real dollars.

Our model also allows each state to have a unique parameter (state fixed effects) to predict GDP per worker. These estimates capture the unique industrial and demographic mix, as well as the capital and educational infrastructure of a state, that influence GDP. This coefficient will reflect state characteristics that change slowly over time, such as overall educational attainment, labor force participation rate and whether a state is a retirement destination or has natural resources that contribute to extraction industries or outdoor recreation economic benefits.

We used American Community Survey (ACS) data on degrees obtained, field of study and occupation to classify currently employed engineering and computer science degree holders into three categories: 1) Working in an occupation that usually requires a computer science or engineering degree (e.g., chemical engineer or computer scientist and systems analyst); 2) Working in an occupation where they are likely using the knowledge obtained in their degree, but the specific degree is not required (e.g., industrial production managers and cost estimators); and 3) Working in an occupation where they are using little of the knowledge relative to their degree (e.g., funeral director or bartender.)

We consulted with an associate dean of the College of Engineering at the University of Arkansas to determine which ACS occupation codes belong in each category. As the number of people with degrees in engineering and computer science increases, we would expect to see more in the second category if the number of graduates is growing faster than employer demand for degree-specific employment. Our initial models showed no differences in the coefficients for the share of the labor force in categories 1 and 2, so we combined them in the models used for our estimates. This suggests engineering and computer science graduates are as productive working in widely varied roles as they are when employed as engineers or computer scientists—when productivity is measured in GDP.

RESULTS

Our final model accounts for 98.8 percent of the variation in GDP per worker across states from 2012 to 2021, and all the explanatory variables of interest are highly significant and have a positive effect on GDP. On average, state-level annual GDP per worker has risen by $30,332—from $111,575 to $141,907—over the 10-year span. Of that gain, **25%** is attributable to increased outputs of engineering colleges.

Across the U.S., states had an average economic growth of $7,631 per worker over the decade associated with increased research activity and engineering/computer science graduates.

- The rate of patents rose from one per 1,836 workers to one per 1,290, which is associated with an additional **$2,991** in GDP per worker.
- The rate of new Ph.D.s in engineering and computer science rose from one per 17,513 workers to one per 13,793, which is associated with an additional **$200** GDP per worker.
- The average share of the work force consisting of engineering/computer science degree holders rose from 3.3% to 4.1%, which is associated with an additional **$2,846** GDP per worker.
- University R&D rose from $401 per worker to $492 per worker, which is associated with an additional **$1,593** GDP per worker.

The implications of this model are clear: States that educate or import more engineering and computer science graduates, as well as states that conduct more engineering and computer science R&D, have a higher GDP per worker. Our model indicates the lag is three years from graduation and employment or research discovery to see the GDP effect.

Economic data from the state of Arkansas from 2012 to 2021 shows that GDP per worker increased from $86,452 to $111,603. Of that gain, 27.7% ($6,958) is attributable to the activities of engineering colleges across the state.

- The rate of patents rose from one per 8,157 workers to one per 3,273, which is associated with an increase of $2,378 GDP per worker.
- The rate of new Ph.D.s in engineering/computer science rose from one per 35,894 workers to one per 21,277, which is associated with an additional $296 in GDP per worker.
- The engineering share of the workforce rose from 1.6% to 2.5%, which is associated with an additional $3,210 GDP per worker.
- University R&D rose from $201 per worker to $262 per worker, which is associated with an additional $1,073 GDP per worker.

With these estimated relationships between the outputs of engineering colleges and GDP, we can isolate the longer-run influence on the GDP of Arkansas attributable specifically to the UA – Fayetteville College of Engineering. To estimate the effects of the college, we used their data on the number of graduates broken down by bachelor's, master's, and doctorates, along with R&D spending, placement location of graduates (when known) and intellectual discoveries each year for the last 10 years.

TABLE 3: SUMMARIZING GDP GROWTH DUE TO ENGINEERING COLLEGES

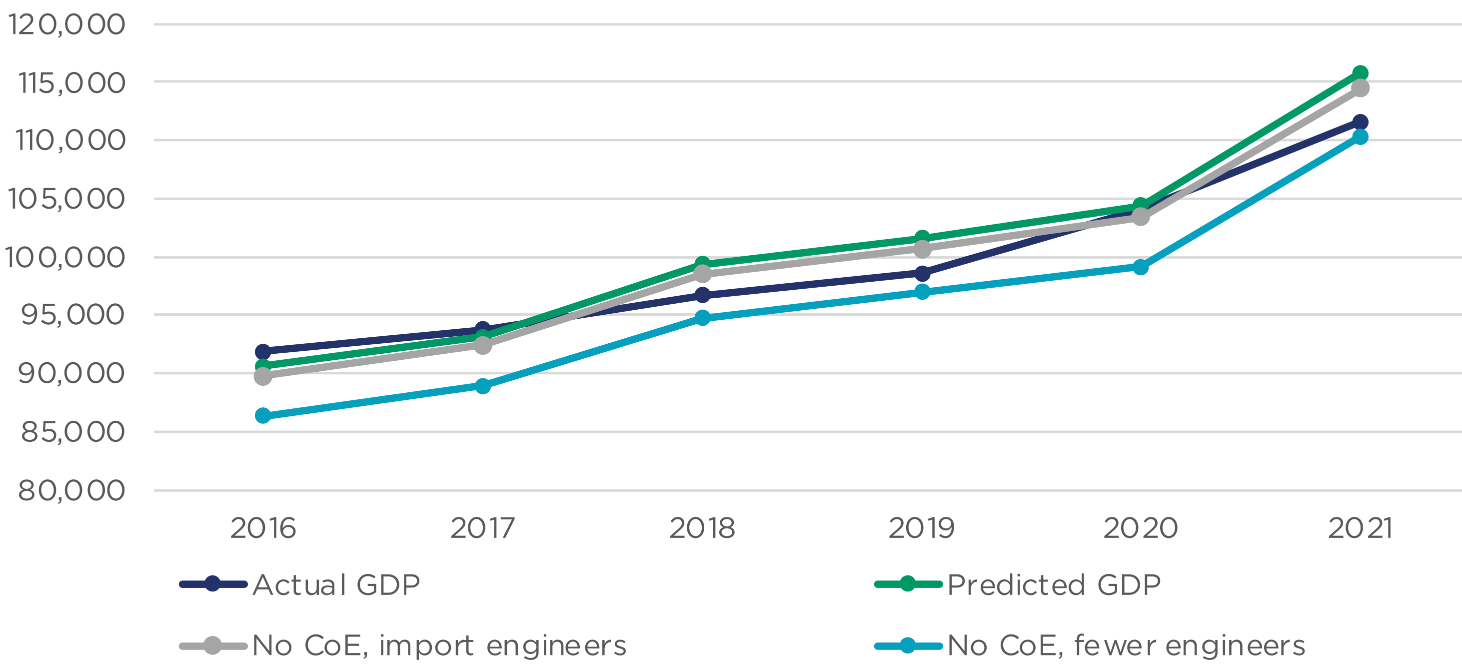
	US STATE AVERAGE			ARKANSAS		
	2009	2018	CONTRIBUTION TO GDP GROWTH	2009	2018	CONTRIBUTION TO GDP GROWTH
PATENTS PER WORKER	0.00054	0.00077	$2,991	0.00012	0.00031	$2,378
PHDS PER WORKER	0.00006	0.00007	$200	0.00003	0.00005	$296
ENGINEER LABOR SHARE	0.03308	0.04091	$2,846	0.01662	0.02545	$3,210
PER WORKER UNIVERSITY R&D ($1000S)	0.40185	0.49275	$1,593	0.20130	0.26253	$1,073
TOTAL GDP PER WORKER (2012 - 2021)	**$111,575**	**$141,907**	**$30,332**	**$86,452**	**$111,603**	**$25,151**
GDP GROWTH DUE TO ENGINEERING COLLEGES			**$7,631**			**$6,958**
PERCENT OF TOTAL			**25.16%**			**27.66%**

To estimate the current impact of the college, we used our models to approximate the state GDP per worker each year and then recalculated what each of our independent variables would be without the college's data included in the state totals. Most of the metrics were straightforward, but the engineering share of the workforce required special treatment.

We estimated one set of effects assuming the labor share of engineers would not change, which assumes engineers would get degrees at other schools and still work in the state. This estimate is our lower bound of effect of GDP for the college. An alternative set of effects was estimated where the labor share of engineers is adjusted as if the college quit producing engineers in 2009 and those were not replaced by graduates from other schools. This is the upper bound of estimated effects.

Figure 4 below shows GDP per worker from 2016 to 2021 as measured and as our model predicts in the three scenarios explained above. The navy line shows the GDP per worker from economic data; the green line shows the GDP per worker our model predicts when Arkansas measures are plugged into the empirical model; the gray line shows GDP per worker when we exclude the College of Engineering patents, R&D spending and Ph.D.s, but leave the engineering share of the workforce unchanged. The difference between the gray and green lines is the GDP lost if the college quit producing graduates in 2009 and we imported engineering graduates from other states—our lower bound estimate. The turquoise line shows GDP per worker if the College of Engineering data is excluded, and we allow the engineering share of the labor force to dwindle over time as the engineering graduates are not replaced from other states. The difference between green and turquoise lines is the GDP lost when assuming schools in other states do not provide additional engineers in the absence of the College of Engineering—our upper bound estimate.

FIGURE 4: ARKANSAS ANNUAL GDP PER WORKER WITH AND WITHOUT UA - FAYETTEVILLE COLLEGE OF ENGINEERING



Using this methodology, we estimate the GDP attributable to the College of Engineering at 1.15% to 4.74% of current statewide GDP. This is the additional GDP coming from research activities and a higher share of engineering/computer science degrees in the workforce. This is up to 15 times greater than the contemporaneous effect when we use the more conservative lower bound of the estimated impacts on all calculations.

TABLE 5: EFFECT OF THE UA - FAYETTEVILLE COLLEGE OF ENGINEERING ON ARKANSAS GDP

YEAR	ACTUAL GDP	LOWER BOUND EFFECT	UPPER BOUND EFFECT
2016	$119,151,911,000	$1,063,658,318	$5,488,555,010
2017	$122,460,765,000	$872,083,166	$5,495,453,966
2018	$127,524,642,000	$1,128,761,688	$6,091,628,307
2019	$131,570,436,000	$1,130,751,962	$6,159,689,924
2020	$133,960,641,000	$1,217,879,235	$6,745,460,217
2021	$148,664,847,000	$1,768,712,391	$7,316,994,268

This effect comes despite the state producing relatively low levels of all outputs associated with engineering colleges. For the past decade, Arkansas has consistently had a very low, if not the lowest, share of the workforce with degrees in engineering or computer science. Another report specific to engineers found Arkansas employs the fewest relative to the size of the labor force and only had 48% of the engineers expected based on the national rate of engineers in the workforce.[17] Meanwhile, the share of the workforce with such a degree is growing more rapidly in the leading states, widening the gap across the states.

Not only does Arkansas have fewer engineering or computer science graduates in the workforce, but the rate at which new Ph.D.s are earned is consistently below that of other states. This contributes to lower GDP and suggests we have fewer potential faculty members should we wish to grow our engineering colleges.

Arkansas is consistently near the bottom on patents granted relative to workforce size, although the rate has improved in the past few years. Still, the state is well below average.

FIGURE 6: SHARE OF WORKFORCE WITH ENGINEERING OR COMPUTER SCIENCE DEGREES

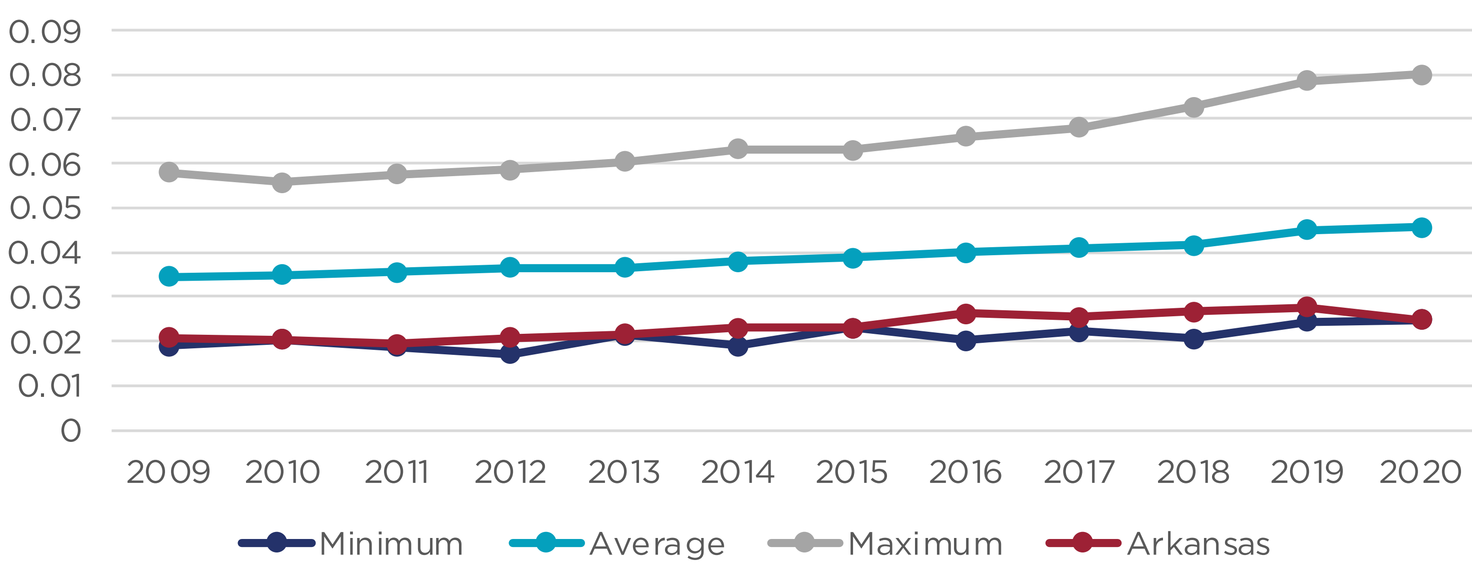
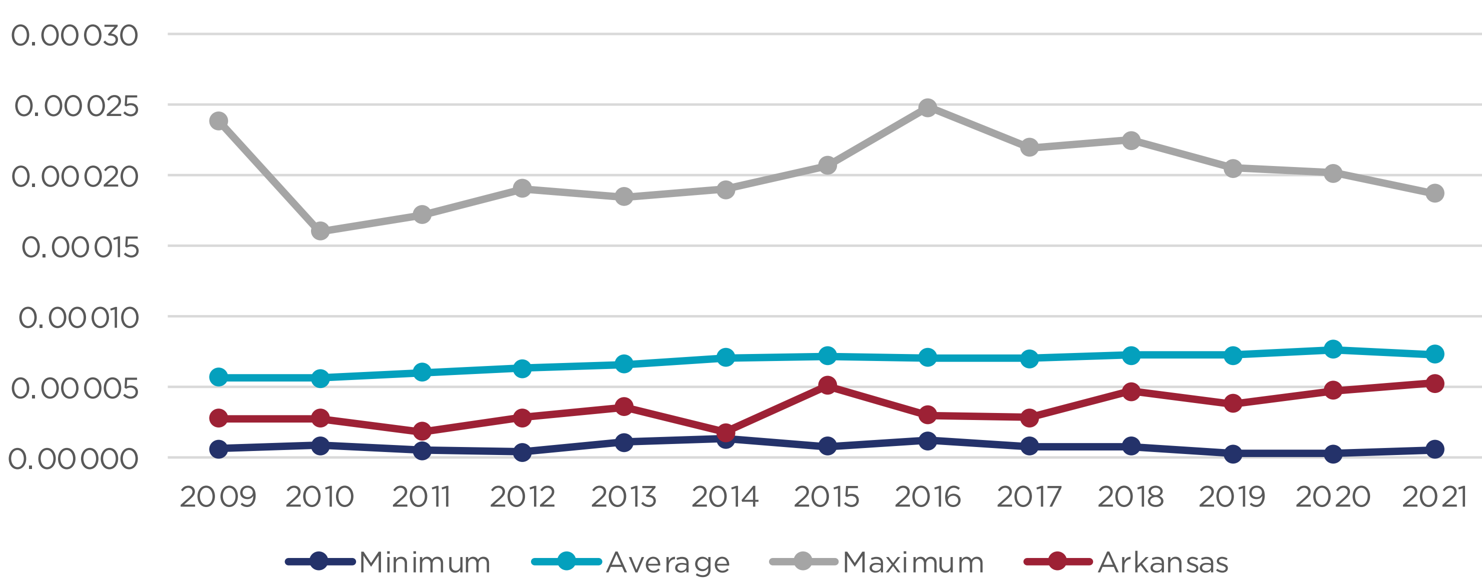


FIGURE 7: ENGINEERING AND COMPUTER SCIENCE PH.D.S CONFERRED PER WORKER



The rate of university R&D in engineering/computer sciences is yet another metric where Arkansas is well below most states. For each year in our dataset Arkansas is below average and closer to the minimum than the average rate of R&D. Research funding in the states that do more research has accelerated the past few years, leading to a larger gap between those that invest more and those that spend less on R&D.

The estimated relationships between engineering colleges and GDP let us project GDP with different levels of commitment to the flagship engineering college over the next decade using a very similar strategy.[18] What would growth look like if Arkansas could begin to close the gap between states with more engineers and computer scientists in the workforce?

FIGURE 8: PATENTS PER WORKER

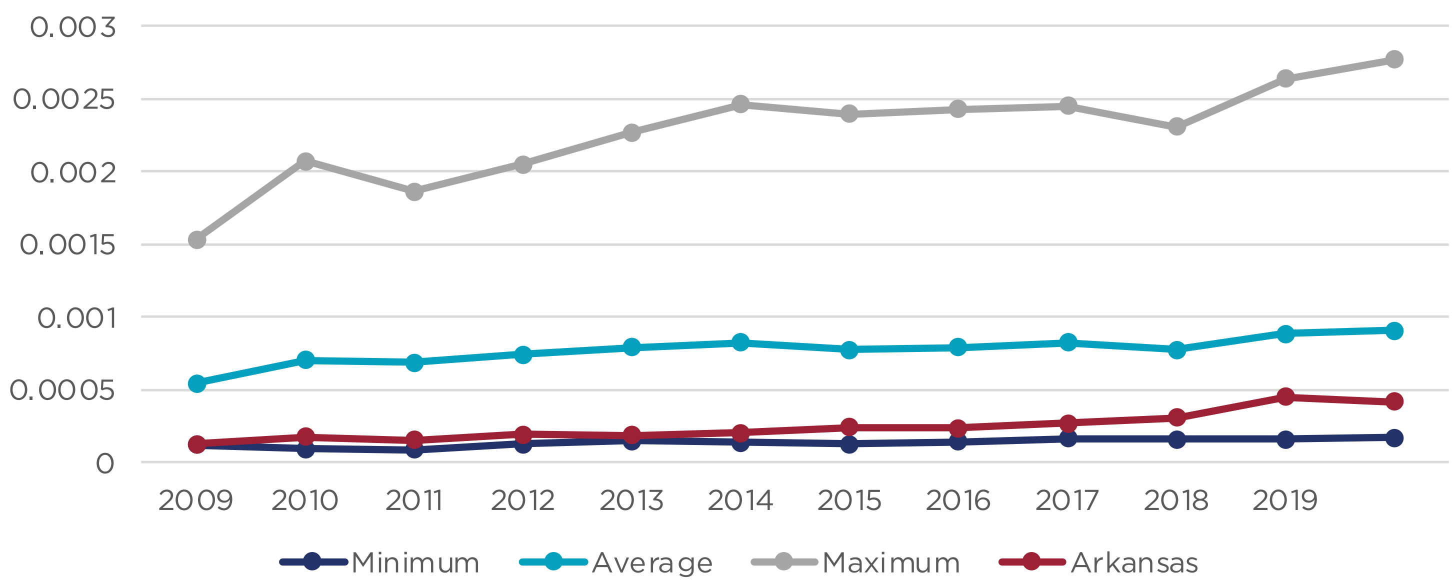
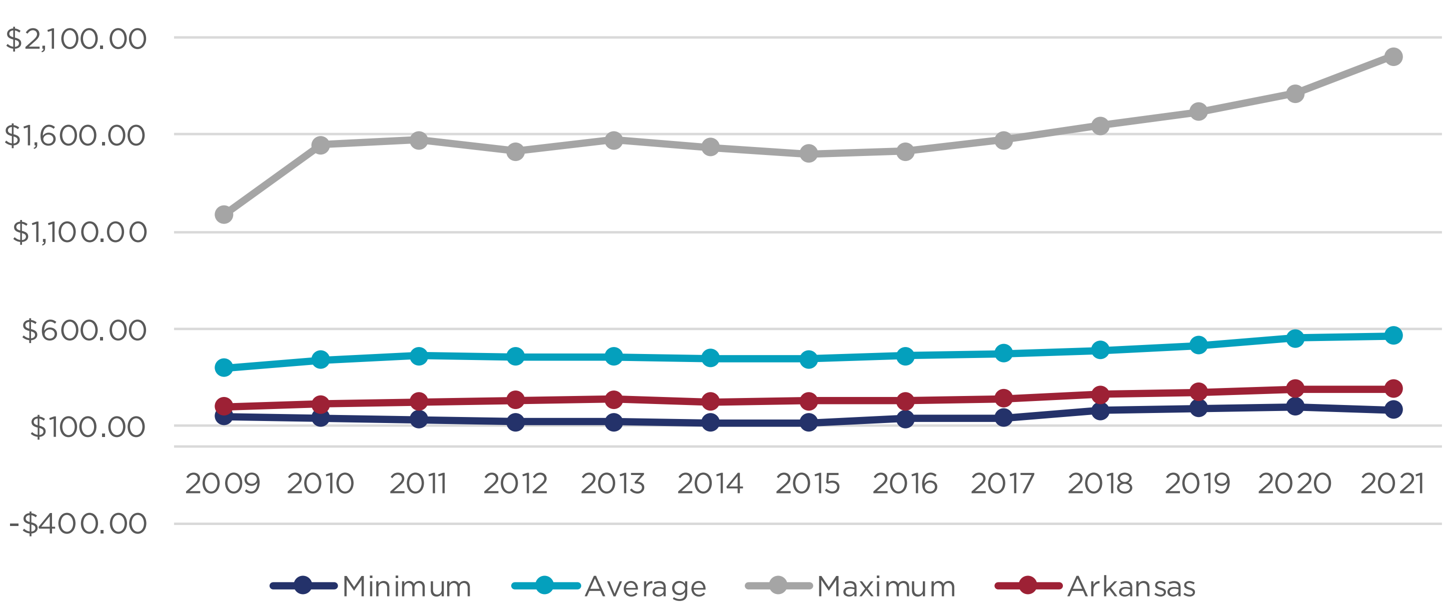


FIGURE 9: ENGINEERING R&D SPENDING PER WORKER



PROJECTIONS OF FUTURE GROWTH

To explore the potential growth that could come from increased graduates and research at the College of Engineering, we assume all activities at other Arkansas schools continue their recent trends. We then calculate what each independent variable would be—and therefore the state GDP per worker—if UA - Fayetteville's College of Engineering has 1) all outputs fixed at 2022 levels; 2) a 50% increase in graduates, R&D spending and patents from 2024 to 2035; and 3) a 100% increase in graduates, R&D spending and patents in the same time period.

For these projections, we adjust the engineering/computer science share of the state's labor force by assuming the overall workforce will grow at the rate projected by Chmura Analytics' macro models for the next 10 years and assume 2% of current engineers/computer scientists retire each year and 65% of University of Arkansas graduates take in-state employment. This is not changing the overall size of the labor force because of the extra investment, but simply allowing more of the expected workers to have engineering or computer science degrees.

The additional GDP increases demand for workers of all types which tends to increase wages overall. The higher wages cause more people to be willing to work and increases the labor force participation rate. We also calculate how many additional jobs will be created (beyond the projected growth) as more people join the labor force because of the higher GDP and wages from increased investment in the College of Engineering. For these estimates, we rely on the elasticity of employment growth with respect to GDP estimated by Burggraeve, de Walque and Zimmer (2015).[19]

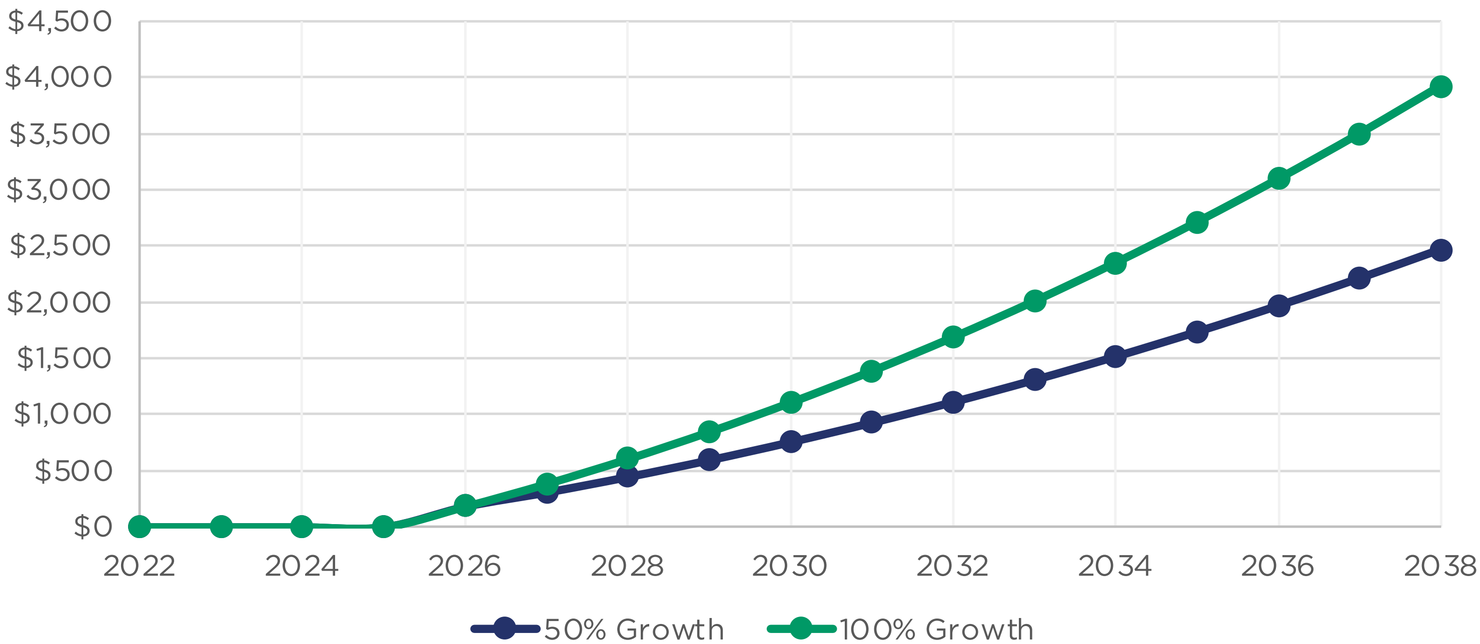
These projections assume that doubling the state's investment in R&D will produce double the number of patents, or that there are constant returns to scale for R&D spending. Despite recent increases in R&D funding, the College of Engineering remains well below the per-faculty funding rates of other engineering colleges, and Arkansas is well below the state average of funding per worker. These measures suggest R&D funding is likely at a scale where increasing or constant returns to scale are likely to apply.

With regards to educational expenditures, there are reasons to believe that there are increasing returns to scale for engineering, allowing the number of graduates to double while spending on educational expenditures less than doubles. The College of Engineering has been intentional about improving retention and graduation rates. It has an associate dean dedicated to student success and has opened an engineering one-stop office to simplify many administrative processes for students. The most recent retention rates and student progress metrics suggest these efforts are already paying off.

TABLE 10: PROJECTED FUTURE GDP PER WORKER AND JOBS WITH ENGINEERING COLLEGE INVESTMENT

	BASELINE PROJECTIONS BASED ON 2022 GRADUATIONS, R&D SPENDING AND NUMBER OF PATENTS		ADDITIONAL GDP AND JOBS WITH A 50% INCREASE IN COLLEGE OF ENGINEERING OUTPUTS BY 2035		ADDITIONAL GDP AND JOBS WITH A 100% INCREASE IN COLLEGE OF ENGINEERING OUTPUTS BY 2035	
YEAR	GDP PER WORKER	JOBS	GDP	JOBS	GDP	JOBS
2022	$120,629	1,345,402	0.00%	0	0	0
2023	$123,340	1,354,820	0.00%	0	0	0
2024	$125,131	1,364,303	0.00%	0	0	0
2025	$128,041	1,373,853	0.00%	0	0	0
2026	$131,037	1,383,470	0.10%	1,146	0.10%	1,146
2027	$134,050	1,393,155	0.16%	1,893	0.21%	2,360
2028	$137,081	1,402,907	0.23%	2,676	0.31%	3,637
2029	$140,130	1,412,727	0.30%	3,492	0.43%	4,974
2030	$143,200	1,422,616	0.37%	4,340	0.54%	6,368
2031	$146,290	1,432,575	0.44%	5,217	0.66%	7,815
2032	$149,402	1,442,603	0.52%	6,123	0.78%	9,311
2033	$152,537	1,452,701	0.59%	7,054	0.91%	10,854
2034	$155,697	1,462,870	0.66%	8,010	1.03%	12,440
2035	$158,882	1,473,110	0.74%	8,989	1.16%	14,068
2036	$162,094	1,483,422	0.82%	9,989	1.29%	15,734
2037	$165,334	1,493,806	0.89%	11,009	1.42%	17,437
2038	$168,604	1,504,262	0.97%	12,048	1.55%	19,172

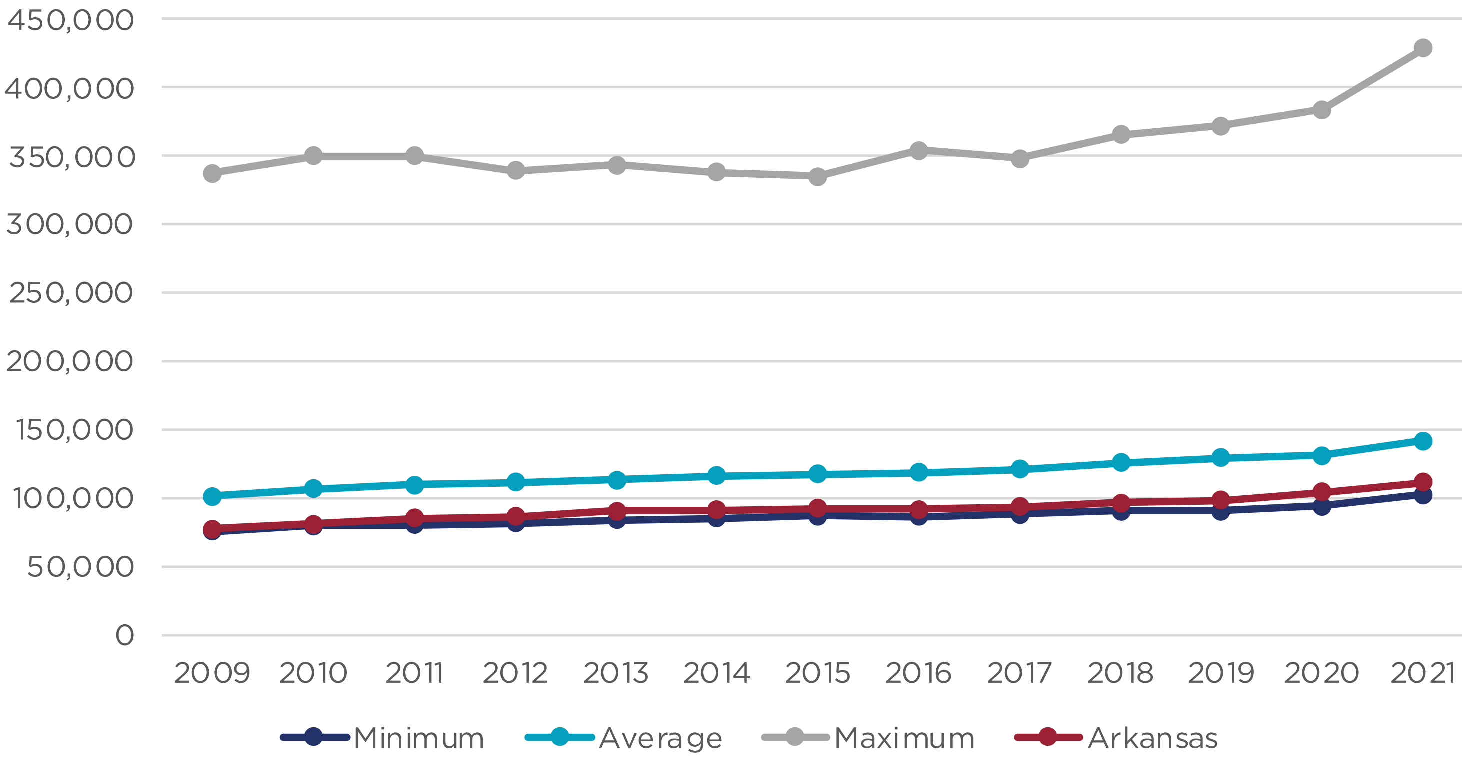
FIGURE 11: ADDITIONAL GDP PER YEAR WITH EXPANDED COLLEGE OF ENGINEERING



In Arkansas, an engineering college that represents less than 1/10th of 1 percent of current GDP in the state has the potential to increase annual GDP more than one percent above our baseline projections. This means annual GDP would be $3.9 billion higher than what is currently projected 15 years out if we invest resources in producing engineers and computer scientists taught by expert faculty. But if we fail to make this investment, Arkansas will likely fall even further behind in producing engineers and computer scientists, and all Arkansans on average will earn the lower incomes that come with less innovation in the regional economy.

Even doubling the number of degrees awarded by the College of Engineering by 2035 would not bring the engineering share of the workforce up to the current national numbers. We project the Arkansas share would be 0.034, while the current average among states is 0.045. To better realize the economic benefits, a coordinated strategy is needed to produce and employ more graduates within the state and give engineers and computer scientists in other states a compelling reason to come work in Arkansas.

FIGURE 12: ANNUAL GDP PER WORKER



To date, Arkansas' GDP per worker has been near the bottom. Naturally, all states cannot be above average; however, it is possible for all to grow consistently and converge so that the highest and lowest are closer to the average. Recent GDP growth in the U.S. has been concentrated in states that were already well above average. States near the bottom need to embrace proven growth strategies if they are to close the gap. Increasing the quantity of engineering and computer science degree holders in the labor force is a well-established path to growing GDP.

ENDNOTES

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[11] https://news.uark.edu/articles/56027/startup-awarded-1-million-grant-for-water-cleaning-technology

[12] https://news.uark.edu/articles/34860/nsf-awards-225-000-to-u-of-a-affiliated-technology-company

[13] https://news.uark.edu/articles/38775/surftec-receives-1-2-million-energy-award-to-develop-novel-coating

[14] https://news.uark.edu/articles/58576/local-startup-siev-technologies-earns-256-000-small-business-award

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[18] Year fixed effects are easily estimated from historical data, but problematic for making projections for future GDP. To get around this we also estimated a model with a linear time trend rather than year fixed effects. We used this estimated coefficient on time to project average growth in GDP per worker each year.

[19] Burggraeve, K., de Walque, Grégory and Zimmer, H., (2015), The relationship between economic growth and employment, Economic Review, issue i, p. 32-52, https://EconPapers.repec.org/RePEc:nbb:ecrart:y:2015:m:june:i:i:p:32-52


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