Economic Impact on Missouri

of the UM System

A report by

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Executive Summary

The University of Missouri System (UM) is comprised of four campuses and University Hospitals. We start with the premise that a university has two primary missions: to discover and to disseminate knowledge. In actively pursuing these two goals, the university is an engine of economic growth. Economic research has developed an explicit link between economic growth and both basic research and human capital accumulation. We use widely accepted economic models to quantify the economic impact that the UM System has on three separate issues: (i) gains in lifetime earnings; (ii) increases in state economic growth rate through the research and development efforts; and (iii) increases in aggregate income associated with human capital investment.

None of these actions are captured by a "snapshot" of the economy. Indeed, the effects of newly discovered knowledge and the returns to higher education are processes that occur over time. Therefore, our approach is to present a "video" of the economic impacts. More concretely, we compare the growth path of the Missouri economy with and without UM System R&D and without the enhanced skills that increase graduates' lifetime earnings.

Our report's key findings:

- UM students who graduate have invested in their human capital, yielding higher lifetime incomes. Applying careful estimation techniques to Missouri data, relative to a lifetime of work commencing upon completing high-school, a bachelor's degree from UM campuses increases present-value lifetime earnings by about $415,000, or $589,000 for UMC graduates, and from $584,000 to $858,000 for master's degrees.
- If the UM System did not exist and its basic research was foregone, the growth rate of the Missouri economy would decline from an already slow 0.93 percent to 0.74 percent. This 19-basis-point reduction means Missouri's economy grows roughly a one-quarter faster due to UM's R&D. Over 70 percent of UM's R&D occurs at the Columbia (MU) campus. Over a generation, the discounted sum of real GDP that would be lost without the R&D by the UM System is $87.8 billion.
- If UM stopped educating people, aggregate income would decline. Over a generation, the discounted sum of lost real GDP due to the reduction in human capital produced by the UM System is $252.7 billion.
- About 60 percent of UM System graduates remain in Missouri and add to the state's productivity.
- State appropriations account for 32.8 percent of UM expenditures, though a much lower fraction of MU expenditures. Over a generation, the discounted sum of state appropriations to the UM System is, if continued at current levels, $6.2 billion. That appropriation is turned by UM into $238.4 billion in present value of higher Missouri real GDP.
- Thus, every $1 in reduced appropriation to UM reduces Missouri's real GDP by $38.43. (Because of the concentration of R&D at MU, any reduction in appropriations directed at the MU campus will have a higher impact.) Indeed, per $1 spent in UM appropriations, state tax revenue increases in present value by $1.46.

This report presents a quantitative estimate of the University of Missouri System's ("UM") impact on the growth of the Missouri economy and on the time path relating UM activity and support to state income-tax revenue. We do not make any guesses about "multipliers," instead using the economic models and empirical studies in the peer-reviewed literature that have been the most widely accepted in economics and the most relevant to the task at hand. Our analysis starts with the premise that an economy is a video rather than a snapshot. These models are then calibrated to the size of Missouri's economy, combining publicly reported data with data on the number of UM alumni known to be living in Missouri (provided by the Alumni Associations of the four campuses).

The thought experiments that we consider in these model economies are stark. What happens to the Missouri economy if the discoveries and knowledge disseminated at the UM System campuses did not exist? Moreover, there is no substitution for the basic research or matriculation of the UM System campuses at other Missouri universities or colleges. Such thought experiments are commonly used to quantify the economic impact of a university.[1] In short, suppose the university's productive capacity vanished. What is the economic impact? If possible, economic impact would be measured by observing one State of Missouri with the UM System operating, and holding everything else constant, another State of Missouri without the UM System operating. Then compare the two "Missouris" to quantify the economic impact. Such clean aggregate experiments do not exist in the social sciences. That said, there is compelling evidence that public *research* universities have larger economic impacts than public universities.

The Investment Decision

We start with a numerical description of the basic economics underlying the decision to seek a college degree. As with most decisions, there is a tradeoff. A high-school graduate can choose to join the workforce, obtain a job, receive income, and enjoy the independence that goes with being an employed, responsible adult. Alternatively, the young adult can opt for higher education, foregoing income, investing in building her or his human capital, and anticipating higher future incomes as the return on this investment. The decision problem facing our high-school graduate, therefore, depends on the rate of return to obtaining a bachelor's or master's degree.

Going back at least to Jacob Mincer (1974),[2] economists have studied how experience and education affect people's earnings. So, we use the evidence compiled by researchers to examine the tradeoff associated between entering the workforce—that is, investing in experience—and attending higher education. To make the comparison over a person's lifetime, suppose we have an 18-year high-school

[1] See, for example, the report issued by the University of Wisconsin-Madison at http://news.wisc.edu/system/assets/84/original/2015_NorthStar_Study.pdf?1428944681.

[2] Mincer, Jacob (1974), *Schooling, Experience, and Earnings*, New York: Columbia University Press.

graduate with two options. One option is immediately entering work life. The other option is to defer working for four years, attend one of the UM System schools and then enter work life at age 22. We compare the path of future earnings for each option.[3]

In 2015, our high-school graduate begins working. Average compensation of an 18-year-old high-school graduate in 2015 was $30,000.[4] Heckman, Lochner, and Todd (2006) present evidence that wages increase with increases in experience, but at a decreasing rate. Formally, $\%\Delta W = 0.059 - 0.001 * \exp$. In other words, the percentage increase in an average person's wage is equal to 5.9 percent each year *less* 0.1percent multiplied by the years of experience (abbreviated "exp"). For our 18-year-old high-school graduate, wages increase according to this experience formula.

Alternatively, suppose the 18-year in 2015 foregoes work and attends MU, MST, UMKC, or UMSL for four years. Based on 2015 data, the average new college graduate will earn $48,520 per year beginning in 2019. Experience increases the college graduate's wages by the same formula as for the 18-year-old entering the workforce.

There is one additional consideration. Not all UM System campuses are necessarily the same. Based on evidence looking at monozygotic twins, there is a wage premium paid to a twin graduating from a large public research university compared with a twin graduating from a large public university. The analysis done by Behrman, Rosenzweig and Taub (1996) indicates that a person graduating from a large public university would earn 20.3 percent more in first-year wages than if the person entered the workforce directly from high school. Their evidence further indicates that person graduating from a large public research university would earn 31.7 percent more than if the person entered the workforce after high school. Hence, the wage premium for those attending the University of Missouri-Columbia (MU) is estimated to be $1.317/1.203$.[5] Thus, as a third option, we consider a person graduating from MU and earning $53,129 in 2019. We assume that an additional year's worth of work experience affects a college graduate's wages by the same percentage as it does for a high-school graduate. In other words, $\%\Delta W = 0.059 - 0.001 * \exp$.

Figure 1 plots what a person is expected to receive in wages for each of the three education options. Specifically, we project annual earnings for a high-school graduate entering the workforce, a

[3] In this comparison, we abstract from many issues that affect lifetime earnings. Each person is constantly employed once entering the workforce, a conservative assumption: the evidence finds persons with only a high-school education on average suffer more and longer periods of unemployment before retirement than college graduates.

[4] See https://nces.ed.gov/programs/digest/d14/tables/dt14_502.30.asp for the data on annual wage income by educational attainment level.

[5] There is an open question regarding graduates from Missouri University of Science and Technology. Based on size and focus, MST does not meet the criterion to be labelled a large, public university, as defined in Jere Behrman, Mark Rozenweig and Paul Taubman (1996), "College Choice and Wages: Estimates Using Data on Female Twins," *The Review of Economics and Statistics*, 78(4), 672-85.

person graduating from a large, public university, and a person graduating from a large, public research university. The plot covers the period 2015 through 2062, at which time the person would be 65 years old. For the first four years, the high-school graduate is earning more than the college attendees. However, in 2019, when the college graduate enters the workforce, wages are $48,530 for those graduating from a large, public university or $53,129 for those graduating from a large, public research university compared with $37,094 paid to the high-school graduate. By age 65, the high-school graduate is projected to earn an annual wage of $137,428 compared with the graduate from the large, public university earning $212,375 and the graduate from the large, public research university earning $323,500.

Figure 1

Annual Wage Income for Three Different Education Options

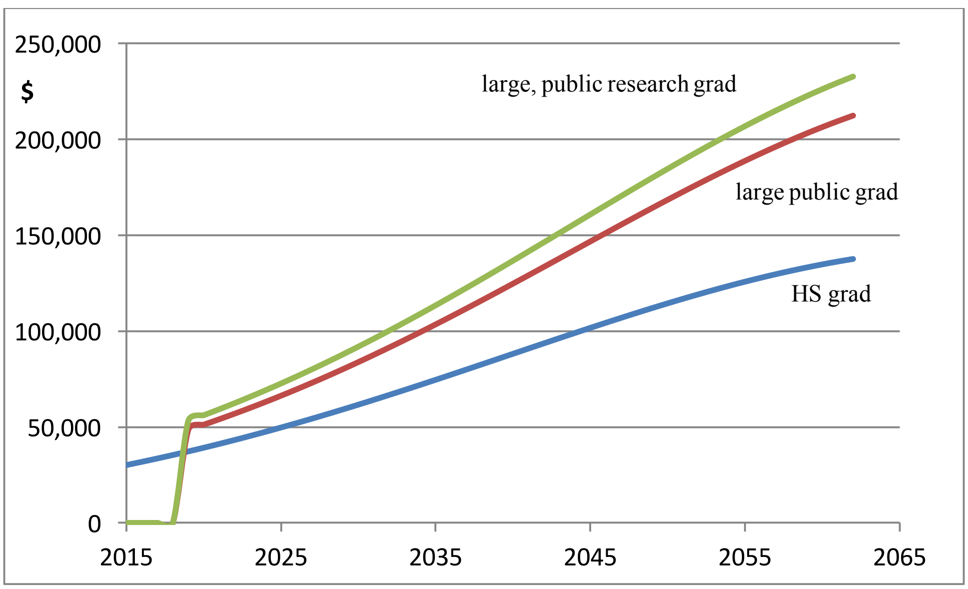


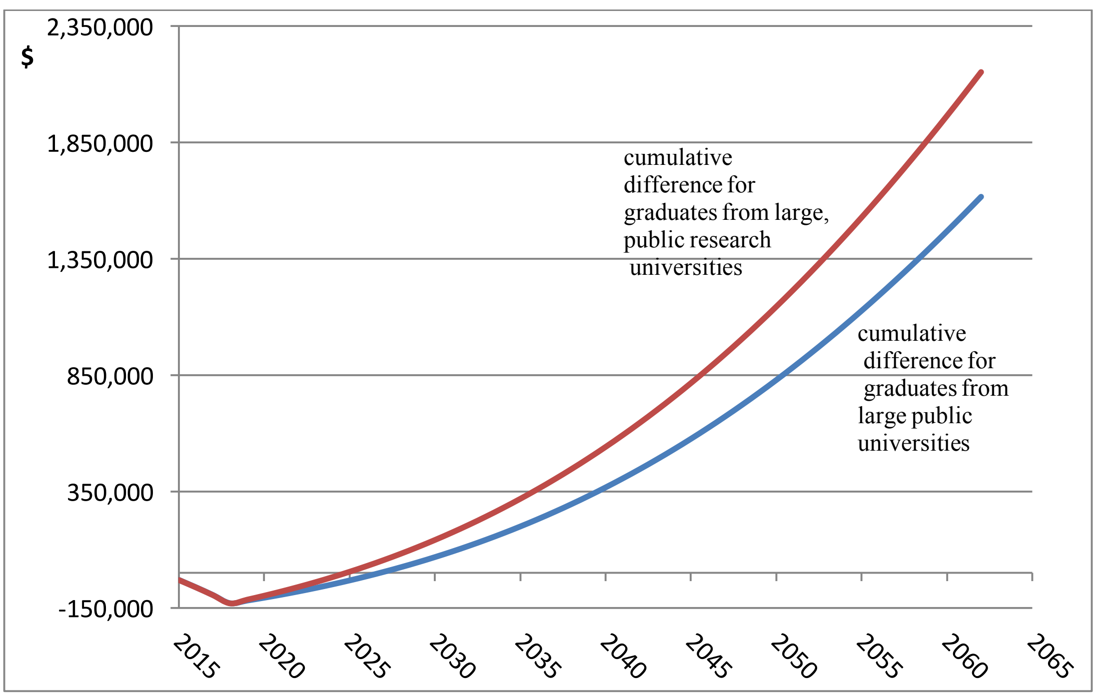
Figure 2 plots the difference in lifetime earnings at each age. In other words, we plot total earnings be for a person who attended university, subtracting the lifetime earnings of a person who entered the workforce. This difference is calculated at each age from 18 to 65. We compute total wages paid to those graduating from university and those entering the workforce after high school. We then compute the difference in total wages at each from age 18 to age 65. As the reader can see, the high-school graduate has an advantage for a while as the college attendees do not work. However, between 2025 and 2030, college graduates have caught up to the total wages paid to the high-school graduate. By age 65, the graduate from a large, public university will on average earn $1.62 million more than the high-school graduate. The person graduating from a large, public research university will on average earn $2.15 million more in wages than the high-school graduate.[6]

For the sake of completeness, we also consider an 18-year-old who opts for a bachelor degree and then a master's degree. For this person, wage income begins six years after high school. The average annual wage level for a person with a master's degree is $59,570. Figure 3 plots the difference in annual wages for a person with a master's degree and a high-school graduate, relative to no education beyond high school. At age 65, the person with a master's degree is earning $253,289 compared with the person with a high-school diploma who is earning $137,428. Over a lifetime, the person with the master's degree will on average receive $2.39 million more in wages than a person with a high-school diploma.

Figure 2

Comparing Lifetime Earnings for a

Bachelor's Degree with a High-school Diploma



The three figures are illustrative, but overstate the true benefit of collegiate degrees for our hypothetical 18 year old. Primarily, the figures treat a dollar received 47 years from now as if it were just

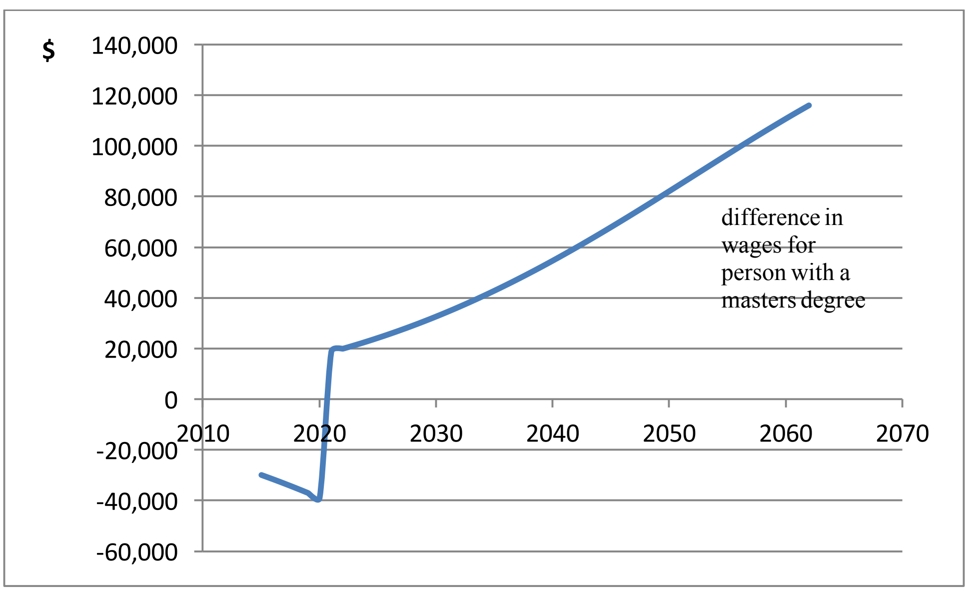
[6] To avoid rather extraneous complications, we assume average retirement at age 65 without regard to educational attainment. If by 2062, people are retiring at older ages, the differences we find here would be enlarged.

as valuable to our 18 year old as a dollar earned today. So we next convert those future values to present values.[7] Table 1 presents the present value of the difference in lifetime earnings for three options: (i) the large, public university graduate; (ii) the large, public research university graduate; and (iii) the master's degree. In each case, the difference is relative to the lifetime earnings of a person with a high-school diploma. In this analysis, we use the average, risk-free real return of 4 percent to discount future payments. The table indicates that the present value of graduating from a large, public university is over $400,000. In addition, a person graduating from large, public research university can expect to earn additional wages that are worth nearly $600,000 in present value terms compared with a high-school graduate. The average discounted value of a master's degree is slightly less than graduating from a large, public research university. This result owes chiefly to the small difference in starting salaries combined with the two-year wait for those earnings by a person with a master's degree.

Figure 3

Comparing Lifetime Earnings for a

Master's Degree with a High-school Diploma



[7] Many people are used to thinking about putting a dollar into a savings account today. The future value of that dollar, assuming it earns 5 percent interest, is $1.05 one year from now and $1.1025 two years from now. The $1.1025 two years from now is the future value of today's dollar. Present value is simply reverse engineering; that is, the future value of a payment, like future wages, is converted into what those future wages are worth today. If you borrow the present value amount today, you could purchase goods and services, using the stream of future wages to payoff that obligation.

In Table 1, we add a fourth case, in which a person with a master's degree earns in the first year of employment higher wages calculated at the average percentage wage change associated with each year of additional education. We refer to this case in Table 1, the fourth row, as the average return because it applies the average return to a year's worth of higher education rather than just taking the average wage level. Precisely, we assume a person receives a wage equal to the wage received by a person graduating from a large, public research university times the return to each of two additional years of education; formally, this average percentage change yields first-year wages $\$53{,}129*(1.129)^2 = \$67{,}720.$ Under the average-percentage-change assumption, the person graduating with a master's degree will receive wages equal to \$287,944 at age 65. And, as Table 1 reports, the present value of lifetime wages is \$858,197 greater than what a person with a high-school diploma receives over their lifetime.[8]

Table 1

Discounted Difference in Lifetime Earnings

for Three Options Relative to Earnings for High School

Education Option	Present Value of Lifetime Earnings
Large Public University	\$414,788
Large, Public Research University	\$588,621
Master's Degree (avg level)	\$584,054
Master's Degree (avg return)	\$858,197

Higher education is, among other advantages, an investment in skills. An opportunity cost is that a person foregoes investing in skills that would have been obtained through work experience during those four years. Based on the average market outcomes, the numerical analysis indicates that the return to higher education is greater than the return to work experience. We have ignored the investment cost of higher education. What we can say is that as long as the cost of higher education is not greater than \$414,000, the present value of returns to a university education exceeds its costs. While this explains why a person would invest in higher education, this is only the first step toward measuring the economic impact that UM has on the state economy.

[8] The four years of added education are already included in the calculations for a bachelor's degree.

The results indicate that not all universities are the identical. Students attending large, public research universities—which MU and quite possibly Missouri S&T—realize sizeable wage gains compared to ones attending public universities. Thus, one must reject the claim that students can substitute from the menu of identical state-funded schools without suffering any loss. Indeed, the evidence suggests that basic research creates an "income spillover" for undergraduates.

Discovering Knowledge and Growth

Basic research is one of the cornerstones of the university. While academic freedom is its hallmark, there is an underlying market test that applies. Researchers must produce results, answering questions that are valuable to society. Engineers create new materials, scientists increase our understanding of the building blocks of nature, and economists study how public and private ventures can be conducted more efficiently. Such discoveries are the foundations for technological progress. Technology combines inputs—labor, machines, buildings, and raw materials—to produce the final goods and services that people want. Indeed, it is such innovations, or technological advances, making it possible to produce either larger quantities or higher qualities (or both) of goods and services from given quantities of inputs. The value of final goods and services produced is how we assess whether an economy is expanding. At the end of this logic chain, universities' research and development is an important factor contributing to economic growth.

In this section, we use a model economy to quantify the effect that research and development spending (hereafter, R&D) has on productivity growth. More specifically, our approach is to derive a control path, or baseline, for the Missouri economy over a generation (conventionally, 25 years). We then reconsider the Missouri economy, assuming that R&D undertaken within the University of Missouri System for the same period is eliminated. The difference between the control path and the elimination path closely estimates the economic impact of UM System R&D on the Missouri economy.

Economists have made a simple observation: economic growth does not converge across countries; some countries continue to exhibit higher growth rates than others for generations. Researchers can account for the non-convergence as the outcome of decisions made by people, firms pursuing their self-interest, and public-sector decisions. The research has become known as "endogenous growth" models because the mathematical expression that solves for the equilibrium level of economic growth depends on behavior, including peoples' and firms' reactions to tax policies.[9] Government policies that affect R&D spending then affect productivity growth.[10]

Charles Jones (1995) developed an economic model that allows for the impact of R&D on productivity to vary with the stock of R&D.[11] More recently, Argentino Pessoa (2010) presented evidence that R&D is systematically related to economic growth in the United States. Pessoa offers a model in which there is free entry in the market for new technologies. The upshot is that while there is some markup on patents, there is a zero (expected) economic profit condition that applies to innovating companies.[12] We use a calibrated version of Pessoa's model economy to quantify the economic impact of foregone R&D.

We begin with a measure of the amount of R&D conducted by researchers in the UM System. The National Science Foundation (NSF) follows international guidelines, measuring R&D as resources spent on the creative work "undertaken on a systematic basis to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications."[13] (p.30) The 2012 NSF report offers a measure of domestic R&D spending by state. In Missouri, total R&D expenditures that year were $6,982 billion.[14] This is the denominator in a measure of the UM System's relative importance in state R&D. According to the fiscal year 2013 UM Budget Report, 2012 expenditures on instruction and research totaled $847.3 million.[15] Thus, UM undertook approximately 12.1 percent of Missouri's private R&D output in 2012.

The baseline path for the Missouri economy is built on the average annual growth rate for real GDP. Between 1997 and 2014, Missouri's real GDP increased at 0.93 percent annual rate. Thus, we construct

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[9] See, for example, Robert E. Lucas, Jr. (1988), "On the mechanics of economic development," *Journal of Monetary Economics*, 22, 3-42, Paul Romer, (1986), "Increasing returns and long-run growth," *Journal of Political Economy*, 94(5), 1002-37.

[10] The flow of R&D spending is for a year. These original models imply "scale" predictions: that the economic growth rate would double, for instance, if spending on R&D doubled. See Gene M. Grossman and Elhanan Helpman (1991), "Quality ladders in the theory of growth," *Review of Economic Studies*, 58, 43-61 and Phillippe Aghion and Peter Howitt (1992), "A model of growth through creative destruction," *Econometrica*, 60, 323-51. Empirical evidence, however, indicates that the number of U.S. scientists and engineers engaged in R&D quintupled between 1950 and 1987; the growth rate of per-capita real GDP did not quintuple, thus rejecting the hypothesis that scale effects exist in the data.

[11] Charles I. Jones (1995), "R&D-based models of economic growth," *Journal of Political Economy*, 103, 759-84.

[12] That is, on average, these companies attain just enough revenue to cover all costs, including opportunity costs.

[13] Source: Organization for Economic Cooperation and Development (OECD), *Main Science and Technology Indicators*, Volume 2002, No. 1.

[14] See http://www.nsf.gov/statistics/2016/nsf16301/pdf/tab14.pdf .

[15] Instruction and research are the two line items that seem most closely related to the NSF's definition of R&D activities. Because the expenditure accounts may not line up exactly with the NSF's definition, we excluded some budget items in effort to err on the conservative side of measuring UM System R&D.

the baseline path for Missouri real GDP by applying the formula: $Y_t = Y_{2012} * (1 + 0.0093)^{t-2012}$, where t denotes the future date and Y stands for real GDP Here, we consider $t = 2012, 2013, ..., 2036$.

The treatment is to remove the value of R&D undertaken in the UM System. With state R&D reduced by $847.3 million, the amount of R&D expenditures in Missouri falls to $6.132 billion. Pessoa specifies that total factor productivity growth is $\%\Delta \text{A} = \dfrac{\rho - \%\Delta Y}{\frac{\eta - 1}{\eta}\frac{\alpha}{R} - 1}$, where ρ is the discount factor, η is the markup rate for patents, $\%\Delta Y$ is the annual average growth rate of real GDP, α is the share of income paid to capital, and R is the share of real GDP spent on R&D.[16] Table 2 reports the values for computing the average annual growth rate for total factor productivity.

Table 2

Parameter Values for Computing Economic Growth

Parameter	Meaning	Value
ρ	Discount factor	0.96
$\%\Delta Y$	Annual real GDP growth	0.0093
η	Patent markup rate	1.2
α	Capital's income share	1/3
R (actual)	Actual R&D / GDP	0.2629
R (treatment)	Treatment R&D / GDP	0.231

We assume that the ratio of treatment (i.e., hypothetical) to actual total factor productivity growth is equal to the ratio of treatment to actual real GDP growth. Thus, the treatment value of Missouri's real GDP growth with no UM System R&D expenditures is 0.00737.With this treatment growth rate, we can compute the treatment path for real GDP. Formally, $Y_t^* = Y_{2012} * (1 + 0.00737)^{t-2012}$, where the "*" indicates the treatment value of Missouri real GDP.

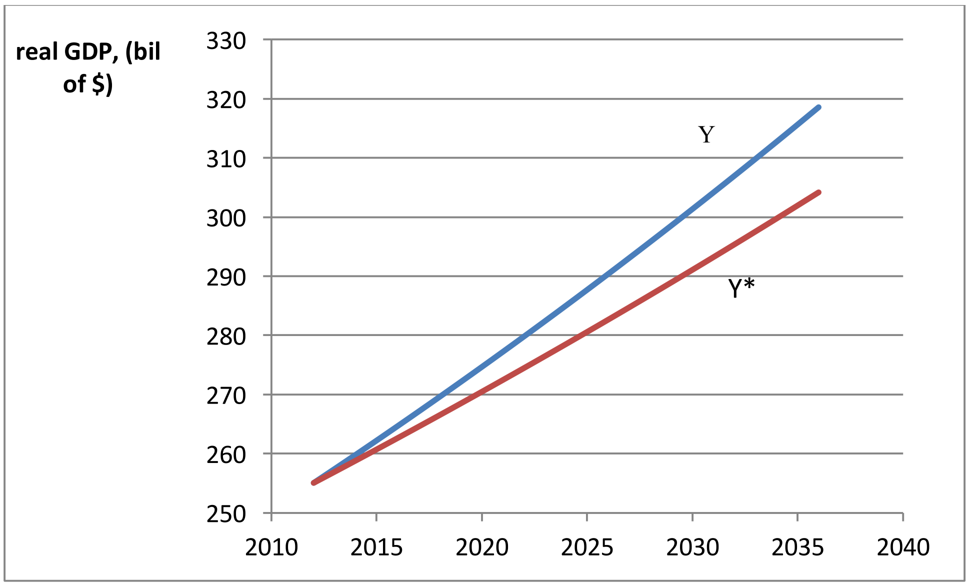
Figure 4 plots Missouri real GDP with and without UM System R&D spending. The blue curve is baseline path for Missouri real GDP while the red curve is the treatment path for Missouri real GDP when

[16] Total factor productivity is a scale factor that captures how technology combines labor and capital. Technological progress is, therefore, reflected by an increase in total factor productivity since a given amount of labor and capital will produce more real GDP. See Argentino Pessoa, (2010), "R&D and Economic Growth: How Strong Is the Link," *Economic Letters*, 107, 152-154.

UM R&D is zero. By 2036, the baseline value of real GDP is $318.5 billion. In contrast, without UM R&D, the 2036 projected real GDP is $304.2 billion. Within one generation, the cost of foregone R&D spending is $14.3 billion a year. In dollar terms, the total amount of real GDP lost is $168.1 billion over twenty-five years. If we discount future dollar values to their present value, the total value is $87.8 billion.

Figure 4

Baseline and Treatment Path for Missouri real GDP, 2012-2036



One critical part of measuring the economic impact of the UM System is to quantify the value of knowledge discovery. We apply an economic model that can account for the effect of R&D spending on economic growth. If the UM System were to vanish, UM R&D activity—that is, knowledge discovery—would vanish. For Missouri, the impact is to reduce the state's economic growth rate from 0.93 percent to 0.74 percent. Hence, our estimates indicate that UM R&D spending accounts for 19 basis points of Missouri's real GDP growth. The cumulative impact of UM R&D is then a straightforward calculation. Over the 25-year period, we compute the present value of differences in Missouri's real GDP with and without UM System R&D spending. By shutting down university R&D activity, we estimate that the present value of real GDP the Missouri economy loses over the next generation is equal to $87.8 billion.

Growth and Human Capital

Earlier in this report, we considered the microeconomic decision whether to attend a university. In this section, our aim is to measure the macroeconomic implications of that investment in human capital. In other words, with more productive people earning higher wages, what is the impact on Missouri's real GDP? We first need to address where the human capital is productive; specifically, we initially assume that the returns to investment in human capital produced at the UM System's four campuses will be paid to people living in Missouri. As we proceed with our analysis, we use data from each of the four campuses to compute the fraction of people graduating from the UM System four campuses. We then apply the fraction of graduates living in Missouri as a proxy for the fraction of human capital investment that produces goods and services in Missouri. Appropriate accounting will quantify the economic impact of human capital accumulation on the aggregate Missouri economy.

The first step is to provide a measure of what it costs UM to produce a year's worth of human capital. The human capital will generate returns in the form of higher productivity with increased wages to the workers possessing it. We use budget data for Fiscal Year 2013, adding together operations and total restricted monies spent on instruction, research, academic support, student services, institutional support, operations and maintenance, and scholarships and fellowships. These measure the resources expended by UM to produce a year's worth of human capital gained by the students attending the four campuses.[17] These expenditures totaled $1,282.37 million in 2012. Thus, $1.28 billion is the size of the investment in human capital produced by the four UM System campuses.

The next step is to compute the impact that this investment would have on the Missouri economy. As we did with the productivity change, we calculate the change to the economy were the UM System to vanish. In particular, we calculate first the impact of a one-year loss in human capital investment associated with a one-year disappearance of the UM. Such a loss will create a one-year gap in the production of final goods and services in 2012. With the smaller base of Missouri real GDP, we assume that the both the control and the treatment increase at the 0.93 percent annual rate for a 25-year period. The aggregate model treats the change as 'small' and uses a simple linear computation of the effect that the one-time change would have on the economy. Following Heckman, et al., and that literature, we assume the average real return on human capital is 12.9 percent.[18]

Figure 5 plots the baseline path for Missouri real GDP and the treatment path for Missouri real GDP if one year's worth of human capital investment through the UM is taken away. With each year of

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[17] Our approach is analogous to a National Income and Products approach to measuring public goods. In other words, we use the measure of costs for a public institution to quantify the investment by students, their families, and taxpayers.

[18] We use that literature as in, for example, Peter N. Ireland (1994), "Supply-side economics and endogenous growth," *Journal of Monetary Economics*, 33(3), 559-71.

education, on average, earning a 12.9 percent return, the amount of human capital lost will result in Missouri real GDP falling by $1.45 billion. Because the growth is applied to smaller base when human capital investment is reduced, the gap is getting larger over time between real GDP and the projected level without human capital acquired through the UM. By 2036, the control level of Missouri real GDP is $1.8 billion greater than the treatment level. If we sum up the lost real GDP associated with one year's loss of human capital investment, the 25-year total is $40.4 billion. Or, alternatively, the present value of the total losses in real GDP is $25.3 billion during the period 2012 through 2036.

Consider a permanent reduction in human capital investment. In other words, suppose UM's human capital accumulation is permanently removed; how is Missouri real GDP affected? The idea is that if the UM System stops operating, there will be a permanent decrease in human capital investment. For our purposes, we assume that the amount of human capital investment lost is the same each year. Thus, each year the value of inputs going into the Missouri economy shrinks by $1,282.37 million. The return to that investment is what amounts to lost real GDP each year. In contrast to our earlier experiment, however, the reduction in human capital accumulates year after year.

Figure 5

Missouri real GDP with and without 1 year's

Human Capital Investment through UM System

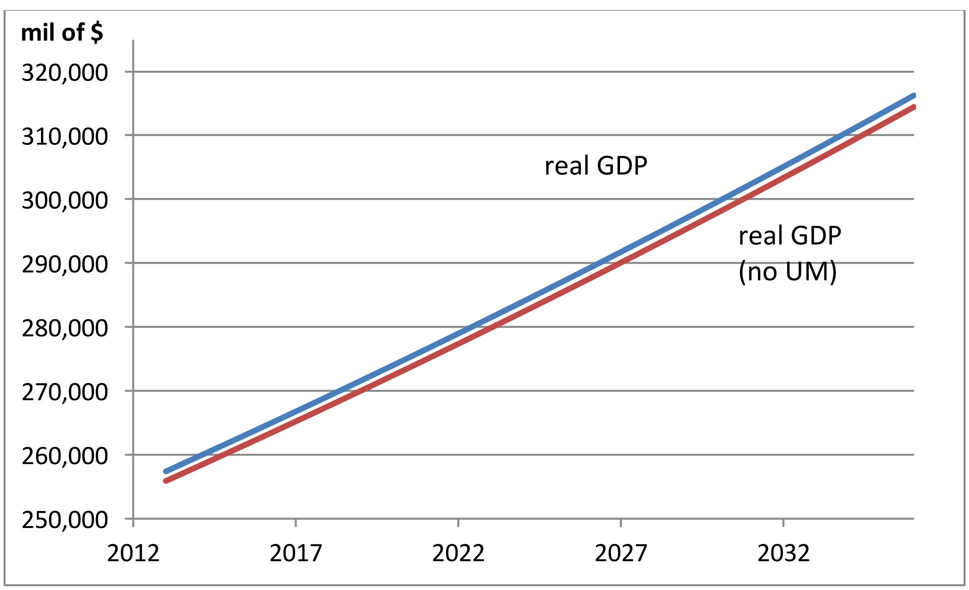


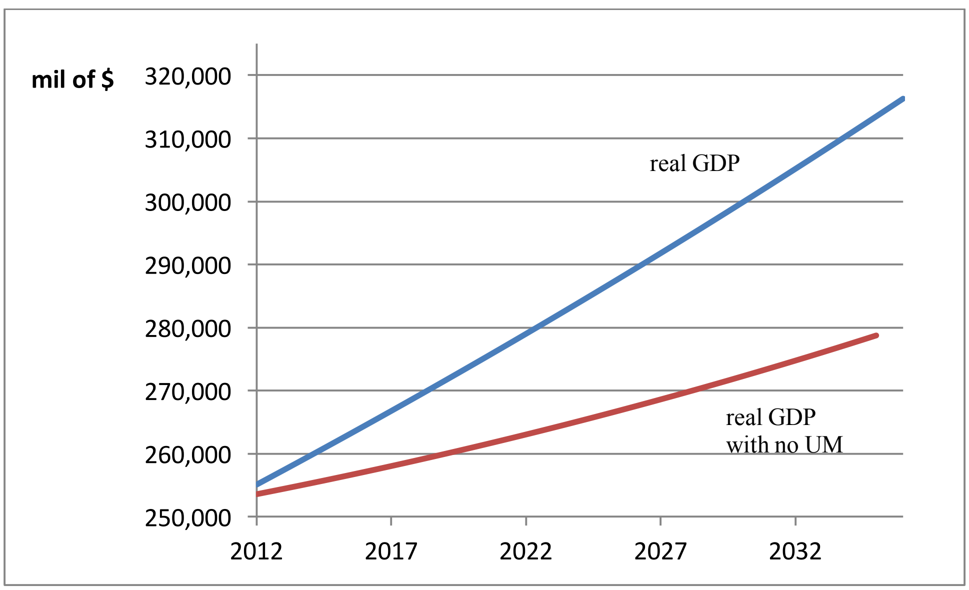
Figure 6 plots the value of Missouri real GDP if UM continues to operate and the growth rate continues to be 0.93 percent. It also plots Missouri real GDP with a permanent, annual reduction in human capital investment equal to $1,282.37 million. Note that by 2036, the projected value of Missouri real GDP is $280.1 billion in the case without human capital investment through UM. In twenty-five years, the human capital acquired from UM would result in Missouri real GDP being $36.2 billion lower. The cumulative, total loss to Missouri real GDP is $470.6 billion over twenty-five years. In present value terms, Missouri is projected to lose $252.7 billion in lost real GDP. Interestingly, the present value of total real GDP losses over twenty-five years is roughly equal to one year of Missouri's real GDP.

Note that the loss of real GDP associated with a reduction in human capital investment is not necessarily a loss solely borne by the Missouri economy. Indeed, the students investing in human capital via UM degrees are free to locate throughout the world. The main point of this analysis is to quantify the impact associated with losses of human capital that correspond to reductions in UM System resources. Next we incorporate data on the fraction of UM graduates residing in Missouri during their working life.

Figure 6

Missouri real GDP with and without a

Permanent Human Capital Investment through UM System



State Impact Calculations

This section reinterprets the key computations in the report in terms of dollars generated per dollar appropriated by Missouri's General Assembly to the University of Missouri System. In effect, we are characterizing our results in terms of the gross real rates of return—that is, principal and interest—that the State of Missouri sees on its appropriations to the UM System.

As we have stressed in the report, the only sensible way to evaluate these impacts is in a dynamic context. Accordingly, consider the following dynamic exercise. In Fiscal Year 2013, \$387.7 million of the UM System's operating budget came from State of Missouri appropriations (including performance funding). As a fraction of total unrestricted monies spent, state government appropriations accounted for 32.8 percent of UM spending. What would happen if the State of Missouri ceased appropriating monies to UM?

We approach the state appropriations question in the same way was have assessed the economic impact of the UM System. The appropriations change affects the path of Missouri real GDP with (the baseline) and without state appropriations (the treatment) over the period from 2012 through 2036. These appropriations, in part, pay the salaries and wages of faculty, staff and student researchers whose research attracts support from other sources; the National Institutes of Health, National Science Foundation, foundations and research divisions of corporations are prominent examples. Thus, the two principal ways in which our report has found that the UM System contributes to the growth of the Missouri economy—enhancing productivity of Missouri workers through research and development, and enhancing productivity through augmenting the human capital of UM graduates—result both from State appropriations and from the other support that UM research attracts. In our analysis, we assume that a 32.8 percent reduction in spending by the UM System would correspond to a 32.8 percent reduction in R&D and in human capital investment.

Two quick recaps. First, we find that over a 25-year horizon, UM research and development is directly responsible for \$87.8 billion (in present value) Missouri economy growth. Second, over the same 25-year horizon, UM human-capital investment losses result, in present value, total real GDP losses of \$252.7 billion. Thus, the present value of real GDP loss associated with a 32.8 percent reduction in UM spending, in billions, is $\left(\$252.7+\$87.8\right)*0.328=\$111.7.$ In other words, the absence of UM basic research and human capital investment results in the discounted sum of total real GDP *lost* equal to \$111.7 billion over 25 years.

What is the cost to the state of Missouri? Research spending adds to the growth rate of the state economy. Therefore, the \$87.8 billion over the 2012-36 period is a measure of lost real GDP for the state of Missouri. However, human-capital investment losses are incurred wherever the graduates live and work.. Based on data of the last decade's alumni with preferred mailing addresses in Missouri, the fraction of graduates earning UM degrees and residing in Missouri is pegged at 59.6 percent.[19] Suppose we compute the fraction of lost real GDP due to reduced human capital investment because of state appropriation cuts. Armed with that value, then we apply the 59.6 percent in-state ratio to obtain the lost real GDP for Missouri. By adding together the lost real GDP due to less R&D and the lost human capital

[19] This is a weighted average of the data reported by the four campuses' Alumni Associations.

investment living in Missouri, the present value of lost real GDP in Missouri is $238.4 billion. Now if we compute the present value of total state appropriations to UM over the same twenty-five year period, we get $6.204 billion.

Overall, per dollar reduction in state appropriations to the UM System, is associated with changes in real GDP. For this case, if the UM System vanished and so did state appropriations, The dollar spent per dollar generated by the UM is the amount of lost real GDP to the Missouri economy divided by the amount of state appropriations; that is, $\$238.4 \div \$6.204 = \$38.43$. On average, Missouri's Department of Revenue collects 3.8 cents per dollar of GDP. Multiplying $38.43 by 0.038 yields $1.46. That is, every $1 reduction in Missouri appropriations to UM reduces tax revenues by $1.46 in present value. To our knowledge, no other appropriations cut that might be considered actually gives the legislature less money to spend (again, in terms of a video, not a snapshot) on appropriations for other purposes. This one does.

The Last Decade

In 2007, we reported on the economic impact of the UM System. Nearly a decade later, people comparing the results in this report with that one will observe that there are differences.[20] If one were to simply compare the total impact of the UM System, the two reports are quite similar. The difference in the total economic impact due to some improvements in our methodology this time is less than two percent. However, there is a significant difference in the economic impact on the state economy. We identify the underlying reasons for the difference.

The difference between the summary impacts of the state appropriations is one place to start comparing the difference between the quantitative impacts across the two reports. In our 2007 report, each dollar of state appropriations resulted in $2.20 in higher state tax revenues upon accounting for the impact on economic growth through R&D and human capital investment. In this 2016 economy, the same two factors project that each dollar of state appropriations results $1.46 in higher state tax revenues. Why?

First, Missouri's economy has grown much less in 2008-16 than it did in 1997-2007. The average annual growth rate in Missouri's real GDP was 1.5 percent between 1997 and 2007. For the 1997-2014 period, the average annual growth rate for Missouri real GDP is 0.93 percent. Over the 1997-2015 period, only Michigan has grown at a slower rate than Missouri. The slower growth rate affects our calculations, especially, assessing the impact of R&D spending, by lowering the trajectory at which real GDP increases in our baseline calculations. After we study the treatment of reducing R&D spending in the UM System, the projected economic growth rate declines, but from a smaller "base." By plotting the trajectory of

[20] The previous study is available at http://eparc.missouri.edu/pubs/um_final.pdf.

Missouri real GDP over a generation, a reduction in the trajectory is smaller when the baseline growth rate is lower. Indeed, in our 12007 report, the projected 25-year impact of R&D spending on real GDP was over $200 billion compared with only $87 billion in this report.

Second, we have observed a reduction in the fraction of graduates of the four UM System campuses staying in Missouri. In our 2007 report, the fraction of graduates listing Missouri as their primary residence was 73 percent. In contrast, in this report, the fraction is 59.6 percent. The smaller fraction of those matriculating at UM System universities *and* living in Missouri will affect our economic impact on the state economy by more of the value-added of human capital leaving the state, less contributing here. At a fundamental level, the UM System brain drain is consistent with slower economic growth. Insofar as the economy's growth rate reflects the underlying opportunities for returns to higher education, it is not surprising that talented young people will opt to be productive in states with greater opportunities.

Third, we observe a decline in Federal support. In each year since 2010, the National Science Foundation reports that, of federal research funding going to the 34 public Association of American Universities (AAU) universities, the share going to the flagship campus MU (Missouri's only public AAU University) , has slipped, from at 1.05 percent in fiscal 2010 to 0.89 percent in fiscal 2014.[21] In addition, research personnel have shrunk within the UM System. The fraction of people occupying administrative positions has risen, offsetting a decline in the number of tenured and tenure-track faculty. We recognize that some of the restructuring is due to added "red-tape" requirements by Federal and State agencies. It is true, however, that taking resources away from basic research will affect the growth rate of Missouri's economy.

Summary

In this report, we quantify the economic impact the that UM System has on private economic outcomes and on aggregate, statewide economic outcomes. At the individual level, the effects of UM education is big. Even after converting to today's purchasing power, a bachelor's degree is worth at least an extra $400,000 in lifetime earnings for a UM System graduate. For a large, research university like MU, a bachelor's degree is worth an expected $589,000 in extra lifetime earnings.

Basic research is an important factor determining how fast an economy grows. It is through knowledge discovery that new materials are provided, new methods developed to structure business operations, and new treatments advanced. Our calculations indicate that over a generation, the State of Missouri would lose $87 billion in present value of real GDP if the basic research conducted by UM System researchers vanished.

[21] The most recent data published are from fiscal year 2014.

In addition, the UM System disseminates knowledge, providing students with skills that make them more productive in the workplace. A generation of human capital produced within the UM System is worth $252.7 billion. When we see how this affects the state economy and revenues collected by the State of Missouri, we get a localized measure of the economic impact. By combining the loss of human capital produced by the UM System and only considering those residing in Missouri with the cost of foregone R&D, the 25-year impact on the state economy is $238 billion. Thus, every dollar of appropriation accounts for over $38 of real GDP. Moreover, every dollar of appropriation returns $1.46 in the form of added taxes collected when the state economic pie is bigger.