Economic Impact of

The UM System

A report by

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Executive Summary

The University of Missouri System is comprised of four campuses and University Hospitals. The University, through its two primary missions—creating and disseminating knowledge—is an engine of economic growth. Economic research provides models that permit us to quantify the impact that these two activities have on the Missouri economy. Knowledge creation, through basic research, affects the economy as technological advancements. Such advancements mean that the same quantities of capital and labor produce more output. The bottom line is that basic research translates into faster productivity growth. Knowledge dissemination creates more productive workers through their human capital investment. No matter where graduates locate, the human capital investment produced by UM campuses increases their productivity, resulting in higher lifetime earnings.

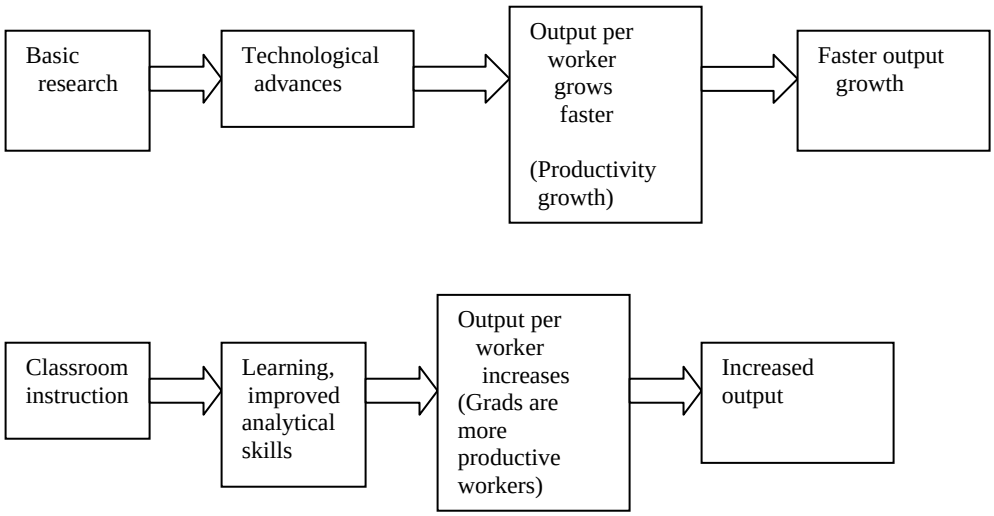
Key findings in our report are as follows:

- Basic research, mostly conducted at the Columbia campus, adds 1/3 percentage point to Missouri's productivity growth. Over the next twenty-five years, we find that the cumulative effect on Missouri's output is, in present-value terms, $212 billion.
- Graduates from UM campuses have invested in their human capital. One measured return comes in the form of higher lifetime earnings. Over a twenty-five year period, research indicates that the present value of earnings of a UM graduate exceeds that of a high school graduate by at least $175,000.
- Human capital investment creates workers with more highly developed analytical skills, problem solving skills, and communication skills. In addition to the internalized returns to this investment, society benefits from more productive workers. Based on the investment across the four campuses, we estimate that one year's worth of human capital produced by UM graduates adds $26.5 billion worth of additional output over a twenty-five year period.
- If we consider the continual improvement in human capital over the same twenty-five years, the cumulative, present-value impact is an additional $267 billion in output.
- Together, the human capital investment and the additional growth owing to basic research and development will add $359.7 billion to Missouri's output over the next twenty-five years. If state government appropriations remain constant in inflation-adjusted terms, our results indicate that the Missouri economy will add $57.83 for every one dollar appropriated by the state to UM. Moreover, we find that state revenues increase by $2.20 for every dollar appropriated by the General Assembly.

Measuring the direct impact of the University of Missouri (hereafter UM) on the Missouri economy might naturally begin with an operating budget report. The UM fiscal 2007 report shows total expenditures and transfers by the four campuses—Columbia, Kansas City, Rolla, and St. Louis—of $957 million. Including the hospitals and auxiliaries, the total would be $1,879 million. Including restricted funds, such as gifts, endowments, state appropriations and grants, brings the total to $2,160 million. By this measure, the UM System contributes about 1% of Missouri's Gross State Product (this term refers to the total output of final goods and services produced within the state's borders; below, we will simply refer to GSP as "output").

However, this accounting-based snapshot is woefully insufficient, omitting two main impacts that UM contributes to the economy over time. The University's principal mission is to create and disseminate knowledge. Figure 1 illustrates the links between these two activities and output. Knowledge creation is the outcome of basic research conducted at the four campuses and the University Hospitals. Knowledge dissemination is treated here (narrowly) as educating undergraduate and graduate students.[1] Neither impact shows up in a snapshot, that is, in a static measurement.

Figure 1



[1] Nobel laureate Gary S. Becker formalized the impact that higher education has on worker productivity in his 1964 book *Human Capital*.

Productivity growth

Calculus, the dynamo and the integrated circuit are three examples of innovations that mankind has developed over time. Technology combines inputs—labor, machines, buildings and raw materials—to produce the final goods and services that make up output. Innovations, or technological advances, make it possible to produce either larger quantities or higher qualities, or both, of goods and services from a given quantity of inputs. Productivity is output per worker; productivity growth is the rate at which productivity changes year-to-year, and is spurred by innovations.

This section first presents an economic analysis that links research and development spending (hereafter, R&D) to productivity growth. Second, it applies this analysis to quantify the impact that the University of Missouri's R&D activity has on the state economy.

Over the past twenty years, economists have sought to understand why economic growth does not converge across countries. Research has emerged to explain economic growth as the outcome of decisions made by people and firms pursuing their self-interest. These economic models have become known as "endogenous growth" models, as the mathematical expression that solves for the equilibrium level of economic growth depends on people's decisions, including their reaction to tax policies.[2] Government policies that affect R&D spending then affect productivity growth.[3]

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 spending.[4] Jones explained that labor employed in R&D activities exhibits decreasing returns. For one thing, more obvious, more valuable, more readily accomplished innovations are developed first. For another, the total number of innovations in a given year is retarded by duplication and overlap in basic research. Here we apply Jones' model to quantify the impact that UM research has on the state economy.

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[2] 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.

[3] 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 output did not quintuple, thus rejecting the hypothesis that scale effects exist in the data.

[4] Charles I. Jones (1995), "R&D-based models of economic growth," *Journal of Political Economy*, 103(4), 759-84.

First, the proportion of Missouri's R&D conducted by UM is measured. 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."[5] (p.30) With this definition in mind, NSF measures total Missouri R&D expenditures at $3,038 million in 2004. This is the denominator in a measure of the UM System's relative importance in state R&D. According to the fiscal year 2005 UM Budget Report, expenditures on instruction and research totaled $707.5 million.[6] Thus, UM undertook approximately 23% of Missouri's R&D output in 2004.

This 23% allows a comparison of the time path of Missouri output including UM R&D to an equilibrium time path that would be attained without UM R&D. Between 1990 and 2002, Missouri's per-capita output grew at a 1.56% annual rate. Missouri's population grew at a 0.9% annual rate between 1990 and 2000. Combining these, output increased at a 2.46% annual rate (setting aside the slight difference in time periods). This historical average serves as our reference point.

The first experiment is to determine the impact that UM System R&D has on productivity growth in Missouri. Suppose that UM System R&D is set equal to zero, with all other Missouri R&D expenditures unchanged. With this new parameter value put into Jones' mathematical expression for per capita output growth, the result indicates that Missouri's per-capita output growth rate would have been only 1.2% annually. Thus, according to the best available economic research, Missouri's annual productivity growth rate would decline by about 0.36 percentage points without UM's basic research.

As a useful illustration, let us project Missouri's output forward for one generation (a quarter century). In the baseline projection, UM R&D stays at 23% of Missouri R&D for the entire 25 years. In the alternative projection, UM R&D spending vanishes. Figure 2 shows the two projected paths for Missouri's output for the period 2007 to 2031. Because of the slower productivity growth, output is systematically lower in the alternative case ($0 UM R&D). Indeed, our projections indicate that UM R&D will have added $36,000 million to Missouri's output in 2031 compared to the zero-R&D case.

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

[6] 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 cumulative impact of UM R&D is then a straightforward calculation. Over the 25-year period, the differences in output along the two paths are computed. In order to take the time value of money into account, we discount these annual differences at a 4.167% real interest rate,[7] and sum their present values. Viewed this way, the cumulative effect is that Missouri's output is $212,000 million higher in present value with the R&D produced by the University of Missouri.

Human Capital Investment

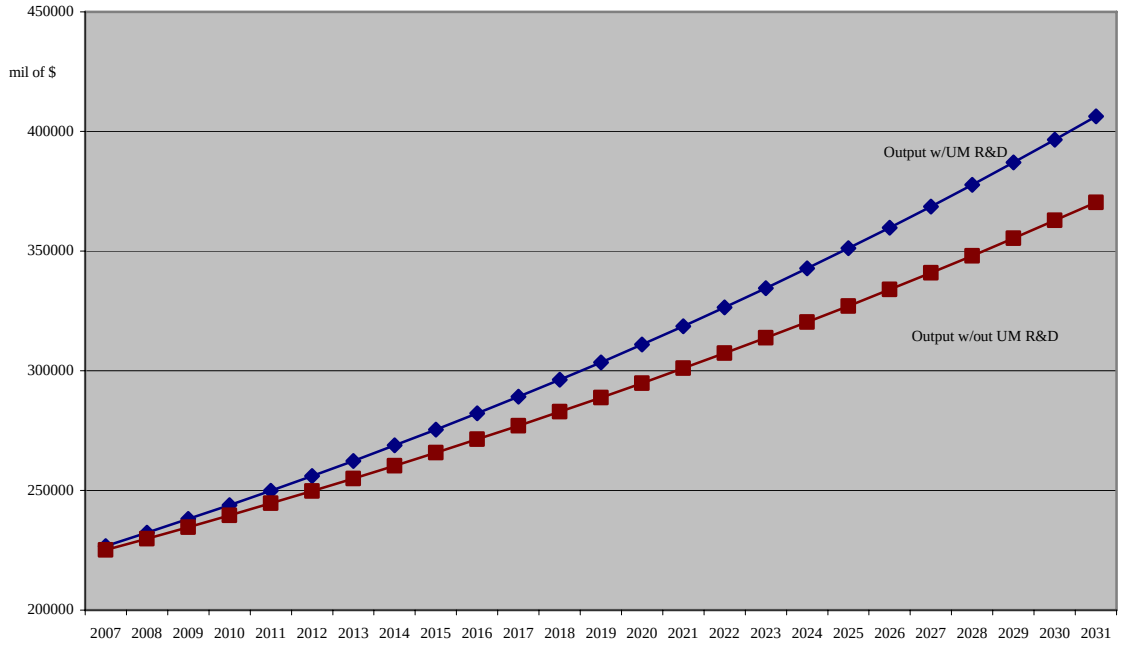
UM disseminates knowledge in addition to creating knowledge. Critical thinking and advanced problem-solving are investments students make, in part to augment their productivity (and earning power) beyond secondary-education levels. Gary Becker (1964) formalized the investment decision, noting that human capital investment, like any investment, must offer a sufficient return. Otherwise, people will forego the costly efforts needed to make the investment.

The purpose of this section is to quantify the impact that UM-provided education has on students' lifetime earnings. A cost is incurred each year that a UM student invests in higher education: tuition and foregone income from a full-time job (primarily the latter).[8] Thus, quantifying the impact requires comparing earnings streams with and without the investment in human capital and compute the net impact as the difference between the present values of the earnings streams with and without UM System-provided human capital investment.

[7] This real interest rate is standard in the literature, including the citations already mentioned. The particular number is chosen because calculations primarily use the multiplicative inverse of (1 +) the rate, which is 0.96.
[8] For simplicity, we omit the possibility that the student may have non-negligible income from part-time labor while attending college.

Figure 2

Projected paths for Missouri Output



Consider a typical eighteen-year-old in 2003. Option I is to go directly into the workforce, receiving real annual earnings of $26,280.[9] Option II is to defer working for four years, invest in a UM bachelor's degree, and enter the workforce in 2007, receiving annual earnings of $44,960. For each of the next twenty-five years, experience in the workforce generates a 2.1% real earnings increase. We compute the present values of the earnings streams from Options I and II for the 2003-2031 period (thus, 29 years of income for high-school graduates, 25 years of income for bachelor's-degree holders). The discounted sum of real earnings under Option II is $174,667 greater than the corresponding sum under Option I.[10]

[9] This value is obtained from the *Current Population Survey*, Annual Social and Economic Supplement (2006). More specifically, we use the sample mean for all people between 25 and 34 years of age, with a high-school diploma but no college degree. We also use the sample mean for college graduates 25-34 years of age from the same survey to obtain the starting salary for university graduates.

[10] In 1998, the Brookings Institution published a book by noted Stanford economist Roger Noll entitled *Challenges to Research Universities*. Noll discusses seminal research by 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], analyzing earnings differentials between female twins who made different college choices. Behrman et. al. find that "with respect to the types of public four-year institutions, the wage gain over a high school degree is 20.3% if an individual graduates from a large public college but is 31.7% if a B.A. degree is instead obtained from a large public research university. Thus, our estimates, which control for the selectivity of attendance at these two types of public and similarly priced institutions, suggest that

Finally, we aggregate across graduates to compute the market value of higher education investment in earning power for all UM graduates in a given year. To do so, the discounted sums of real earnings differentials are multiplied by the relevant numbers of graduates. In 2006, UMC granted 6,449 degrees. The other three campuses granted 5,874 degrees (we treat all degrees as if they were bachelor degrees). Together, the aggregate earnings from one year's graduating class is $4,598 million greater than it would have been had these graduates instead ended their education with a high-school diploma.[11]

Two conservative aspects of these calculations are noteworthy. First, not all degrees granted were bachelor degrees. A premium for master's, professional, and doctoral degrees is ignored.[12] Second, the estimate focuses only on four-year investments, ignoring the impact that each year of investment in a college education has on lifetime earnings (that is, the impact on students who take courses that do not lead to a degree). With over 63,000 students enrolled at the four campuses in 2006, the return on this investment is notably larger than our estimate.

Growth and Human Capital

These calculations of the value of three options only examine impacts on earnings. More generally, higher earnings will generate higher saving and higher capital accumulation. Accordingly, we turn to a more general economic model which can quantitatively assess the economic impact over time.

A measure of the dollar amount of human capital investment produced by the UM System comes first. Doing so sums expenditures on instruction, research, academic support, student services, instruction support, operations and maintenance, and scholarships and fellowships. The

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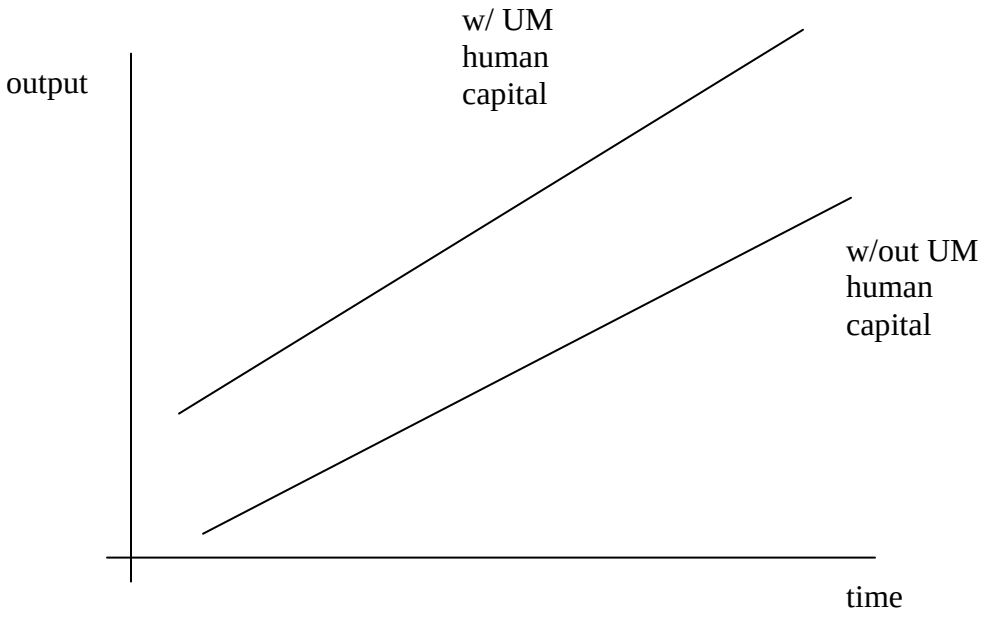
attending the large research 'flagship' university is advantageous in terms of post-college earnings." (p. 682) Using the ratio of those two percentages, Noll concludes "if other effects are held constant, identical twins who attended Ph.D. institutions earned [a] 50% higher" premium over high-school graduates. (p.72) A more recent significant contribution by Dan Black and Jeffrey Smith reconsiders the partial correlations between various measures of college quality, concluding that proper accounting would put the premium on attendance at a Ph.D. granting institution substantially above Noll's 50% benchmark. Based on this research, add Option III. Let Option III be identical to Option II with a 50% premium paid to those leaving an AAU Research University. Option III is designed to account for graduates of the University of Missouri-Columbia (UMC is the only public university in Missouri that qualifies for AAU membership). Option III assumes real earnings increase at the same 2.1% annual rate as in Options I and II. For the 29-year period spanning 2003-2031, the discounted sum of real earnings of a graduate of an AAU Research University is $553,904 greater than the discounted sum of earnings of a high school graduate.

[11] The market value of all degrees granted to UMC graduates in 2006 is 6,449 x $553,904. The market value of the degrees granted by University of Missouri campuses in Kansas City, Rolla and St. Louis is 5,874 x $174,667.
[12] Noll (1998) cites evidence that this premium is larger than the premium on bachelor's degrees.

notion is that these items are involved in producing a year's worth of human capital investment.[13] These expenditures totaled $1,193 million in 2006. Of this, $660 million is investment made at UMC. In order to quantify the impact that this investment had on the economy, we compare a one-time change in the amount of human capital that is equal to our annual measure of human capital investment made by the UM System. The aggregate model treats the change as 'small' and use a simple linear model to compute the effect that the one-time change would have on the economy. Our analysis assumes the average real return on capital is 6.5% for investment.[14]

Next, we compute the market value of output produced by the human capital investment undertaken at campuses in the UM System. This compares, over time, levels of output produced with and (counterfactually) without human capital investment occurring on UM campuses. Calculations correspond to those for R&D above. First consider the gain in output from one year's investment as the product of $1,193 million times 1.065. In terms of a picture, the one-time increase in human capital produced by UM shifts the path for output up relative to the baseline path. (See Figure 3.)

Figure 3



[13] 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.

[14] See, for example, Peter N. Ireland (1994), "Supply-side economics and endogenous growth," *Journal of Monetary Economics*, 33(3), 559-71.

The vertical distance between lines at a particular time is the change in output owing to UM-incurred human capital investment. Over time, we compute the discounted sum of these differences.

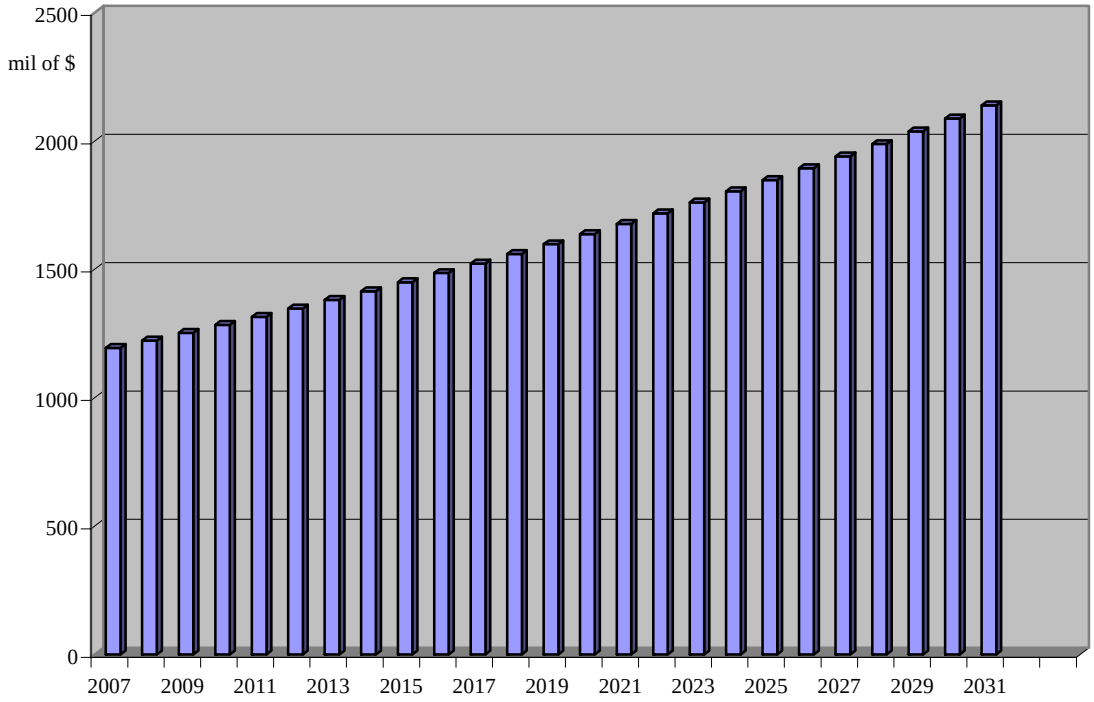
Consider the following experiment. Suppose that we take the human capital investment from a single year, following the impact on output over a twenty-five year period. We refer to this case as the measurement of one-time human capital investment. Next, compute the product of the investment and the gross real return to human capital. This product is the measure of the impact that the human capital investment has each year on the equilibrium level of output.[15] Our results indicate that the one-time impact of the human capital investment by the UM System is small in any one year, increasing from $1,271 million in the first year of the investment, to $2,277 million in 2031. The discounted sum, however, $26,245 million over the twenty-five year horizon, is large for a one-time investment in human capital.

It is important to note that the gain in output from the human capital investment is not to be interpreted as the gain in Missouri's output. Indeed, the graduates embodying these UM-produced human capital resources are free to locate throughout the world. Accordingly, the estimate measures the increased output that arises from UM human capital investment, wherever these graduates are employed.

Consider now a case in which human capital investment in UM graduates is taking place continually over each of the twenty five years. In other words, there is a new investment produced by UM each year. The upshot is that each year's investment would effectively shift the line in Figure 3 further and further above the line representing no UM human capital investment. More specifically, suppose human capital investment produced by UM grows at the same rate as the economy; that is, at a 2.46% annual rate. Figure 4 plots the differences in output due to the UM human capital investment over time.

[15] Note that along the balanced growth path, additional human capital investment will be made. Here, the experiment treats the 2007 level of human capital investment produced by UM System campuses as a one-time shock. The shock shifts production up by the product of the investment and the gross real return to capital. The new path for output is, therefore, permanently higher than the path without the one-time shock.

Figure 4



This calculation follows the same procedure as in the one-time investment case, except now taking into account the additional investment occurring each year. Corresponding to the assessment of the impact of a one-time investment, we compute the discounted sum of the differences in output stemming from UM human capital investment and the baseline case. The increase in output sums to $267,013 million, which happens to be about one year's worth of output of the Missouri economy. The 25th year's additional output is calculated to be $43,189 million. If Missouri's output were to continue to grow at a 2.46% annual rate, it would reach $396,210 million in that 25th year. Our results indicate that the output produced by human capital investment incurred at UM campuses would be more than 11% of Missouri's output in 2031.

Impact Estimation Conservativeness

The economic impact of the knowledge creation and dissemination of the University of Missouri runs into the hundreds of billions of dollars, when viewed in the proper dynamic context. UM R&D, over a quarter century, adds in present value $212 billion to Missouri's output. Over the same time frame, UM's graduates add $267 billion in productivity to the economies where

they work. The bachelor's degrees that UM grants in a single year add $4.6 billion in present value to the lifetime earnings of those graduates.

Our estimates—sensible, scholarly and substantial—presumably underestimate by a considerable amount the full impact of the University of Missouri on the economy and the quality of life in the State of Missouri, in several dimensions.

First, only those aspects we could measure unambiguously, and model straightforwardly, impact these estimates. Only those research and development expenditures *directly* made by the UM System impact the rate of growth of the Missouri economy. UM research, as mentioned, is about 23% of all research and development in the state. It is surely the case that some of the other 77% results from the research UM conducts. Private-sector research firms located in Columbia, using MU faculty as founders, officers or advisers, employ well over 500 Missourians. Four of the five VA Medical Centers in Missouri are in cities with UM campuses; two have close relations, with VA researchers collaborating on projects with UM faculty.

Second, it is likely that the proven added economic benefits of getting a degree from a research university are not fully captured by the higher level of wages drawn from careful studies. Over years of employment, the productivity of an employee exposed to a research environment is likely to grow faster, and to yield higher raises. Both our growth model and our wages model would show greater impacts if this factor were built in; however, no serious economic studies have yet begun to tie down the relationship between college quality and individual rates of productivity growth. It is also well established that workers do not capture the full impact of their human capital. In particular, workers in Missouri who do not have a UM education will have higher productivity, and earn higher wages, if they work in teams where some teammates have UM educations.

Third, those obtaining graduate and professional degrees from a Ph.D.-granting university substantially out-earn those obtaining the same degrees from schools less oriented toward research; the degree to which this happens is roughly known (Noll comments on it), but has not been incorporated in our models. These aspects insure that our earnings estimates above are conservative.

Fourth, Missouri businesses and non-UM graduates are led to more valuable economic efforts because they compete with UM graduates and UM-produced activities. Journalists strive to compete with UMC Journalism School grads; artists compete with, and are inspired by, UM-trained artists. Moreover, audiences are drawn to performances, and buyers to artistic exhibitions,

to a greater extent because of talent nurtured by UM. These economic impacts, too, have been omitted.

Major aspects of these latter activities go well beyond economic impacts. The quality of life in Missouri is higher because of the finer arts education that artists trained by UM incorporate in their paintings, performances, and the like. University of Missouri Hospitals and physicians improve the quality of life of hundreds of thousands of Missourians. The quality of newspapers and broadcast journalism statewide is influenced by the presence of the UMC Journalism School. Many dentists know they have the option of contacting UMKC Dentistry faculty if an unusual problem arises, and optometrists the option of contacting UMSL Optometry faculty. Many engineers similarly can rely on UMR faculty. Also, Missouri farmers and agribusinesses have higher yields due to the efforts of MU researchers and extension agents—this aspect, the higher yields, has been incorporated in our estimates. That they can relax more because they know they've employed the best techniques has not been.

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 University of Missouri 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 2006, $389.8 million of the UM System's operating budget came from State of Missouri appropriations (including formula funding). For a dynamic impact, we assume a 25-year period, fiscal 2006-30, in which State appropriations to the System's operating budget increase exactly at the rate of inflation, so that the real or inflation-adjusted level of appropriations is constant. This assumption is made solely to obtain a clean rate-of-return calculation; it does not match the recent history of inflation-adjusted appropriations levels. Moreover, our report shows that the UM System is the principal engine of growth of the Missouri economy, and this assumption rules out any of that growth finding its way back into that growth's principal engine. In particular, this assumption envisions an unwise scenario in which state appropriations to the System are a continually falling fraction of State expenditures. Nonetheless, it is the assumption that makes determination of a

returns on State appropriations to the UM System as straightforward and transparent as a legitimate calculation can be.

These appropriations, in large part, pay some of 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.

Our study has found that, over a 25-year horizon, UM research and development is directly responsible for growth of the Missouri economy equal in present value to $212 billion. Over that horizon, human capital investments in UM graduates yield economic growth equal in present value to $267 billion. It is conservative, though to a negligible error, simply to add these impacts. However, not all UM System grads provide their human capital in-state; some leave Missouri for jobs elsewhere. The best available data on the extent to which this happens comes from "Destination Study: Graduation & Employment Survey Results, 2005-06," produced by the UMC Office of Enrollment Management. Their most recent results are typical: when surveyed last fall, 25% of UMC's 2006 Bachelor's degree recipients had gone on to graduate education (many at MU); of the remaining 75%, 73% had taken a job in Missouri. Of those alumni for whom the MU Alumni Association is able to obtain current addresses, the decline in the fraction remaining in-state is very small, comparing recent alumni to those who graduated 10 or 25 years ago.

For our estimate, we will multiply the 75% finding jobs times the 73% remaining in Missouri to yield an assumption that 54.75% of the increase in output due to the human capital investment in UM graduates is an increase in Missouri output, with the remaining 45.25% adding to output in other states or outside the US (and thus ignored for a rate-of-return calculation). The 54.75% number is conservative based on MU Alumni data, and assumes that the number of students turning to employment in Missouri after graduate education at MU or elsewhere do no more than counteract those graduates in their cohort who take their first job in Missouri and later move elsewhere. (Data from UMKC also suggest considerable conservativeness of this estimate, while recent data from UMSL is of less use due to changes in definitions (but appears supportive),

and that from UMR affected by an unusually high number of recent graduates that did not report successfully getting employment.)[16]

To assess the impact on the state economy, we can add together the two economic impacts. After taking into account the human capital investment enjoyed by Missouri residents and the faster growth attributable to basic research and development, we want to consider the funding source. In particular, we are interested in quantifying the number of dollars spent by the State of Missouri on the four campuses compared to the total economic impact. As such, we are measuring the extent to which State monies are leveraged by the activities conducted in the University of Missouri System.

To begin, note that the state of Missouri appropriates $389.8 million to the UM System in 2006. Suppose that this appropriation increases at the rate of inflation for the next 24 years. The present value of this stream of state spending is $6.2 billion over the next generation. Further suppose that the UM continues to produce basic research and human capital investment. Combined, we estimate that that the present value of the stream of additions to Missouri's output over the same twenty-five years is $359.7 billion. In other words, for each dollar that the state appropriates to the UM System, the Missouri economy generates $57.83 in additional output owing to the return to UM human capital investment and to faster productivity growth due to UM graduates. Based on historical standards, state net general revenue is about 3.8 percent of output. When viewed through the prism of state government, every dollar put into the UM System by the state government will yield $2.20 in state revenue.

To illustrate how important this is, consider a favorite economic development tool—an investment tax credit. Suppose there is a 6 percent credit on investment spending in Missouri that lasts for four years and applies to up to $1 billion of capital spending. Over the next twenty-five years, the additional physical capital will generate $1.8 billion in additional output after adjusting for the time value of money. The present value of the state's spending on revenue reduction due to this tax credit is about $213 million. Thus, each dollar "spent" on the investment tax credit yields $8.37 in additional output. In terms of the impact on state coffers, each dollar spent by state government brings ***32 cents*** back into state coffers. Higher education provided by the UM System begins to look pretty good by comparison.

[16] At any rate, while UMC graduates number 52% of the total, our study shows they provide fully 78% of the added productivity due to human capital investments.

Concluding Summary

This study examines and quantifies the economic impact of the University of Missouri System. Our approach measures the direct impact of UM in terms of its spending. However, the economic impact owes more to the UM System's deliverables than to its static size. The origin of UM's economic impact lies in basic research and in higher education yielding human capital formation.

Economic research has understood that higher education produces returns in the form of high lifetime earnings. A University education gives students opportunities to develop stronger analytical skills, build critical thinking, and begin their professional development. Economists group these activities as investments in human capital. Using widely cited economic studies, we quantify the size of this investment and translate into a quantitative measure of the increase in the *level* of output due to UM graduates' human capital.

Basic research creates new technologies—such as new, lower cost products and new ways of producing output—that also have economic impacts. Indeed, technological advancements resulting from research and development efforts at the University of Missouri System increase the *growth rate* of goods and services produced in Missouri. Through the effects of compounding, UM R&D produces large gains for the state economy.

Together, human capital formation and productivity growth are not captured by a single snapshot. Rather, the gains to the Missouri economy are only sensibly evaluated over time. We find that the next generation of UM grads and UM R&D will raise the Missouri economy substantially. Research and instructional spending by the University of Missouri System will add $359 billion, after discounting, to the Missouri economy. Our evidence demonstrates that the UM System offers an excellent return to Missourians, strongly dominating the returns offered by other economic development plans under consideration.