Inquiry: The University of Arkansas Undergraduate Research Journal

Volume 4 Article 11

Fall 2003

The Impact of Intrastate Variations in Higher Education Funding on Intrastate Research and Development Expenditures

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THE IMPACT OF INTRASTATE VARIATION IN HIGHER EDUCATION FUNDING ON INTRASTATE RESEARCH AND DEVELOPMENT EXPENDITURES

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Abstract:

The paper examines the question "Does specialization in higher education result in improved economic outcomes for a state as measured by increased research and development (R&D) in the state?" A fixed effects model is employed to estimate how the variation in state funding per pupil across institutions of higher education (a measure of specialization) impacts R&D funding in the state. Expenditure per pupil data from the Integrated Postsecondary Education Data System (IPEDS) from 1992-2000 for the approximately 600 public, 4-year institutions in the U.S., is used to capture the variation in state funding in institutions of higher education. The results of this study indicate that an increase in the proportion of a state's funding appropriated to higher education leads to a statistically significant increase in R&D expenditures in that state. The policy implication of this finding is a greater proportional investment in higher education implies a significant return on investment. The study also indicates that an increase in the variation of state expenditures per pupil leads to a positive, but not statistically significant, increase in R&D expenditures in that state. The data suggest, albeit weakly, that specialization in higher education funding leads to improved economic outcomes for the state as measured by R&D expenditures.

"There was that law of life, so cruel and so just, that one must grow or else pay more for remaining the same." - Norman Mailer, The Deer Park

Introduction:

The role of education is to facilitate the realization of the potential of each citizen, the economy, and society. Higher education is specifically undertaken to create opportunities for moving beyond our current state. However, investments in creating such opportunities come at the expense of other programs that require public funds. Therefore, the efficiency of education funding is a particularly crucial matter due to the stagnant, if not decreasing, resources available for higher education. With the strain on these funding resources, it is imperative to allocate them in the most organizationally efficient and effective way. The introduction of new graduate degree programs and the duplication of degree programs which is occurring within Arkansas and throughout the nation raises questions regarding the logic behind the expansion of expensive graduate programs which must come at the expense of alternate uses for the funds including targeted funding which encourages research activity at research institutions. The potentially inefficient allocation of state funds is one factor affecting the current amount of Research and Development (R&D) dollars available to research universities. It is necessary to determine whether those responsible for dispersal of funds are being responsible stewards of the taxpayers' money. To responsibly allocate funds, legislators must be aware of structural efficiency issues to correct any structure-based problems in allocations of educational funding. They need to have relevant information regarding the impact their decisions can and do have upon economic factors such as education. More importantly, they must understand that failure to maximize educational outcomes implies the state's economy is operating at less than its potential.

Literature Review:

The role of knowledge in economic growth is an increasingly popular topic. Economists are continually adapting traditional growth models to account for science and technology applications stemming from higher education. The general link between specialization, increased productivity, and increased economic outcomes has been established for several centuries. Adam Smith's

The Wealth of Nations, which was published in 1776, was one of the first works to establish this link and opened the door for future research. The work opened with a description of the manufacturing of pins and describes how specialization of labor increases the productivity of the workers as a whole (Landry, 1997). In the production process, he detailed that those with strengths in an area should take on the responsibility for that area with the phrase, "as one man draws out the wire, another straights it, a third cuts it" (Fajardo-Acosta, 2003). His work had two main themes. The first involved how increasing the division of labor increased the productivity of labor. He emphasized specialization as a key factor in this increase and pointed out a desire for a higher standard of living as the motivation behind it.

The second theme related to the limits of division of labor depending upon the size of the market. He stressed that large markets are essential to the division of labor and to high productivity (King, 2003). Smith discussed the link between higher productivity and higher income, and then connected this to increased demand and larger markets. He discussed the propensity to exchange, which leads to division of labor, thereby increasing productivity (Kilcullen, 1996).

Many may argue that technology is responsible for advancement in productivity. Adam Smith argued that the division of labor enabled technology to develop and progress, and therefore, specialization of labor is the key to material well-being (Kilcullen, 1996). Our standard of living is affected by three variables: productivity of labor, the division or specialization of labor, and the size of the market (Kilcullen, 1996). Smith expanded upon the policy of Europe and how irresponsible allocations of public funds for education only led to economic downturn (Kilcullen, 1996). On the division of labor Adam Smith specifically stated:

> "Those ten persons, therefore, could make among them upwards of forty-eight thousand pins in a day. Each person, therefore, making a tenth part of forty-eight thousand pins, might be considered as making four thousand eight hundred pins in a day. But if they had all wrought separately and independently, and without any of them having been educated to this peculiar business, they certainly could not each of them have made twenty, perhaps not one pin in a day; that is, certainly, not the two hundred and fortieth, perhaps not the four thousand eight hundredth part of what they are at present capable of performing, in consequence of a proper division and combination of their different operations *(The Library of Economics and Liberty, 2003: 5)."*

While it may be one of his more quoted phrases, Smith used the "invisible hand" analogy only two times in his publications.

> "every individual necessarily labours to render the annual revenue of the society as great as he can. He generally, indeed, neither intends to promote the public interest, nor knows how much he is promoting it. By preferring the support of domestic to that of foreign industry, he intends only his own security; and by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention (2003, 5)."

These comments are applicable to the higher education system in the United States. Education and educators are the hand guiding our youth to prosperity, and in doing so, stimulating the economy through increased productivity and technological advancement. Smith's work has been long established, and the fact that specialization generally leads to better outcomes is proven; however, the link between specialization in higher education and improved economic outcomes has not been established.

Another noteworthy economist, David Ricardo used the example below to illustrate the importance of specializing in the most efficient ways according to strengths and to avoid duplication of work if it is not necessary or the most efficient means:

> *"To produce the wine in Portugal, might require only the labour of 80 men for one year, and to produce the cloth in the same country, might require the labour of 90 men for the same time. It would therefore be advantageous for her to export wine in exchange for cloth. This exchange might even take place, notwithstanding that the commodity imported by Portugal could be produced there with less labour than in England. Though she could make the cloth with the labour of 90 men, she would import it from a country where it required the labour of 100 men to produce it, because it would be advantageous to her rather to employ her capital in the production of wine, for which she would obtain more cloth from England, than she could produce by diverting a portion of her capital from the cultivation of vines to the manufacture of cloth* (2003: 3).

In the 21st century, program duplication in university systems within states is one example of a domestic problem that leads to financial inefficiencies. A study commissioned by the Arizona Board of Regents in 1988 studied the internal and external needs for program duplication, the need to avoid duplication in the absence of a need for duplication, why avoidance was a more efficient system than elimination of programs once they were in place, and how university structures and systems do and could review programs before they are implemented. The study emphasized the need for accountability for resources allocated to public universities through continual review of the procedures used to both begin new programs and sustain the existing programs. Other studies pertaining to program duplication, especially those in Montana and Colorado were reviewed by Arizona (Macvicar, 1988).

Another study by Owen Cargol in 1983 stressed the importance or limiting program duplication and referred to the topic as "a bugaboo in discussions of higher education" (Cargol, 1983: 2). Cargol discussed the decline in government support for higher education that caused budget cuts that may result in selective or sweeping cuts. He discussed the varying levels of program initiation policy by state. The report details the current policies for program review and creation. Fifteen states currently practice a "review and recommend only" responsibility for existing programs. State boards or commissions are given "review and approval power" in thirty-one states (Cargol, 1983: 3). Cargol contended that this level of oversight was not enough to push our institutions to become more efficient on a statewide basis.

The connection between improved economic outcomes and university research has been established on an international level. One of the more recent works is a study by Fernand Martin in 1998. His examination of Canadian university research revealed that university research is a powerful stimulus for economic development, producing measurable increases in GDP and employment. According to his study, university research accounted for one percent of Canada's GDP and more than .05 percent of all jobs. He also found that university research had a "profound effect on the underlying productivity of the economy" (Martin, 1998: 2). His report revealed that university research equipped students with the ability to generate new ideas and that companies benefited from this research by hiring graduates with knowledge and research skills. "The total dynamic impact of university research is approximately $15.5 billion each year, which is equivalent to about 150,000 to 200,000 jobs" (Martin, 1998: 2). Martin used Total Factor Productivity (TFP), the economic growth that results from increases in the efficiency and productivity of labor and capital, to quantify productivity growth. While his work provided a convincing link establishing the importance of university research to economic growth, it did not suggest specific methods for comparing specific institutions and making university allocations more efficient, nor did it examine the impact of university research in the United States.

Several recent studies discuss growth models in relation to R&D in the United States. One such study by Charles Jones suggested, "growthÖis generated endogenously through R&D and growth in the economy is tied directly to growth in productivity, which in turn depends on the discovery of new designs through R&D" (Jones, 1995: 759). Another study seeking solutions to the European Union's attempt to close the gap with the US in income per capita states that investment in human capital, through education, and R&D are "essential for high productivity in all industries", especially high technology industries (Corley, et al.; 2002). Two studies by Paul Romer published in 1986 and 1990 in the *Journal of Political Economy* discussed previous growth models and the theoretical gaps left by them due to dependence on exogenously specified population growth and its relationship to per capita income. The gap was widened by "the loose treatment of specialization as a form of increasing returns with external effects" (Romer, 1986: 1034). He attempted to fill the gap by providing a model with both increasing marginal productivity of knowledge and decreasing marginal productivity of physical capital (Romer, 1986). The second study by Romer created a model where growth is driven by technological change arising from "intentional investment decisions made by profit-maximizing agents" (Romer, 1990: S71). It concluded that human capital determines the growth rate of the economy and subsidizing the accumulation of total human capital is positive (Romer, 1990).

In September 2002, the Milken Institute's *State Technology and Science Index Research Report* for the U.S. provided a current link between increasing the knowledge base of a state's population through university degree programs and research and increased economic outcomes. It detailed the "intangible economy", those factors that contribute to economic outcomes, and the importance of research in developing the economic progress within a state. Stress was placed upon the importance of higher education for direct research, providing a knowledge-based workforce, attracting industry, and the creation of technology clusters. These technology clusters have a tendency to develop and remain in regions with existing research and development operations, such as institutions for higher education. (DeVol, 2002). A key finding in the report states "those states with vibrant technology clusters will experience superior economic growth" (DeVol, 2002: 5). The report also finds that human capital is driven by the ability to attract and leverage science and technology assets (DeVol, 2002). The efficiency in university-based research and development, however, limited or expanded R&D's ability to be a driver of economic development. The Milken Report authors argued that R&D dollars must be spent wisely within the states. It used the Academic R&D dollars per capita to illustrate the importance of university research, and outlined a connection between allocations to universities based upon strength and competence of the university systems. It addressed the importance of the percentage of a state population with a Ph.D. due to the need for advanced researchers within a state to enable advancement in industry and further the knowledge and understanding of the surrounding population. While the Milken Report illustrated the importance of science and technology across the states and their impact on economic conditions, it did not pinpoint specific methods that would assist in the appropriate allocation of resources.

Research Methodology:

In this study, specialization in educational funding is measured through the variation of state appropriations to institutions across a state. Economic theory would predict that specialization in higher education would lead to improved outcomes in a variety of directly measurable outcomes. Such direct outcomes include number of undergraduate, graduate, and professional degrees, reputation, R&D dollars, and journal article publications. The quantity of R&D dollars is a proxy for current and future economic vitality. Indirect outcomes of specialization include migration of industry and corporations to areas near institutions to strengthen their employee quality, an increase in per capita income from higher quality degrees resulting in better jobs, and an increase in the number and qualification of jobs within a state. Limits on data resources, however, prevent the measurement of several of the direct outcomes, so the measure of R&D dollars within the state provides a proxy for an index of possible outcomes and the variation in higher education funding within a state serves as the measure of specialization. Higher education funding has a direct impact on R&D expenditures in a state and the economic impact resulting from R&D dollars within that state. While program duplication is a good variable to address efficiency issues with regard to state allocations, it does not allow for differentiation between programs on a qualitative basis and is difficult to measure due to data inconsistencies. No study has succeeded, due to measurability, qualitative factors, and data constraints, in providing a direct link between program duplication and a change in educational or economic outcomes.

Research Question:

The research question for this study is "Does specialization in higher education funding result in improved economic outcomes for a state?" Specialization in higher education funding is measured by the differentiation in state appropriations per student a state makes in its funding process between institutions. The improved economic outcomes are measured by the change in R&D expenditures within a state. Factors influencing this outcome, discussed below, are taken into account in the study. State appropriations for higher education are a key factor in determining R&D's relationship to economic development because they show how much money is allocated to each institution within a state to operate their university systems and the priority level of education within the state, as opposed to other funding categories. Shifts in appropriations to institutions give insight into the focus of the legislature and in state spending patterns. By efficiently funding higher education systems, the capital to maintain and improve academic and athletic programs that attract students to higher education, which in turn provides more capital to research and development projects, is readily available (DeVol, 2002). The lag in the economic value and long-term results of university research has been proven, but there is no indication that there is no short-term payoff to university research.

Hypothesis:

Total Research and Development (R&D) expenditures in state *i* in time *t* at institutions of higher education is a function of Gross Domestic Product at *t-j* (to account for economic lag), variation in educational expenditures among institutions per capita in state *i*, state expenditures in higher education as a percent of total state funding, and the number of scientists and engineers in the state. The primary question of interest is, as state *i* specializes its educational expenditures, does R&D funding experienced in the state change? Mathematically, this relationship can be expressed with the following equation; using a fixed effects model to explain the level of research and development (R&D) expenditures across states for the period 1992 through 2000.

$$RD_t^i = \alpha_i + \beta_1 RD_{t-1}^i + \beta_2 HEDEXP_t^i + \beta_3 PhD_t^i + \beta_4 PhD_{t-1}^i + \beta_5 \ln(Vat_t^i) + \varepsilon_t^i \quad [1$$

Variables and Data Collection Procedures:

RD_t^i is the dollar amount of R&D expenditures (in millions of dollars) in state *i* in year *t*, and RD_{t-1}^i is the lagged dollar amount of R&D in state *i*. The R&D data come from Table B-29 of the 1992- through 2000-edition of the National Science Foundation publication entitled "Academic Research and Development Expenditures." The table provides the total dollar amount of R&D expenditures at each institution of higher education in each of the fifty states. The table also provides the sources of the R&D expenditures at each institution, e.g., federal government, state and local governments, industry, and institutional funds. (See Appendix A-1.)

The R&D values for 1991 come from Table B-23, "R&D expenditures at doctorate-granting institutions, by geographic division and state: fiscal years 1985-92," of the same NSF publication. All dollar amounts were adjusted for inflation to 1996 constant dollars using the Gross Domestic Product (GDP) implicit price deflator from the U.S. Commerce Department, Bureau of Economic Analysis (BEA). For the purposes of this analysis, the total amount of R&D expenditures in each state is used.

For the period 1992 through 1995, Table B-29 displays data for R&D expenditures *at doctorate-granting institutions*. For the remainder of the sample period, the data from the table displays R&D expenditures *at universities and colleges* (both doctorate-granting and non-doctorate granting institutions). Technically, this is comparing apples (the R&D data for 1992-95) to oranges (the R&D data for 1996-2000); however, the proportion of R&D expenditures at universities and colleges that is attributed to non-doctorate granting institutions is very small and would therefore have a negligible impact on the results of our estimation. The importance of the R&D expenditures lies in the impact of the expenditures in driving technological advancement, and hence, driving economic growth. The level of expenditures is directly impacted by the variables below.

$HEDEXP_t^i$ is the proportion of state expenditures going to higher education in state *i* in year *t*. The data come from the annual National Association of State Budget Officers' (NASBO) State Expenditure Reports 1992-2000 (NASBO, 1992-2000). Some states had missing values for this variable; as such various state budget agencies were contacted (see appendix). Not all phone calls were returned, so to estimate the missing values for a state, the average value of the remaining data points was used.

If our estimates are incorrect, the parameter estimate for this variable will be biased either upwards or downwards. The variable is important because the percentages allocated to higher education give an indication of the priority level of the category within the state. This ratio should be positively correlated with R&D expenditures within a state because as a greater percentage of the state's funds are allocated to institutions of higher education, more funds are available for R&D at the institutions. In turn, this increases the skill level of students that will become the labor force of the state. The data points for the following states and years were filled with the averages from the remaining years: Mississippi (1992), Alaska (1996), Nevada (1992-1994, 1996-1998), and Wyoming (2000). (See Appendix A-2.)

PhD^i_{t-1} is the number of doctoral scientists and engineers in state *i* in year *t*, and PhD^i_{t-1} is the lagged number of doctoral scientists and engineers in state *i*. The data come from Table 25, "Employed doctoral scientists and engineers, by geographic location and broad occupation," from the NSF publication *Characteristics of Doctoral Scientists and Engineers in the United States* for the years 1993, 1995, and 1997. The 1999 data come from Table 25, "Employed doctoral scientists and engineers, by employer location and broad field of doctorate," from the 1999-2000 edition of the same publication. A constant growth rate method was used to estimate values for 1991, 1992, 1994, 1996, 1998, and 2000. If the estimates are not correct, the parameter estimates will be biased either upwards or downwards. These advanced degrees are an indication of a state labor force's knowledge base, skill level, and sophistication. States with high levels of Ph.D. degree holders have quality research and development centers (DeVol, 2002: 82). This variable will be positively correlated to R&D expenditures because as the number of researchers within a state increases, a greater demand for R&D dollars within the state will result. (See Appendix A-3.)

$\ln(Var^i_t)$ is the natural logarithm of the sample variance of state expenditures per pupil (adjusted for inflation to 1996 constant dollars using the GDP implicit price deflator) across four-year institutions of higher education in state *i* in year *t*.[1] The data come from the Integrated Postsecondary Education Data System (IPEDS) from the National Center for Education Statistics of the U.S. Department of Education. The state appropriations per student were derived by dividing the total state appropriations for institution *x* by the total enrollment at the institution for a given year. The variance within the state appropriations was found using the state appropriations per student. The variation among those allocations reflects the degree of specialization in higher education funding within a state. (See Appendix A-4.)

There are three major issues with the state expenditures per pupil data. First, not all schools existed for the entire sample period, and other schools had missing values for one or more years. To fill in the missing values, various state budget agencies and institutions were contacted. Not all phone calls were returned; consequently, for each school that had only one year of data missing, that year's value was estimated by taking the average of state expenditures per pupil at that institution. If the estimates are not correct, the parameter estimates will be biased either upwards or downwards.

Because of the relatively short length of the sample period, schools that had more than one missing year of data were dropped from the data set. Taking the average of the remaining values as the estimate of the missing values would be unreasonably restricting the values of expenditures per pupil. Doing so would also have the potential of making our estimates of the sample variance less robust. Therefore, these observations were dropped from the data set. The following institutions were removed from the data set due to missing values for more than one year: Arizona State East Campus, Arizona State West Campus, California State University Monteray Bay, California State University Channel Islands, San Diego State University, Southern University Law Center, Benjamin Franklin Institute of Technology, University of Maryland University College, Truman Medical Center for Nurse Anethesis, Nevada State College at Henderson, University of New Hampshire Manchester, Rutgers University Camden, Rutgers University New Brunswick, Rutgers University Newark, Rogers State University, OGI School of Science and Engineering at OHSU, University of Pittsburgh Bradford, University of Pittsburgh Greensburg, University of Pittsburgh Johnston, A&M University System Health Science Center, University of Texas Anderson Cancer Center, Education Service Center Region 2, Washington State University Spokane, Washington State University Vancouver, and Washington State University Tri-Cities.

Schools that did not exist for the entire period were omitted when calculating the sample variance. Visual inspection of the data suggests that when a new school came into existence in a state, per pupil expenditures at other institutions within the state did not change significantly. The number of schools that were omitted from the data set, for either having more than one missing year of data or for not existing for the entire sample period, totaled 25 (from a population of around 600).

The second major issue with these data is that medical schools were counted as four-year institutions. Since expenditures per capita at medical schools tend to be quite large, the existence of these institutions tend to inflate the variance of state expenditures per pupil, suggesting a greater degree of specialization in a state's higher education system than may actually exist. This would tend to decrease the reliability of the parameter estimate for this particular variable. However, because the R&D expenditure data to medical schools were not explicitly given in the NSF data, it was necessary to keep the medical schools in the data set to compute the sample variance of state expenditures per pupil.

Third, the University of Wyoming was the only university in the state of Wyoming to receive state funding for the sample period. Consequently, the variation in state expenditures per pupil across institutions of higher education in this state is zero for the entire sample period. The natural logarithm of zero is, of course, negative infinity. Therefore, in our estimation of equation [1], the state of Wyoming was omitted. However, this should not have a major impact on the results of our estimation.

Results:

Estimating equation [1] using ordinary least squares gives us the following estimates, shown in Table 1.[2] (See Appendix A-5 for complete results.)

The model implies that, all else equal, a $1 million increase in R&D in year *t-1* will lead to, on average, a $986,000 increase in R&D in year *t*. Given that many R&D projects span more than one year in duration, this finding is as expected. This variable is significant at the 0.01 level of significance.

Table1: OLS Estimates of Equation [1]

Variable	Estimate	Standard Error	t-value	p-value
RD_{t-1}	0.986	0.0293	33.68	<0.0001
$HEDEXP_t$	1.215	0.620	1.96	0.05
PhD_t	0.00319	0.00167	1.92	0.06
PhD_{t-1}	0.00787	0.00228	3.45	0.0006
$\ln(Var_t)$	4.841	3.787	1.28	0.20
F-value	9016.57			<0.0001
Root MSE	21.73			

According to the model, all else equal, a 1.0 percent increase in the proportion of a state's expenditures going to higher education in year *t* will lead to, on average, a $1.2 million increase in R&D in that state in the same year, assuming total state expenditures in year *t* are equivalent to the previous year's total state expenditures. This variable is significant at the 0.05 level of significance. States that spend proportionately more of their expenditures on higher education experience greater levels of R&D expenditures within the state. This can come through a number of channels, including (1) direct state-level spending on R&D at institutions of higher education and (2) state-level investment in facilities conducive to R&D activities and in personnel to participate in R&D activities.

According to the results of the model, all else equal, a one-person increase in the number of employed doctoral scientists and engineers in a state in year *t* will lead to, on average, a $1,670 increase in R&D expenditures in that state in the same year. This variable is significant at the 0.05 level of significance. The sign of this variable is as expected; the more employed doctoral scientists and engineers in a state increases the likelihood that there are more doctoral scientists and engineers engaged in R&D activities in a state. The number of doctoral scientists and engineers engaged in R&D activities should be positively correlated with the level of R&D expenditures in a state in a particular year.

According to the model, all else equal, a one-person increase in the number of employed doctoral scientists and engineers in a state in year *t-1* will lead to, on average, a $7,870 increase in R&D expenditures in that state in year *t*. This variable is significant at the 0.01 level of significance. This result suggests that doctoral scientists and engineers, by their presence, help attract R&D expenditures in a state in the next year, i.e., funding follows the scientists and engineers.

According to the model, all else equal, a one percent increase in the sample variance of state expenditures per pupil in a state in year *t* will lead to, on average, a $4.84 million increase in R&D expenditures in that state in year *t*. Contrary to our a prior beliefs, this variable is not found to be significant at any tolerable level of significance.

There are three possibilities in explaining why this variable is not statistically significant. First, it may be due to medical school's skewing the sample variance and thus overstating the degree of specialization of the system of higher education within a state. Second, the coefficient may not be statistically significant due to the omission of relevant covariates. Third, a longer and complete times series, i.e., no estimated values for state expenditures per pupil or for the proportion of state expenditures going to higher education, would increase the validity and robustness of the parameter estimates. All three of these need to be addressed in future research.

Overall, though, the model appears to be relatively "good." We note that the F-statistic for the model is highly significant. Moreover, an F-test rejects the hypothesis that the fixed effects are jointly zero at the 0.01 level of significance. Lastly, a Durbin-

Watson statistic of 1.893 implies no positive autocorrelation in the error term, and visual inspection of the residuals suggests that the error term follows a white noise process.

Discussion:

The policy implications arising from the results reached in this study relate to the areas of the higher education funding structure and process, state legislative appropriations, and educational attainment and funding in general. Due to the finding that an increase of one percent in funding for higher education from the state budget will result in a $1.2 million increase in R&D funds within a state, legislators need to consider the positive impact of increased R&D funds upon a state's economy, which has been shown in a variety of studies (e.g. the Milken Report), and therefore, consider allocating a larger percentage of state funding to higher education. While this is not an original finding and was therefore expected, it reinforces the positive relationship between higher education funding and R&D. The policy implication of the finding that an increase in employed doctoral scientists and engineers within a state is positively correlated to increased R&D dollars is that states should pursue policies to increase the level of educational attainment of their populations in order to increase the level of R&D expenditures within the state, and by extension, the level of economic growth within the state. Retention of these doctoral scientists and engineers within the state should be a goal as well. Similar results have been reached in other studies, such as the Milken Institute's Science and Technology Research Report, and were therefore expected. The finding that a $1 million increase in R&D in a given year will lead to, on average, a $986,000 increase in R&D in the next year implies that those responsible for allocations of R&D funding should consider the impact their decisions on allocations will have in the future. While the variation in appropriations to institutions within a state was not statistically significant, it did have the positive sign on the coefficient that was expected. If the data had been available for a longer time series and had excluded skewing factors, the variation may have proven to have a major impact upon R&D. The model itself has also been proven to be more accurate than other models explored.

Need for Further Research:

Data limitations and time prevented the length and completeness of the time series and number of institutions that were possible to include in the study. Further research based on a superior dataset would allow for a broader scope, and therefore, provide a more far-reaching and dependable set of conclusions. Any future research will also need to account for private institutions and the possibility that they may have an impact upon the R&D dollars being allocated to public institutions. States with private institutions that receive a substantial proportion of either national or state R&D dollars would most likely have an impact upon the public institutions within that state. The reason for this consideration would be to account for the either complementary or substitution relationship between the private and public institutions. The former implies that a public institution is more capable of generating R&D dollars because of the private institutions' strength, which results in a synergistic relationship. The latter implies that the state may withhold R&D dollars from public institutions because the private institutions are filling the R&D role for the state. This factor should be considered due to the fact that several private institutions dominate their state in receiving R&D dollars within that state and nation. In future research, a longer time series may result in more accurate results. Any future work would also need to consider omitted variables. Finally, accounting for the impact certain medical schools had upon the funding variation within the states is another issue that needs to be addressed. This factor may be the main reason that the variation variable was not statistically significant.

End Notes:

[1] The logarithm, instead of levels, was chosen for interpretive purposes.

[2] We report the fixed-effects intercepts in the appendix.

Editor's note:

Ms. Gosnell's paper has both an extensive bibliogrpahy and appendix. Space limitations preclude the publication of these items in the journal. However, her paper, complete with bibliopraphy and appendix can be found on the *Inquiry* website.