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LONG GONE LAKE WOBEGON?

The State of Investments in University of Minnesota Research

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ABOUT THE TITLE

The Lake Wobegon effect refers to the tendency for individuals (or groups) to overestimate their own abilities or achievements in relation to others (see, for example, Maxwell and Lopus 1994). It is named for the fictional town of Lake Wobegon from the radio series *A Prairie Home Companion*, where, according to University of Minnesota alumnus Garrison Keillor, "all the women are strong, the men are good looking, and all the children are above average." The principal finding of this report is that while the University of Minnesota remains a strong public research university, it is no longer "above average" in a range of research funding metrics. Research expenditures at several competing institutions—primarily during the 1990s—have grown at a faster pace, placing the University, and the state of Minnesota, at a competitive disadvantage.

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ABOUT INSTEPP

The International Science and Technology Practice and Policy (InSTePP) center is located in the Department of Applied Economics at the University of Minnesota. InSTePP brings together a community of scholars at the University of Minnesota and elsewhere to engage in economic research on science and technology practice and policy, emphasizing the international implications. Center research deals with the innovation incentives and R&D actions of private entities as well as government behavior that affect the conduct, performance and economic consequences of R&D worldwide.

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BRIEF 1

Executive Summary

PHILIP G. PARDEY, STEVEN DEHMER, AND JASON BEDDOW

It would be tempting to be complacent and point to a recent study by Harvard University researchers showing that Minnesota now has the second longest life expectancy of all states in the Union, or to a 2006 Milken Institute study placing the University of Minnesota 6th overall among North American universities for the commercialization of biotech research, as evidence that investments in Minnesota research and development (R&D) generally—and the University of Minnesota, in particular—are paying handsome dividends.[1]

To be sure, the biotech commercialization ranking is directly attributable to the new technologies and know-how emanating from University of Minnesota research. Likewise, local investments in health research (including the substantial investments in health R&D done at the University) are linked to the lengthy-lives story. However, local spending on health research accounts for only part of the health outcomes in Minnesota. Certainly, the amount and quality of local health delivery systems are also part (perhaps a big part) of the picture. In addition, health research done elsewhere will affect health outcomes in Minnesota, just as Minnesota R&D spills over and affects people in other states and other countries. Moreover, the lags between investments in R&D and economic outcomes are quite long (at least years, and more likely decades), and so these and similar outcomes are the consequence of past investments. The state of Minnesota, just like a firm, may do fine for a while by drawing upon its existing stock of knowledge capital, which was formed by an accumulation of information and innovations flowing from its history of previous R&D investments. How the state of Minnesota will fare in the future, however, as knowledge-intensive sectors continue to grow relative to the rest of the economy, will crucially depend on its recent and future investments in R&D.

Minnesota's economy competes against economies in other states and other countries, so it is not just Minnesota investments in R&D that matter. The amount and pattern of spending on R&D by the state—and at the University of Minnesota as the state's principal public research agency—relative to research investments made in other states and other countries are also important. This brief summarizes new evidence about academic research investment trends in Minnesota, and compares those trends with developments in other states and other comparable universities. A major focus is on investment in academic research at the University of Minnesota and other comparable universities.

The evidence reveals a significant structural slowdown in the growth of spending in academic R&D in Minnesota, beginning in the early 1990s. Moreover, the amount and intensity of spending on academic R&D in the state of Minnesota is no longer "above average," and the University of Minnesota has lost considerable ground on a range of research spending metrics and is now lagging behind many of its peer group of universities in other states (Box 1.1).

1 See Murray et al. (2006) for a report on the Harvard study and De Vol et al. (2006) for the Milken Institute study.

MINNESOTA VS. OTHER STATES

A central issue is how academic research in the state of Minnesota (including research funds flowing to *all* higher-education entities with the state) has fared. In brief:

- Academic R&D within the state has expanded considerably over the past three decades, increasing from $178.4 million in 1972 to $524.3 million in 2004 (where expenditures are measured in 2004 prices).[2] Notably, in 2004 the University of Minnesota's R&D expenditures were $515.1 million—more than 98 percent of the state total.

- Federal government funds (mainly in the form of competitive grants and contracts, but also some earmarked and formula funding) are the single most significant source of support for academic R&D in Minnesota. They accounted for 59.8 percent of Minnesota's academic R&D spending in 2004, a slightly higher share than three decades ago (57.3 percent).

- Federal funding is important in other states too. However, nationwide the federal share of funds for state-specific academic R&D fell from 68.2 percent in 1972 to 63.8 percent in 2004.

- Notably, since 1990, the growth in federal funding for academic R&D in Minnesota (3.7 percent per year) has fallen behind the growth of federal support for academic research performed nationwide (5.5 percent per year).

- State and local government funding for academic research in Minnesota ramped up rapidly in the 1970s and 1980s, at rates well above the national average. After 1990, however, the trend is much different. State and local government support for academic research in Minnesota was cut back—dropping by 0.8 percent per year (on average) in the

Box 1.1: Falling Behind

Since 1972, the state of Minnesota has moved well down the academic research investment rankings compared with all other states, irrespective of whether the measure is total academic R&D spending or measures normalized on factors that differ among states, such as population or gross state product.

Minnesota's National Ranking in Academic R&D Investments, 1972 and 2004

Investment Indicator	Minnesota Ranking 1972	Minnesota Ranking 2004
Total Academic R&D	19th	26th
Academic R&D per capita	20th	40th
Academic R&D per dollar of gross state product	20th	43rd

Among a group of 14 peer universities located throughout the United States, the University of Minnesota has also lost considerable ground, slipping from 4th in 1972 to 9th in 2004 in terms of total R&D expenditures.

The spending slowdown is structural:

- **Overall, the University of Minnesota grew slowest among its peer group since 1972.**
- **The slower-than-average growth is most pronounced beginning in the early 1990s.**
- **The funding slowdown is across the board, including funds flowing from federal, state and local government, and industry sources.**

2 For the remainder of this brief, unless otherwise specified, all dollar figures are deflated (i.e., adjusted for inflation) to base year 2004 prices. The U.S. GDP deflator (World Bank 2006) was used for this adjustment. The data sources used for this study are summarized in Box 1.2.

1990s and declining even more rapidly (by 1.2 percent per year) since 2000.

- Elsewhere in the country, state and local governments continued to increase their spending on academic R&D after 1990 on average by 3.7 percent per year—slower than their rates of growth in earlier years, but much faster than the corresponding post-1990 rate for Minnesota, which in fact saw a reduction in state support for academic R&D of 1.0 percent per year.

- From a high of 17.1 percent of the total in 1976 (and peaking again in the late 1980s/early 1990s), the state and local government share of total academic R&D funding in Minnesota dropped to 10.2 percent by 2004. This occurred in tandem with a decline in the higher-education share of total state and local government spending in Minnesota (6.3 percent in 1972, down to 3.1 percent in 2004).

- Between 1972 and 2004, the long-run tendency has been for total academic R&D in Minnesota to grow, but this funding has grown more slowly than academic funding in many other states. In 1972, the state of Minnesota ranked 19th in the nation in terms of total academic R&D expenditures. By 2004, Minnesota had slipped to 26th in the national rankings.

UNIVERSITY OF MINNESOTA: FUNDING AT A GLANCE

Total funding and expenditures at the University of Minnesota have evolved as follows:

- Total operating expenditures—including *all* non-capital costs of providing instructional, research, and community services—were $2.2 billion in 2004.

- In inflation-adjusted terms, the University's total operating budget grew at an average annual rate of 4.9 percent per year over the six decade period 1945-2004. However, the rate of growth in more recent years has fallen below the long-run average. During the decade of the 1990s, total University spending grew by only 0.9 percent per year. Although the rate of growth increased a little during the 2000-2004 period to 2.1 percent per year, it is presently less than half the long-run historical average.

- The instructional share of the University's spending has changed very little, averaging 25.1 percent of total annual outlays since 1986. The research share has crept up, increasing from 15.3 percent in 1986 to 21.1 percent in 2004. The public service component of University expenditures also grew a little—from 6.5 percent in 1986, to 7.9 percent 18 years later.

- Between the fiscal years 1972 and 2004, *research* expenditures at the University of Minnesota increased almost three-fold in inflation-adjusted terms, from $173 million in 1972 to $515 million in 2004.

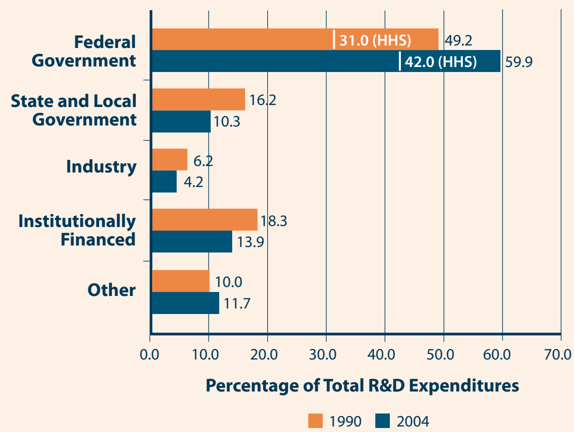
  » Federal government agencies accounted for 59.9 percent of the University's overall research budget in 2004, increasing their combined share by more than 10 percent during the 1990s (Figure 1.1).

  » Funding from the Department of Health and Human Services alone accounted for 70 percent of all federally funded research at the University in 2004.

  » State and local government funding accounted for slightly more than 16 percent of total annual outlays on University R&D for the years 1973-1977 and 1986-1992, but then declined to just 10 percent of the total in 2004.

  » The share of industry funding inched up from 3 percent in 1972 to 7 percent in 1998, but then dropped back to 4 percent by 2004. This is a general pattern observed in many other states.

Figure 1.1: Sources of Support for University of Minnesota Research, 1990 and 2004



Source: National Science Foundation (2006).

Notes: The federal government shares are divided to indicate the portion of funding from the Department of Health and Human Services (HHS) in the federal total.

UNIVERSITY RESEARCH SPENDING RANKINGS: U OF M SLIPPING BEHIND

Like the State, the University of Minnesota has slipped down the rankings of reported research spending as well. Compared with a peer group of 14 universities, the University of Minnesota currently ranks 9th in total R&D expenditures with $515.1 million in 2004, well below its rank of 4th in 1972 (Figure 1.2).[3]

This fall in the rankings reflects a slower than average rate of growth in real research spending at the University of Minnesota compared with its peer universities. In fact, since 1972 the University of Minnesota has grown slowest among its peer group in total academic R&D expenditures. The University's research expenditures grew by the rather modest average growth rate of 1.5 percent per year between 1990 and 2000. The rate of growth of University research expenditures has increased to 3.8 percent over the 2000-2004 period. However, most of the 13 other schools in the peer group have grown even faster—ten of these schools grew by at least 6 percent per year since 2000.

The growth in University of Minnesota research funding from *all* sources—specifically, federal government, state and local government, institutional, and industry sources—was exceptionally strong during the 1970s, when, irrespective of source, funding grew faster than the corresponding national average rate (Figure 1.3, Panel a).[4] During the 1980s, most of the University's funding sources grew at a slower rate than the peer institutions and more slowly than the national average. A notable exception was state and local government funding, whose comparatively rapid growth during this decade helped the University's research budget climb to 2nd among its peers by 1991. Thereafter, the average growth in funding from *all* sources slowed dramatically, both compared with past rates of growth at the University and the contemporary rates of growth of peer institutions (Figure 1.3, Panel b).

TURNING IT AROUND

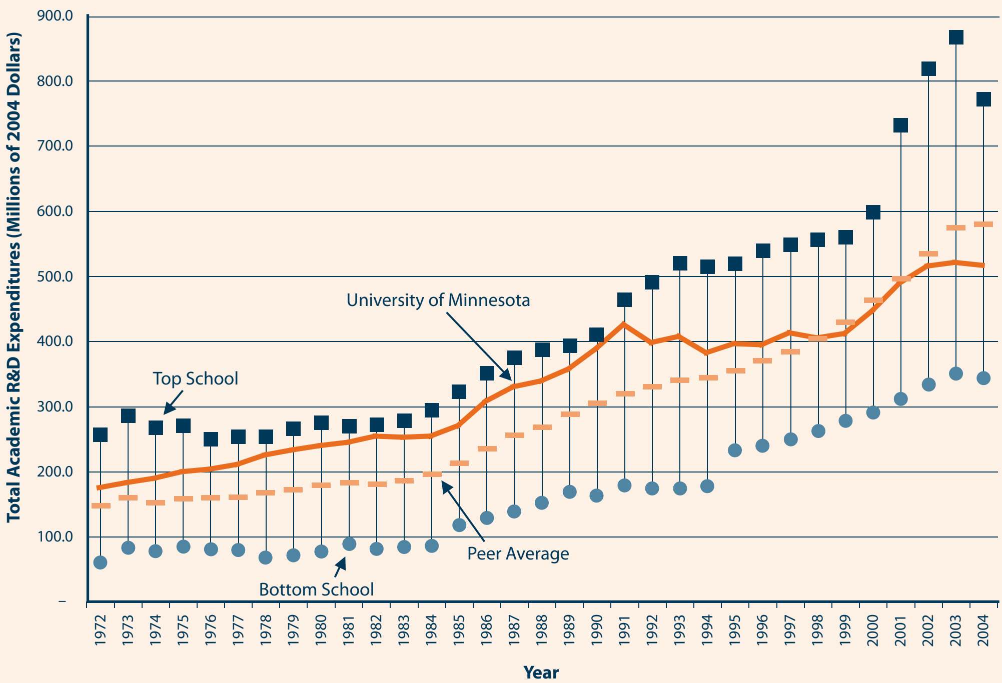
Since 1991, the University of Minnesota has fallen from 2nd to 9th ranked among a group of 14 peer institutions in terms of reported research funding. The evidence presented in these briefs indicates that the University's decline is due to a persistent, long-term slide, and is not a recent development. So what would it take to turn this trend around?

Figure 1.4 reports the results of some alternative funding scenarios since the marked decline in funding that began in the early 1990s. The orange

3 The University of Minnesota's peer group consists of the ten universities identified by the Final Report of the Metrics and Measurements Task Force (2006), which included: the University of California-Berkeley, University of California-Los Angeles, University of Florida, University of Illinois at Urbana-Champaign, University of Michigan-Ann Arbor, University of Texas at Austin, University of Washington-Seattle, University of Wisconsin-Madison, Ohio State University-Columbus, and Pennsylvania State University-University Park, plus the University of California-Davis, University of California-San Diego, and the University of North Carolina at Chapel Hill based on advice from the University's Vice President for Research, R. Timothy Mulcahy.

4 Institutional funds include funds from endowments, royalty revenues, and so forth.

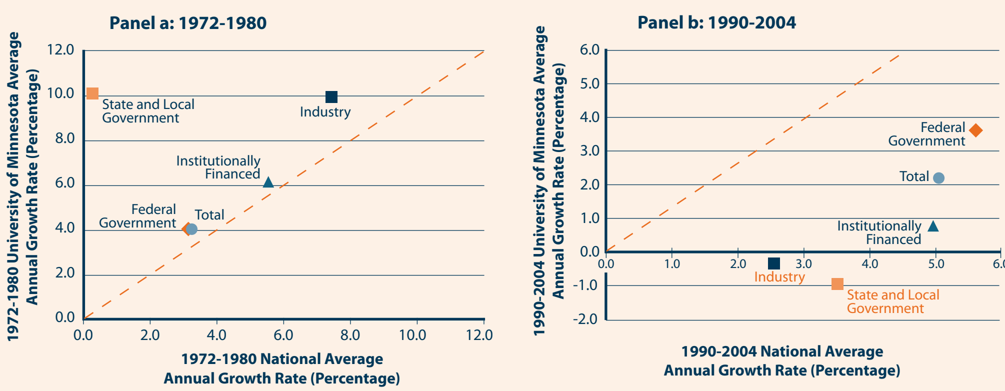
Figure 1.2: Total Academic R&D Expenditures—University of Minnesota and Distribution of Peer Institutions, 1972-2004



Source: National Science Foundation (2006).

Notes: The solid line plots total academic research spending by the University after netting out the effects of inflation using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006). For each year, we also plot a linearized distribution of research spending among the 14 peer universities. The solid square atop the distribution represents the top peer school in terms of total research expenditures for each year; the solid round mark indicates the bottom ranked peer; the horizontal dash indicates the average R&D spending among the 14 peer universities.

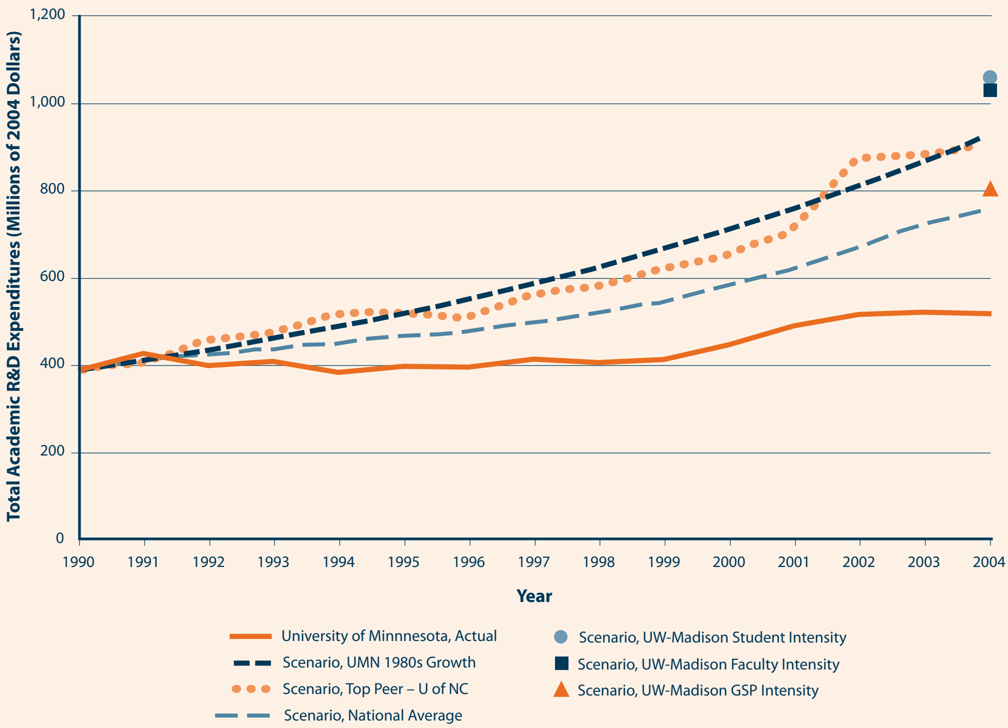
Figure 1.3: Research Funding Sources—University of Minnesota versus the National Average



Source: National Science Foundation (2006).

Notes: Along the 45 degree line, Minnesota is growing at the national average. Points above and below the dashed line indicate Minnesota growth above and below the national average, respectively. Negative growth rates are indicated by orange labels. Average annual growth rates are calculated by taking the mean of the year-to-year growth rates obtained using the arithmetic growth formula. Funding growth rates are inflation adjusted using the U.S. GDP implicit price deflator (World Bank 2006).

Figure 1.4: The University of Minnesota Simulated Academic R&D Expenditures, 1990-2004



Source: National Science Foundation (2006) and Bureau of Economic Analysis (2005).

Notes: All actual and simulated expenditures are adjusted for inflation using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006). The "national average" simulation is based on average annual weighted growth rates, for each funding source, among all academic research institutions in the U.S. The University of Minnesota "1980's growth" simulation is based on extrapolating the University's average annual growth rates for each funding source during the 1980s. During the 1972-2004 period, the University of North Carolina at Chapel Hill had the highest overall growth rate among all of the University's "peer" institutions. This simulation is based on University of North Carolina at Chapel Hill's annual growth rates for each funding source over the 1990-2004 period. The University of Wisconsin-Madison simulations are based on applying respective research intensities to the University of Minnesota. That is, these points are estimated by applying the R&D per faculty intensity to the U of Minnesota's faculty count, the per student intensity to the University's student count, and Madison's funding as a share of Wisconsin's gross state product to Minnesota's gross state product.

solid line plots the actual growth in real research funding at the University of Minnesota since 1990. In 2004, $515.1 million was invested in University of Minnesota research. What if the University of Minnesota's research funding had simply kept pace with its growth trajectory of the 1980s? The short-dashed line illustrates the University would then have invested $924.4 million in research by 2004. Alternatively, if funding had simply grown at the national average rate of all U.S. universities since 1990, investments in University of Minnesota research would have increased to $752.3 million in 2004—almost 46 percent more than was actually spent. However, the University of Minnesota is not simply aspiring to be average, so what if its growth had kept parity with the University of North Carolina at Chapel Hill, the most rapidly growing university among its peer group? The circle-dashed line plots this scenario, under which University of Minnesota spending would have been $904.4 million in 2004. Had any of these scenarios transpired, the University would currently find itself among the top three of its peers in research expenditures.

From another perspective, what would have happened if the University of Minnesota's research spending intensity was more like the University of Wisconsin, Madison in 2004? If Minnesota had maintained parity with Madison's research-spending-per-student ratio, its total research

Box 1.2: Data Sources

Data from a variety of sources were compiled and consolidated in order to conduct the analyses described in this series of briefs. Key data sources include:

- **the annual "Levels and Trends in Sponsored Programs" reports compiled by the University of Minnesota's Office of the Vice President for Research,**
- **the National Science Foundation's "Survey of Research and Development Expenditures at Universities and Colleges,"**
- **the National Science Foundation's "Survey of Federal Funds for Research and Development,"**
- **budget data from the National Center for Educational Statistics Integrated Postsecondary Education Data System (IPEDS) Peer Analysis System.**

A complete list of data sources and a more detailed description of the data used in these reports can be found in Brief 2 of this series.

funding in 2004 would have been $1,059.9 million (more than double the University of Minnesota's actual figure). Parity with Madison's research-spending-per-faculty ratio would have lifted the University's total research spending to $1,029.7 million, while spending the same as Madison's share of Wisconsin's gross state product would have raised the University of Minnesota's total to $805.8 million. Clearly, the University of Minnesota's funding performance has slipped well behind those of its similar sized neighbors and its peers for the past decade or more.

These funding scenarios illustrate two important points. First, the adjustments required to put the University of Minnesota back on a funding trajectory that will enable it to at least keep up with its peers, if not move up a ranking of its peers, are well within reach. Second, given the more rapid growth in University research elsewhere in the country since 1990, moving Minnesota up the research investment rankings will require an across-the-board and sustained revival in funding. A one-time injection of new money will not do the trick—a structural realignment of funding trends is required.

EPILOGUE

The future of Minnesota's economy is inextricably intertwined with these academic research investment indicators. Certainly, research funding alone is not a guarantee of research and economic success. However, the overwhelming evidence is that the social returns to R&D are high, and so failure to adequately invest in R&D (and the enabling environment to make efficient and effective use of the results from research) is a risky social strategy, and one with largely predictable and generally less than rosy economic outcomes.

The relative decline in the rate of growth of academic R&D spending at the University of Minnesota and in the state generally (both compared with earlier decades and with other states and other peer institutions) is a structural phenomenon. The slowdown became more pronounced beginning in the early 1990s and affects funding from federal, state and local government, and industry sources.

The R&D rankings of a university reflect the research skills of the faculty and the financial support they receive or generate for their research. But faculty are mobile, and the academic sector is especially competitive, requiring constant attention to salary and funding differentials among competing universities. Clearly, if the research funding and spending trends revealed in this report are not turned around, it is hard to envisage the University of Minnesota rising up the rankings to resume a position near the top of its peers.

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BRIEF 2

The Structure of R&D at the University of Minnesota

JASON BEDDOW, STEVEN DEHMER, AND PHILIP G. PARDEY

Estimating the economic returns to society flowing from research is tricky—doubly so for research done by public, multi-product agencies such as the University of Minnesota.[1] Getting the costs of research right is difficult to do for a university that engages in a broad range of research (involving academic inquiries that span areas as diverse as astrophysics and archaeology) combined with a host of different educational and public service activities. Measuring the economic benefits attributable to research and development (R&D) is also difficult. Some of the research results in tangible outputs, like new crop varieties, medical procedures, patented innovations, and so forth. A good deal of publicly performed R&D results in new information, ideas, and know-how that are simply reported in scientific journals, books, and other professional publications. Much, but by no means all, of this output has economic value, but reliably quantifying that value requires much additional (often hard to get) information. The new crop variety must be planted by farmers to realize its economic returns. So too must doctors and surgeons adopt new medical procedures before those research results improve the quality or extend the length of life, thereby yielding economic benefits to society. Medical innovations also realize economic value by lowering the cost of treating people's health problems, and providing new, perhaps less risky, disease treatment options.

Many other important subtleties affect the timing, significance, and ultimately the magnitude of the economic benefits attributable to university research. Some research yields results in a year or less, other research takes years or even decades of support and sustained effort before coming to fruition. Moreover, the results of R&D are rarely taken up immediately. Again, years and often decades must pass before R&D findings or new technologies are refined and commercialized and find their way in the marketplace. This has important consequences for linking R&D expenditures to economic impacts. It is rarely the case that research costs incurred one year bear economic fruit the next. The flip side is that some of today's output or productivity growth can be sourced to R&D done in the (distant) past. Thus, investing in university research is not a "quick fix," but is better seen as a strategy for underwriting *long-term* economic growth.

Not only is research an intrinsically risky (but potentially very rewarding) and time-intensive undertaking, the benefits are also hard to fully internalize by those incurring the costs of the research. Research results often spill over from one scientific discipline to another (e.g., many of the technologies for analyzing genomics information in the biological sciences had their origin in the information sciences) and also from agency to agency (e.g., from university to non-university specifically, and public to private entities generally, and vice versa). There are spatial spillovers as well. Research done in Minnesota can have local consequences, but it can also spur economic growth elsewhere in the country and elsewhere in the world. These spatial spillovers can, and do, run in both directions—research done outside the

1 Siegfried, Sanderson, and McHenry (2006) provide a critique of previous studies seeking to estimate the economic impacts of colleges and universities. Notwithstanding the challenges involved, there is a large, well established, but by no means complete literature on estimating the economic benefits of R&D. See, for example, Alston, Norton, and Pardey (1998) on estimating the economic effects of agricultural R&D, Murphy and Topel (2003) for health research, and Pardey and Smith (2004) for policy research.

state has important productivity consequences within Minnesota and also provides insights for University faculty for the furtherance of their own research. Thus, benefiting from other people's research often requires local research capacity to scout, test, and, if need be, adapt the research to local circumstances.

These spatial spillovers have significant impact evaluation implications. On the one hand, not all the R&D-induced productivity gains in Minnesota are attributable to Minnesota-based research; as already noted, some stems from research done elsewhere. Likewise, limiting estimates of the impact of Minnesota research to productivity impacts in just this state will understate the economic consequences of University of Minnesota research. These spillovers also have important policy implications. The economic justification for using federal government funds to support part of the University's research portfolio is precisely because Minnesota research has direct impacts elsewhere in the country (making it reasonable for the rest of the country to pay for some of Minnesota's research).[2] In addition, these direct, out-of-state economic effects can have important, indirect (but nonetheless valuable) local consequences. Minnesota consumers may gain as prices are held down due to economy-wide productivity gains stemming from Minnesota research. Minnesota producers may gain too as economic growth elsewhere in the country (or the world) stimulates demand for exports from Minnesota.[3]

Credible estimates of the returns to research must take into account all of these spillover and research lag effects to achieve a careful matching of research costs to research benefits. Getting a handle on the changing amount and structure of R&D expenditures by the University of Minnesota is a crucial and informative first step in any cost-benefit assessment and is the primary focus of this set of reports. Below we place academic research done at the University of Minnesota in the context of the other activities of the University, and identify shifts in the sources of support and the composition of the research. Box 2.1 describes the sources and nature of the data we assembled for the study. Companion briefs put changes in University of Minnesota research spending in a state-by-state and comparative institutional setting. Aspects of the University's educational mission are evaluated in the paper by Damon and Glewwe (2007).

TOTAL UNIVERSITY OF MINNESOTA SPENDING IN PERSPECTIVE

The University of Minnesota's operating expenditures—including *all* non-capital costs of providing instructional, research, and community services—totaled $2.2 billion in 2004, compared with just $112.1million (2004 prices) in 1945 (Figure 2.1). This represents a long-run, annual average growth in spending of 5.4 percent per year in inflation-adjusted terms, or 9.4 percent per year in nominal terms.[4] The long-run pattern masks significant periods of above and below average growth. The decades immediately following World War II saw a rapid ramping up in spending, perhaps from a depressed or stagnant wartime amount. Real spending grew by 13.2 percent per year from 1945-1950 and 5.8 percent annually during the 1950s, picking up to 8.3 percent per year during the baby boomer years of the 1960s. Growth slowed dramatically during the 1970s to 2.8 percent per year, rebounded a little to 3.9 percent annually during the 1980s then dipped again during the 1990s, growing by 2.9 percent per year during this decade. Growth recovered some during 2000-2004 (4.1 percent per year), but was still less than the historical average.

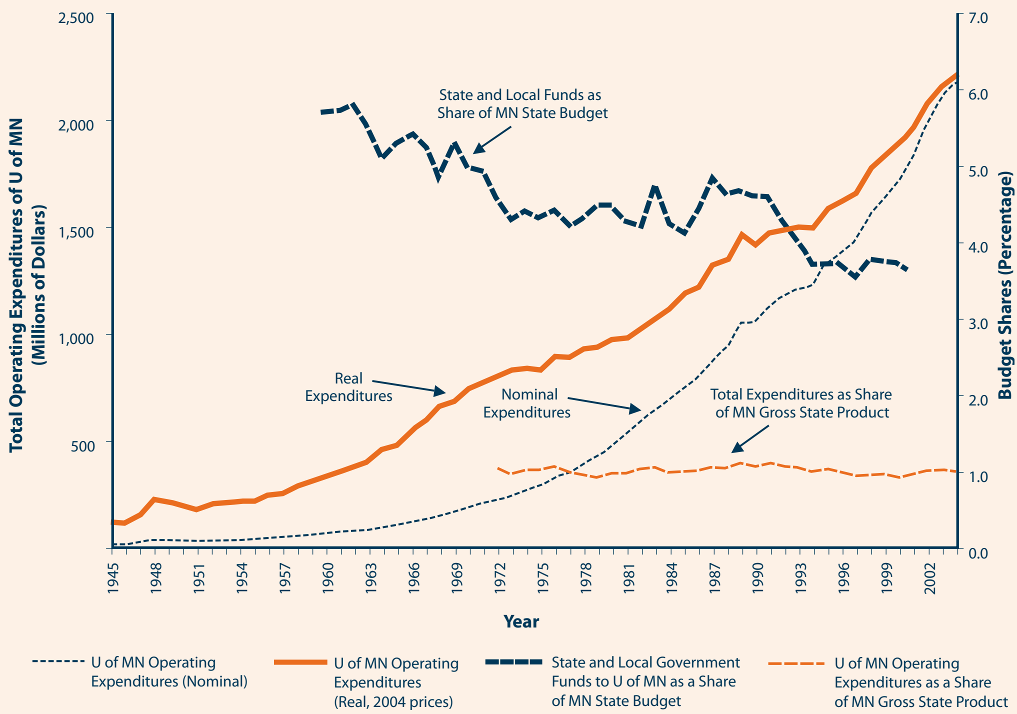
Over the past several decades total University of Minnesota spending grew slightly slower than

2 Research results (and their economic impacts) can spill well beyond the location at which the research is conducted, although an econometric study using U.S. data by Adams (2002, p. 275) reports that "…*university spillovers are more localized than firm spillovers* (our emphasis)… This evidence can be viewed as consistent with policies that have coupled scientific training and research with state agricultural and industrial interests (the industry-university cooperative movement)."

3 In 2004, Minnesota's gross state product was $223.8 billion (Bureau of Economic Analysis 2005) and the state exported goods and services valued at $12.7 billion (U.S. Dept. of Commerce 2006). Thus, exports account for about 6 percent of Minnesota gross state product.

4 Part of this growth was to accommodate the growth in student numbers—from a total of 11,396 graduate and undergraduate students in 1945 to 65,489 in 2004 (50,745 of whom were undergraduates, 14,502 were graduate students) (University of Minnesota, Office of Institutional Research 2003 and 2004).

Figure 2.1: University of Minnesota Total Operating Expenditures, 1945-2004



Source: National Center for Educational Statistics (2006), Minnesota Department of Finance (2006), Zetterberg (2005), Bureau of Economic Analysis (1988; 2005); Pfutzenreuter (2006).

Notes: Total operating expenditures are defined as the sum of expenditures made from the current funds that relate to the functions of instruction, research, public service, academic support, student services, institutional support, operation and maintenance of plant, scholarships and fellowships, mandatory and non-mandatory transfers. In part because of apparent data anomalies for 1991 in the NCES (2006) expenditure data, we used the Pfutzenreuter (2006) and Zetterberg (2005) current revenue data series to backcast the expenditure data for years prior to 2001. Real expenditures are deflated (i.e., adjusted for inflation) using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006).

the growth in Minnesota's economy so that the University's total operating costs as a share of gross state product (GSP) have marginally fallen (from 1.03 percent in 1972 to 0.98 percent in 2004). So too has the University's share of the total state budget fallen over time; state funds invested in the University were 5.7 percent of total state government spending in 1960, down to 3.6 percent by 2001.

Funding to the University supports the delivery of instructional, research, outreach, and public service endeavors, plus a host of other activities. National Center for Educational Statistics (NCES) data indicate that the instructional share of University of Minnesota spending has bounced around but is overall little changed, averaging 25.1 percent of total spending since 1985.[5] The research share has crept up from a 1986-1988 average of 15.0 percent to 21.1 percent by the years 2002-2004, and the public service component also grew slightly from 5.9 percent of the total, on average, in 1986-1988 to 7.8 percent roughly 16 years later (Figure 2.2). The research share has crept up from 15.3 percent in 1986 to 21.1 percent in 2004, and the public service component also grew a little from 6.5

5 The total educational and general expenditures reported by NCES is the sum of expenditures made from the current funds that relate to the functions of instruction, research, public service, academic support, student services, institutional support, operation and maintenance of plant, scholarships and fellowships, and mandatory and non-mandatory transfers.

percent of the total in 1986 and increasing to 7.9 percent 18 years later.

TRENDS IN TOTAL RESEARCH EXPENDITURES

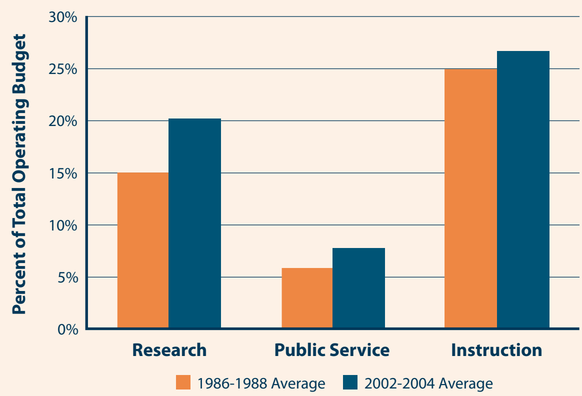
Between fiscal year 1972 and 2004, research expenditures at the University of Minnesota increased more than tenfold, from about $48 million in 1972 to $515 million in 2004—an annual average nominal rate of growth of 7.8 percent per year.[6] Adjusting for the effects of inflation, research funding expressed in 2004 prices grew from about $173 million in 1972 to $515 million in 2004, a real rate of growth of 3.5 percent per year (Figure 2.3 and Appendix Table 2.1.)

Throughout this entire 33 year period, academic research expenditures increased in real terms in all but six years. However, the growth has been uneven. The most rapid growth was during the 1980s (averaging 5.0 percent per year in inflation-adjusted terms) and the 1970s (4.1 percent per year), dropping to 1.5 percent annually during the 1990s.

CHANGING STRUCTURE OF SUPPORT

The source of research funding is important for several reasons. Diversification of funding sources can have implications for the overall stability of research programs. In addition, there is some evidence that the source of university funding has implications for the efficiency of a university's operations.[7] During the 1972-2004 period, the federal

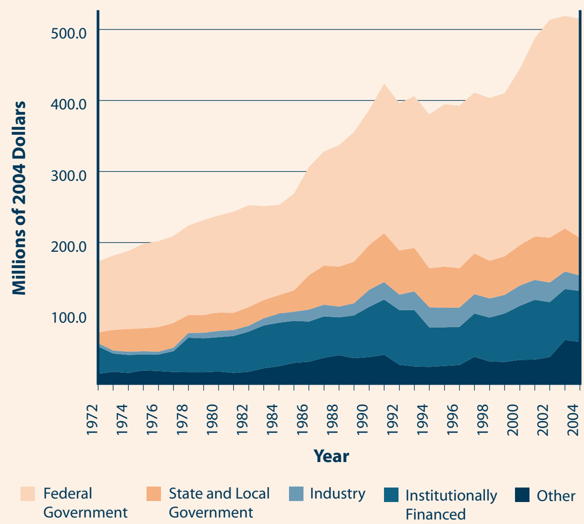
Figure 2.2: University of Minnesota Budget Shares by Function, 1986-2004



Source: National Center for Education Statistics (2006).

Notes: These budget shares do not add to 100 percent. Other functions under the operating budget include expenditures for academic support, student services, institutional support, operation and maintenance of plant, scholarships and fellowships, and mandatory and non-mandatory transfers. These budget shares were calculated as three year weighted averages to mitigate the effects of year-to-year variability.

Figure 2.3: University of Minnesota Academic R&D, Total and by Source, 1972-2004



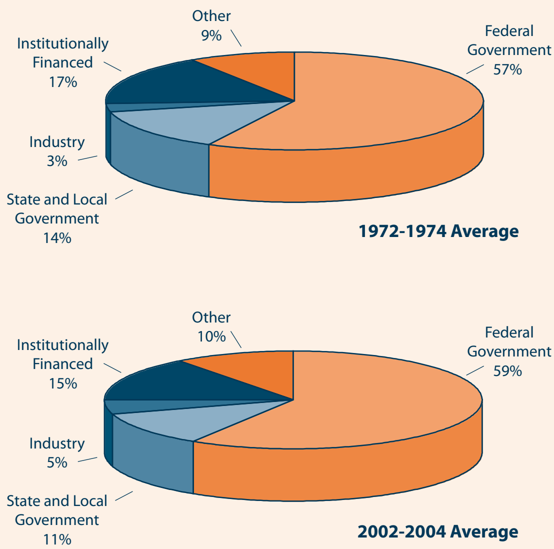
Source: National Science Foundation (2006a).

Notes: Real expenditures are deflated (i.e., adjusted for inflation) using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006).

6 Overall university R&D expenditures are from NSF (2006a).

7 Robst (2000), for example, found that states providing less than about 37 percent or more than 46 percent of higher-education funding were cost inefficient at providing higher-education services relative to other states.

Figure 2.4: Share of University of Minnesota Academic R&D by Funding Source, 1972-2004



Source: National Science Foundation (2006a).

Notes: These budget shares were calculated as three year weighted averages to mitigate the effects of year to-year variability.

government funded an average of 55 percent of the University's research budget, reaching a low point of 49 percent in 1987 but now sitting at almost 60 percent (Figure 2.4). State and local government spending was above a 16 percent share for each of the years 1973-1977 and again during 1986-1992, declining thereafter to just 10 percent of the total by 2004. Industry funding inched up over the years, from 3 percent in 1972 to 7 percent for each of the years 1994-1998, only to drop back to 4 percent by 2004. Meanwhile, institutionally funded R&D (including revenue from royalties, endowment revenues, and so forth) has steadily declined since 1972, from 22 percent to 14 percent in 2004.

With nearly 60 percent of the University's research budget coming from federal government sources in recent years, it is worth analyzing the nature of these funds in more detail (Table 2.1). The lion's share of the federal research funds are from the Department of Health and Human Services (HHS), accounting for 70 percent of the University's federal research funding in 2004.

In 1972, the amounts of funding from the Department of Defense and the Department of Agriculture were similar. During the subsequent period ending in 2003, funding from both agencies trended up at similar overall rates, although the growth in Department of Defense funding was much more irregular, with spikes of (well) above average funding in several years, and a significant dip in funding for the sub-period during 1973-1984. Funding from these two departments each accounted for about 3.5 percent of total federal research funding in 2003. Department of Energy funding has held fairly steady, while the Department of Education as a source of research funds has tended to decline over time. Another feature of these data is that various other federal government agencies (but principally the National Science Foundation) have collectively been a reasonably steady source of support, totaling $57.7 million (or 18 percent of total federal funds in 2004 prices) in 2003 compared with $23.7 million in 1971 (or 24 percent). On balance, the University has become increasingly reliant on a narrower portfolio of federal government funding agencies, emphasizing HHS funding. This trend seems to reflect a shift in the supply of federal funds for university research generally, rather than any structural shifts in the University of Minnesota's ability to secure funding from different federal sources.[8] Notably, National Institutes of Health funding to all U.S. agencies rose nominally by 11.2 percent per year from 1990 to 2004, almost twice the rate of increase in HHS funding directed to University of Minnesota projects (6.7 percent).[9]

8 For all universities, HHS funding for academic R&D increased from 43 percent of federal funding in 1971 to 55 percent in 2004. For the University of Minnesota, the share of federal R&D funding derived from HHS increased from 53 percent in 1971 to about 70 percent in 2004. Thus, the University has maintained an above average share of federal funding from HHS, but has largely followed national trends in consolidation of federal funding for academic R&D.

9 Calculated using data from National Science Foundation (2004, 2005b, and 2006b).

Table 2.1: University of Minnesota, Total Federal Academic R&D Obligations by Source, 1971-2003

Year	Department of Agriculture (USDA)	Department of Commerce (DOC)	Department of Defense (DOD)	Department of Education (ED)	Department of Energy (DOE)	Department of Health and Human Services (HHS)	Department of Housing and Urban Development (HUD)	Department of Labor (DOL)	Department of Transportation (DOT)	Department of the Interior (DOI)	Other Federal Departments and Agencies	Total
						(Thousands of 2004 dollars)						
1971	7,107	–	6,409	1,689	6,666	52,554	–	–	41	1,584	23,747	**99,798**
1972	7,167	–	7,371	4,908	5,148	66,693	–	–	–	1,857	37,543	**130,687**
1973	7,284	14	4,061	2,778	5,094	66,674	–	730	–	934	21,960	**109,528**
1974	6,958	128	2,597	2,943	4,859	80,055	–	75	47	1,174	14,753	**113,588**
1975	7,117	46	1,981	2,271	6,329	76,137	–	26	137	1,141	17,774	**112,956**
1976	7,803	27	2,204	2,083	6,536	84,767	24	–	398	1,254	19,659	**124,756**
1977	9,152	–	2,475	455	5,159	85,451	–	18	139	1,786	22,284	**126,920**
1978	11,637	9	2,832	1,144	6,825	92,790	303	–	142	1,137	24,878	**141,698**
1979	11,543	921	2,403	1,672	5,614	95,288	116	–	482	1,109	22,174	**141,323**
1980	11,270	1,221	2,726	3,088	6,269	99,467	240	100	154	1,015	26,671	**152,221**
1981	10,800	1,039	4,207	1,121	6,097	86,167	97	–	–	865	21,317	**131,711**
1982	10,334	1,223	7,216	1,819	6,413	85,690	–	–	–	481	22,550	**135,725**
1983	9,806	1,236	4,155	552	6,983	79,441	–	–	45	1,355	19,339	**122,912**
1984	10,230	1,274	4,423	1,305	6,882	84,785	–	–	–	379	24,857	**134,135**
1985	10,649	1,117	6,024	1,737	8,174	101,275	–	–	–	1,531	29,671	**160,179**
1986	9,481	1,082	5,348	1,872	7,164	100,569	15	–	–	757	26,796	**153,084**
1987	9,192	1,314	5,993	2,445	7,054	121,751	–	–	391	543	28,115	**176,799**
1988	10,532	36	7,731	1,850	7,123	116,073	–	–	–	530	27,182	**171,057**
1989	9,303	41	6,970	–	7,154	122,381	–	–	–	923	30,266	**177,039**
1990	9,547	981	13,316	388	6,038	119,805	–	–	–	683	31,249	**182,007**
1991	11,441	673	14,500	11,686	7,002	132,702	–	1	–	1,323	36,697	**216,026**
1992	12,447	889	23,578	8,276	6,402	127,319	–	–	944	780	41,011	**221,647**
1993	11,952	98	19,044	4,785	7,528	121,820	–	–	841	1,121	37,438	**204,627**
1994	10,714	988	9,981	1,673	7,192	146,719	–	–	1,139	551	35,948	**214,904**
1995	11,712	1,717	16,131	1,484	6,378	154,322	–	–	1,393	382	44,417	**237,935**
1996	8,926	1,355	15,566	1,986	6,957	145,114	–	–	1,260	500	40,044	**221,706**
1997	11,542	65	41,336	1,537	7,094	147,070	45	–	2,271	465	43,901	**255,326**
1998	8,572	759	16,769	876	7,649	147,181	–	–	228	572	40,022	**222,628**
1999	10,986	658	21,246	1,665	8,891	164,491	–	–	1,901	863	41,778	**252,479**
2000	15,781	920	44,888	655	11,824	180,902	–	–	2,052	1,042	41,060	**299,123**
2001	14,201	1,366	11,616	640	11,408	196,960	–	–	1,908	1,136	48,965	**288,198**
2002	13,874	873	12,488	325	10,199	216,943	19	–	1,950	1,167	45,516	**303,354**
2003	11,938	1,707	11,517	419	7,673	224,540	–	–	1,897	848	57,734	**318,271**

Source: National Science Foundation (2006a).

Note: All expenditures are deflated (i.e., adjusted for inflation) using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006).

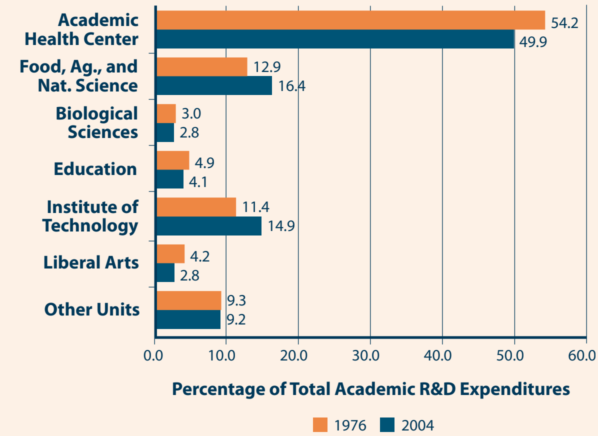
SHIFTING ORIENTATION OF UNIVERSITY RESEARCH

The changing sources of research support is one important dimension of the University's research program, but how the funds are spent matters too, especially in terms of the likely economic impact of the research.

The majority of research expenditures by the University of Minnesota were attributable to just a handful of administrative units. In 2004, more than 80 percent of the University's research expenditures were concentrated in three administrative clusters, with the Academic Health Center[10] accounting for about one-half of the University's total research expenditure (Figure 2.5). In every year since 1976, the top three administrative units in terms of research expenditure were the Academic Health Center, the Food, Agricultural, and Natural Science entities, and the Institute of Technology, respectively.

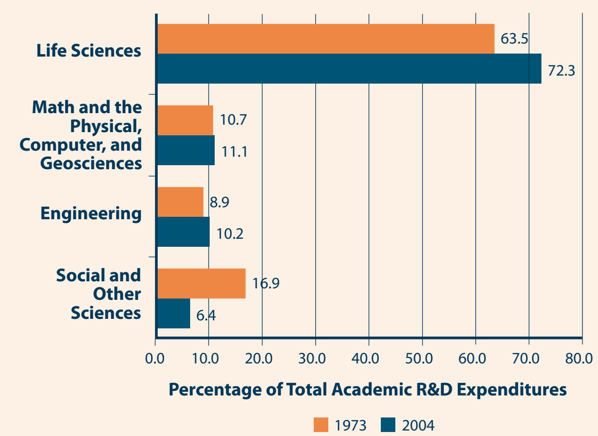
Real funding for the research done by the Academic Health Center, the Food, Agricultural, and Natural Science entities, and the Institute of Technology has generally trended up. However, the rates of growth varied among these administrative clusters and so there is some variation over time in terms of their spending shares. The Academic Health Center began the 1976 to 2004 period with a 54.2 percent share of the University's total research spending in 1976. It then lost some ground, bottoming out with a 44 percent share in 1990 and 1991 and recovering somewhat to a 49.9 percent share in 2004. Over this same period, the Food, Agricultural, and Natural Resource units grew their share from 12.9 percent in 1976 to a 19.6 percent share in 1986, and mainly hovered thereafter in the 16.5 to 18.5 percent range. The Institute of Technology share trended erratically upward, beginning at 11.4 percent and ending the period at 14.9 percent with some intervening years in the 18-20 percent range. Appendix Table 2.2 presents time-series data on

Figure 2.5: University of Minnesota, Share of Academic R&D Expenditure by Academic Unit



Source: University of Minnesota, Office of the Vice President for Research (various years).

Figure 2.6: University of Minnesota, Share of Academic R&D Expenditure by Field of Science



Source: National Science Foundation (2006a).

10 The Academic Health Center includes the Medical School, School of Nursing, School of Dentistry, College of Pharmacy, College of Veterinary Medicine, University Hospital, and the University of Minnesota Duluth Medical School, as well as other expenditures by the Academic Health Center.

the amount of research expenditures incurred by these various units.[11]

Figure 2.6 breaks down the same research totals, this time by broad "fields of science" rather than the administrative units shown in Figure 2.5. It is of little surprise that the life science share (which would encompass much, but not all, of the spending incurred by Academic Health Sciences, plus the Agriculture, Food, and Natural Resource units) accounts for 70-75 percent of the University's research spending since 1973.

These spending differentials across fields of science or academic units represent a combination of supply and demand phenomena. On the supply side of research, some of the sciences (typically medical, engineering, some biological, and other, similar sciences) are intrinsically costly, requiring expensive laboratory hardware and experimental equipment, while many of the social sciences are much more labor intensive pursuits requiring much less physical capital. All areas of scientific inquiry rely crucially on the talent and training of researchers, and so the composition of the faculty in terms of tenure status (e.g., the mix of assistant, associate, and full professors) and other attributes will affect the relative costs of research. Notably, in the globally competitive labor markets that epitomize most areas of research, the quality (and reputation) of scientists affects their salaries (as well as their sign-on or retention support packages). The University of Minnesota must compete with other universities to recruit and retain top-ranked researchers. Moreover, there are structural salary differences among different areas of inquiry arising from the differences in opportunity costs of University of Minnesota faculty as revealed, for example, by the earning potential of Minnesota faculty in other universities and other, non-academic careers. Scientific reputation and competence, among a host of other factors, also affect the ability of University of Minnesota faculty to secure outside funding, much of which is offered on a nationally competitive basis.

Table 2.2: Number and Average Amount of Research Awards by Unit, 1990-2005

Academic Unit	1990-1995	1996-2000	2001-2005
Average Number of Awards Per Year			
Academic Health Center	1,284	1,372	1,490
Institute of Technology	664	631	591
CFANS	310	320	359
Education	134	130	133
Biological Sciences	126	121	113
Liberal Arts	99	87	99
Others	406	408	394
All Academic Units	**3,022**	**3,069**	**3,178**
Average Award Amount *(Thousands of 2004 Dollars)*			
Academic Health Center	135.0	159.3	202.9
Institute of Technology	122.7	134.2	144.1
CFANS	63.3	70.9	81.2
Education	108.7	124.5	205.7
Biological Sciences	102.3	114.9	154.4
Liberal Arts	112.4	132.1	159.5
Others	91.2	116.6	150.5
All Academic Units	**115.8**	**135.3**	**168.8**

Source: University of Minnesota, Office of the Vice President for Research (various years).

Table 2.2 gives an indication of the number and average amount of funding secured for research awards among various administrative units at the University of Minnesota since 1990. Since this date, the annual number of research awards received by the University has remained fairly constant, hovering at around 3,000 awards per year. The individual academic units exhibit a similar trend. However, the average real amount of these awards has increased from an average of $115,800 per award in the period 1990-95 to an average $168,800 per award during 2001-05. Together, these trends imply that the growth in the University's research program over the past fifteen years resulted from an increase in the average size of projects rather than

11 To estimate the R&D expenditure for each academic unit, we first used University data (University of Minnesota, Office of the Vice President for Research, various years) to calculate the proportion of University R&D expenditure attributable to each academic unit. Specifically, we use reported values for "sponsored research," "sponsored training and public service," "departmental research," (where available) and "special appropriations for research" as reported in the University's annual "Levels and Trends" reports. Then, these shares were applied to the total R&D expenditures that were reported to the National Science Foundation. This process was followed so that the figures reported here are directly comparable with the estimates presented in the other briefs in this series.

from simply expanding the number of projects that were successfully funded from external sources.

FINAL REMARKS

Investments in the University of Minnesota's research program roughly doubled in inflation-adjusted terms over the past three decades. However, this increase was neither consistent across all sources of funds, nor across the University's academic units. The federal government provided a relatively stable (in fact, marginally increasing) share of the University's research budget while the relative amount of research funding from state and local governments, most of which was provided by the state of Minnesota, decreased.

The research spending shares directed to different administrative units (and scientific fields) has shifted slowly over time. Compared with 1972, fewer relative research resources go to Academic Health Center (now 49.9 percent compared with 54.2 percent in 1972), the Food, Agricultural, and Natural Resource cluster has increased its share (from 12.9 percent to between 16.5 and 18.5 percent in more recent years), while the Institute of Technology has moved its share erratically up from 11.4 to 14.9 percent. As a consequence of these changes, the social and other sciences share of University research has decreased.

Overall, the variability and trends in funding across the University appear consistent with a portfolio of research programs and sponsors that is sufficiently diversified to hedge against undue year-to-year variability in any particular sponsor or research program. Notably, however, state and local government funding for University research is shrinking relative to the federal government.12

This shift in funding sources implies that the ability of the state government to influence the University's research agenda is diminishing and, as a consequence, the University's research program may become less focused on issues of local and regional concern. In addition, in striving to be one of the top three public research universities, the state and local government can play an important role in attaining and maintaining a competitive edge. Precisely how that process plays out depends on the structure and growth in support for University of Minnesota research *relative* to funding trends in other states and other peer institutions, the subject of Briefs 3 and 4, respectively, in this series.

Box 2.1: Data Sources and Methods

The academic R&D series used in this and the companion briefs are based on data for 805 academic institutions. Each university and college reported their data to the National Science Foundation (NSF) which provides public access via the NSF's WebCASPAR Integrated Science and Engineering Resources Data System. Research expenditures include all "… funds that are separately budgeted and restricted for research, such as sponsored research accounts or general accounts that are specifically budgeted for research (NSF 2005a, Appendix C, p. 11)." Effectively, this means a portion of the salaries of faculty in disciplines that receive comparatively little grant or contract funding (but nevertheless undertake some research in addition to their teaching and other responsibilities) are omitted from reported academic research—thereby understating the amount actually spent on R&D. NSF data also explicitly exclude expenditures on large capital items such as buildings, but do include funding for salaries of research faculty and scientific support staff, the costs of scientific equipment, and the general operational costs incurred in the conduct of R&D.

Respondents to the NSF surveys compiling the "Science and Engineering (S&E)" expenditure data used here are requested to "… exclude fields that are considered to be non-science—education, law, humanities, business, music, the arts, library science, and physical education (NSF 2005a, Appendix C, p. 10)." Based on ancillary

continued ▶

12 The shrinking share of state and local government research funding also follows the national trend. In fact, in 2004, 68.3 percent of all the academic R&D across the country was funded by the federal government, compared to 6.6 percent by state and local governments. This dichotomy is much more pronounced on the national front than at the University of Minnesota, where the respective funding shares were 59.9 and 10.3 percent in 2004.

Box 2.1: Data Sources and Methods (cont.)

NSF surveys, non-S&E expenditures were $1.6 billion in fiscal year 2004, or 3.7 percent of the $42.9 billion of total academic R&D spending (NSF 2006c).

S&E data for all 805 academic institutions were aggregated across all years for calculating national growth rates. Faculty and student counts were also taken from the WebCAPSPAR database, but tailored aggregations were required to obtain counts consistent with expenditure totals (e.g., to compare against the total research expenditures of all campuses of the University of Minnesota, student counts from each of the University's campuses were summed).

The top 25 lists of the Top American Research Universities and the Top Public Research Universities (presented in Brief 4) are based on the University of Florida's TheCenter "ordering" system (see also the 2004 Rand Corporation study by Fossum et al. and that by Shanghai Jiao Tong University additional ranking information). TheCenter does not rank individual institutions, but rather orders them in groups according to the number of times a university scores in the top 25 of one of 9 comparison categories. In forming the ordering, each category is given equal weight.

Data for spending by University of Minnesota academic unit were taken from the annual "Levels and Trends in Sponsored Programs" reports which are issued by the University of Minnesota Office of the Vice President for Research. These data were adjusted to assure direct comparability with the NSF data used for overall expenditures (see footnote 11). Beginning with FY 2001, expenditures for the Minnesota Agricultural Experiment Station (MAES) and the University of Minnesota Extension Service were calculated using data provided by the Minnesota Extension Service using the procedures described in the notes accompanying Appendix Table 2.2.

Other data came from the National Center for Educational Statistics (NCES) (for shares of overall budget functions) and the World Bank (U.S. GDP deflator time-series). NCES data were collected using the University of Minnesota's access to the Integrated Postsecondary Education Data System (IPEDS) Peer Analysis System. Data from the IPEDS Data Cutting Tool was extracted from the 2005 "universe" back to 1984.

Throughout this series of briefs, average annual growth rates for designated periods are the means of the corresponding year-to-year growth rates obtained using an arithmetic growth formula.

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Appendix Table 2.1: University of Minnesota, Total Academic R&D Expenditures by Source, 1972-2004

Year	Federal Government	State and Local Government	Industry	Institutionally Financed	Other	Total
			(Millions of 2004 Dollars)			
1972	99.9	15.5	4.3	38.6	15.1	**173.5**
1973	104.6	28.9	4.3	25.8	17.9	**181.5**
1974	109.7	32.1	4.4	25.5	16.4	**188.1**
1975	119.0	32.3	4.3	22.6	19.9	**198.2**
1976	121.2	34.6	4.0	23.1	19.2	**202.1**
1977	122.5	34.8	5.0	29.1	17.8	**209.2**
1978	125.9	25.2	6.7	48.6	17.5	**223.9**
1979	133.5	25.1	7.9	47.7	17.3	**231.6**
1980	137.0	25.7	8.7	48.5	18.4	**238.3**
1981	142.4	24.1	8.3	52.0	16.5	**243.4**
1982	143.2	26.6	8.1	56.5	18.2	**252.5**
1983	132.1	25.8	9.9	60.5	22.9	**251.2**
1984	127.1	25.8	12.9	61.1	26.1	**252.9**
1985	136.1	30.2	12.6	59.3	30.6	**268.8**
1986	152.2	48.3	16.9	56.5	32.2	**306.1**
1987	160.9	55.1	16.3	58.1	37.9	**328.3**
1988	171.0	56.1	15.2	53.2	41.5	**337.1**
1989	182.8	58.5	17.0	60.1	37.3	**355.7**
1990	190.4	62.8	23.9	70.7	38.8	**386.7**
1991	211.0	68.6	24.7	77.9	42.0	**424.1**
1992	207.5	62.2	21.9	76.9	27.9	**396.5**
1993	213.6	61.0	26.3	79.3	25.8	**405.9**
1994	216.7	54.8	28.4	55.7	24.9	**380.6**
1995	228.6	58.1	27.5	54.2	26.4	**394.8**
1996	229.0	55.1	27.3	53.8	27.6	**392.8**
1997	226.7	57.2	27.4	60.8	39.0	**411.2**
1998	229.3	52.7	27.0	62.1	32.4	**403.6**
1999	229.4	54.2	26.4	68.0	32.1	**410.0**
2000	248.5	56.6	28.5	76.0	35.0	**444.5**
2001	278.9	61.3	27.9	84.2	35.3	**487.6**
2002	306.9	63.1	27.6	77.1	39.0	**513.7**
2003	299.4	60.5	24.7	71.9	62.7	**519.1**
2004	308.4	52.9	21.8	71.8	60.1	**515.1**

Source: National Science Foundation (2006a).

Notes: All expenditures are deflated (i.e., adjusted of inflation) using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006).

Appendix Table 2.2: University of Minnesota, Dollar Amount and Share of Research Expenditure, by Unit, 1976-2004

Year	Academic Health Center	Food, Ag and Nat. Science	Biological Sciences	Education	Institute of Technology	Liberal Arts	Other Units	Total
Expenditure Per Year *(Millions of 2004 Dollars)*								
1976	109.6	26.1	6.1	9.9	23.0	8.6	18.8	**202.1**
1977	111.2	28.9	6.4	8.6	25.9	9.0	19.2	**209.2**
1978	112.0	34.5	7.5	8.2	28.5	10.9	22.2	**223.9**
1979	117.8	35.1	8.9	8.3	30.0	11.3	20.3	**231.6**
1980	120.5	37.0	9.8	9.2	30.7	11.1	20.0	**238.3**
1981	121.4	36.6	9.3	9.3	35.0	9.5	22.3	**243.4**
1982	126.1	41.6	10.8	7.9	37.5	8.0	20.6	**252.5**
1983	119.0	44.7	11.0	6.9	39.8	7.0	22.7	**251.2**
1984	117.2	47.5	10.8	6.4	43.4	5.7	21.8	**252.9**
1985	121.8	47.4	12.0	7.4	46.3	5.9	28.1	**268.8**
1986	135.6	60.0	13.2	7.3	55.4	6.5	28.1	**306.1**
1987	148.7	61.7	13.1	7.2	57.7	7.4	32.5	**328.3**
1988	164.1	62.0	11.8	8.2	53.9	7.5	29.6	**337.1**
1989	166.4	64.2	13.2	11.6	60.6	8.0	31.7	**355.7**
1990	169.1	63.1	15.8	11.3	72.4	8.4	46.7	**386.7**
1991	186.3	65.3	15.1	11.4	94.6	10.6	40.8	**424.1**
1992	187.3	65.2	14.6	11.9	73.2	9.8	34.5	**396.5**
1993	187.1	68.0	15.4	13.0	73.2	10.8	38.4	**405.9**
1994	166.4	64.1	14.4	13.1	76.7	10.2	35.6	**380.6**
1995	180.7	63.9	15.0	15.1	70.6	10.2	39.3	**394.8**
1996	180.4	77.2	12.7	12.6	64.4	8.3	37.3	**392.8**
1997	187.3	76.7	12.7	12.1	70.9	9.3	42.1	**411.2**
1998	172.5	75.4	12.0	11.7	82.6	9.4	40.0	**403.6**
1999	179.4	80.2	13.3	14.0	70.1	9.3	43.7	**410.0**
2000	194.7	81.0	12.4	15.8	87.8	9.8	43.1	**444.5**
2001	231.8	88.8	12.8	18.0	81.7	10.5	44.1	**487.6**
2002	252.7	92.2	14.4	20.8	70.0	12.2	51.5	**513.7**
2003	254.0	90.1	15.2	21.8	73.7	13.3	51.1	**519.1**
2004	256.8	84.3	14.2	21.1	76.8	14.4	47.6	**515.1**
Expenditure Share Per Year *(Percentage of Total)*								
1976	54.2	12.9	3.0	4.9	11.4	4.2	9.3	**100.0**
1990	43.7	16.3	4.1	2.9	18.7	2.2	12.1	**100.0**
2004	49.9	16.4	2.8	4.1	14.9	2.8	9.2	**100.0**

Source: University of Minnesota, Office of the Vice President for Research (various years).

Notes: All expenditures are deflated (i.e., adjusted for inflation) using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006). The category "Food, Agriculture and Natural Resources" includes the following units: the College of Natural Resources, the College of Agricultural, Food and Environmental Sciences, the Minnesota Agricultural Experiment Station and the University of Minnesota Extension Service. Beginning with FY 2001, research expenditures for the Minnesota Agricultural Experiment Station (MAES) and the University of Minnesota Extension Service were estimated using a different method from that used for the other units (see footnote 11). First, the annual growth rates in research expenditure for MAES were derived using data provided by MAES. Then, FY 2000 expenditures for both the MAES and the Extension Service were projected forwarded using the derived growth rates to estimate expenditures for FY 2001-2004.

Appendix Table 2.3: University of Minnesota, Total and Share of Academic R&D Expenditure by Field, 1973-2004

Year	Engineering	Math and the Physical, Computer, and Geosciences	Life Sciences	Social and Other Sciences	Total
Expenditure Per Year *(Millions of 2004 dollars)*					
1973	16.21	19.43	115.27	30.58	**181.5**
1974	16.10	18.27	123.17	30.59	**188.1**
1975	15.49	16.34	144.42	21.96	**198.2**
1976	13.67	17.81	150.17	20.43	**202.1**
1977	15.11	19.79	156.02	18.29	**209.2**
1978	18.06	19.03	168.16	18.65	**223.9**
1979	19.05	19.86	172.88	19.76	**231.6**
1980	18.58	20.30	181.45	17.94	**238.3**
1981	21.95	22.00	182.03	17.42	**243.4**
1982	22.04	23.21	190.94	16.37	**252.5**
1983	24.19	24.75	191.45	10.81	**251.2**
1984	25.47	24.25	192.86	10.36	**252.9**
1985	28.01	28.43	197.34	15.05	**268.8**
1986	32.04	33.07	223.48	17.50	**306.1**
1987	34.20	34.86	239.37	19.91	**328.3**
1988	34.52	34.30	247.78	20.45	**337.1**
1989	38.11	38.91	257.66	21.00	**355.7**
1990	37.00	55.37	270.90	23.43	**386.7**
1991	35.13	78.19	284.67	26.08	**424.1**
1992	32.58	58.04	280.40	25.44	**396.5**
1993	35.28	57.56	289.02	24.04	**405.9**
1994	36.67	58.88	262.48	22.53	**380.6**
1995	38.04	52.51	280.76	23.54	**394.8**
1996	39.24	49.09	281.97	22.53	**392.8**
1997	43.81	45.06	298.42	23.90	**411.2**
1998	42.11	45.34	292.56	23.57	**403.6**
1999	42.58	47.10	297.06	23.30	**410.0**
2000	44.67	53.30	321.91	24.62	**444.5**
2001	43.97	64.65	354.71	24.27	**487.6**
2002	49.22	51.97	386.83	25.72	**513.7**
2003	51.22	56.18	379.75	31.97	**519.1**
2004	52.31	57.19	372.49	33.07	**515.1**
Expenditure Share Per Year *(Percentage of Total)*					
1973	8.9	10.7	63.5	16.9	**100.0**
1990	9.6	14.3	70.1	6.1	**100.0**
2004	10.2	11.1	72.3	6.4	**100.0**

Source: National Science Foundation (2006a).

Notes: All expenditures are deflated (i.e., adjusted for inflation) using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006).

BRIEF 3

Minnesota's Decline: A State-by-State Comparison of Academic R&D Expenditures

STEVEN DEHMER AND PHILIP G. PARDEY

U.S. university research has a long, evolving, and important role in stimulating technical advances in industry, and economic growth generally. However, as Rosenberg and Nelson (1994) make clear, university research is typically long term and complementary to privately performed research. Moreover, the amount and nature of interactions with state, local, and federal governments, regional industry, and the research community set the stage for university research and its subsequent economic impact.[1] Similarly, political and other forces shape public spending priorities and affect private interests in funding and collaborating with publicly performed R&D in universities and other institutions.

In this vein, we assess how academic R&D expenditures in the state of Minnesota compare nationally over the past few decades. We consider the levels, trends, and intensities (i.e., adjusted for various indicators of size) of research spending to gain a better understanding of the landscape in which the University of Minnesota finds itself relative to its goal to be one of the top three public research universities in the world. According to a variety of measures developed for this study, the state of Minnesota has slipped relative to other states in academic research expenditures.

1 More contemporary writers such as Etzkowitz and Leydesdorff (2000) dub this university-industry-government triumvirate as a "triple helix model of innovation" and echo many of the points raised by Rosenberg and Nelson.

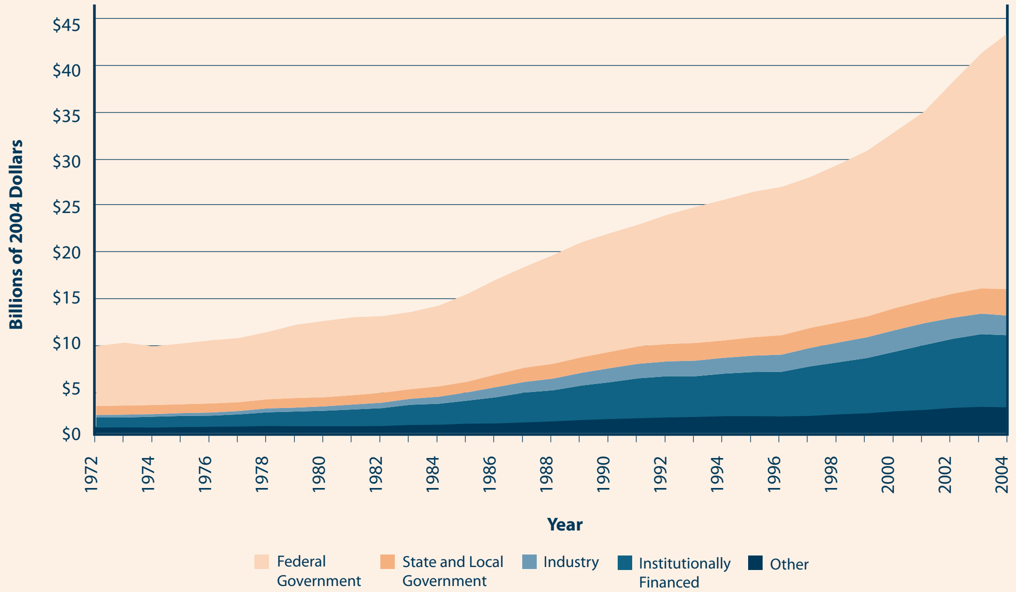
NATIONAL TRENDS IN ACADEMIC R&D EXPENDITURES[2]

Before describing Minnesota trends, it is instructive to provide a sense of national patterns of academic R&D. Total investments in academic R&D in the United States grew substantially over the past three decades—from $9.4 billion in 1972 (2004 prices) to $42.9 billion in 2004 (Figure 3.1).[3] In 2004, academic R&D accounted for approximately 15.1 percent of all the publicly and privately performed R&D in the United States. In other words, U.S. universities as a group perform nearly the same amount of research as the entire economies of the United Kingdom and Spain, together, or more than all the economies of South America, the Middle East, and sub-Saharan Africa, combined (Pardey, Dehmer, and El Feki 2007).

2 Academic R&D expenditures reported in this brief and the companion briefs in this series include only spending in science, engineering, and related fields. This is because the national compilation of academic research indicators reported by the National Science Foundation (NSF) only includes data related to science and engineering (S&E), and thus excludes research in the humanities and arts. This omission is not of major consequence for our consideration of academic research expenditure patterns; recent NSF surveys that seek a comprehensive measure of academic R&D spending suggest that non-S&E research constitutes only 3 to 4 percent of total academic R&D (NSF 2006a).

3 For the remainder of this brief, unless otherwise specified, all dollar figures will be deflated (i.e., adjusted for inflation) to base year 2004 prices. The U.S. GDP deflator (World Bank 2006) was used for this adjustment.

Figure 3.1: U.S. Total Academic R&D Expenditures by Source, 1972-2004



Source: National Science Foundation (2006c).

Notes: All expenditures are deflated (i.e., adjusted for inflation) using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006). The expenditure totals include R&D performed in public and private academic institutions. In 2004, public universities made up 68.2 percent of the total, compared to 61.8 percent in 1972.

The federal government accounts for the largest share of this total, funding 63.8 percent of all academic research in 2004, down from its 68.2 percent share in 1972 (Figure 3.2). The next largest funding source is institutional funds (e.g., self-generated funds or endowment revenues), accounting for 18.1 percent in 2004, up from 11.6 percent in 1972. As may be guessed, the share of industry funds has also increased during this period, from 2.8 percent in 1972 to 4.9 percent in 2004. Conversely, the share from state and local governments has declined from 10.2 percent in 1972 to 6.6 percent in 2004.

During the past three decades, academic R&D investments have grown fastest from industry and institutional sources, increasing at average annual inflation-adjusted rates of 6.8 and 6.4 percent, respectively (Table 3.1). Meanwhile, federal and state and local government funding grew at more modest, but still appreciable annual rates of 4.7 and 3.5 percent, respectively. Notably, the patterns of growth in funding sources for academic R&D since 2000 represent a sharp break with previous periods, characterized by a reduction in funding from industry sources and a rapid ramping up of federal government funding. This shift has considerable (positive) impact on research budgets, given the relatively large share of total research that is federally funded. Industry funding, on the other hand, saw consistent and considerable growth, particularly after the passage of the Bayh-Dole Act in 1980[4]; however, industry's comparatively small funding share of academic research has diminished in recent years, with real declines in industry funding of academic R&D mirroring recent declines in private industry R&D spending generally (National Science Foundation 2005, 2006a, 2006b).[5]

4 The Bayh-Dole Act, passed in 1980, established the general right of grant recipients (e.g., universities) to apply for patents on most federally-funded research. This made it possible for industry to negotiate intellectual property rights over university research it co-financed in conjunction with federal funds. The upward trend in industry funding of academic R&D since 1980 is clear, but the causal relationship to the Bayh-Dole Act has been less certain. See Mowrey et al. (2001) for more discussion of this Act in a university context.

5 Total industrial R&D expenditures in the United States did

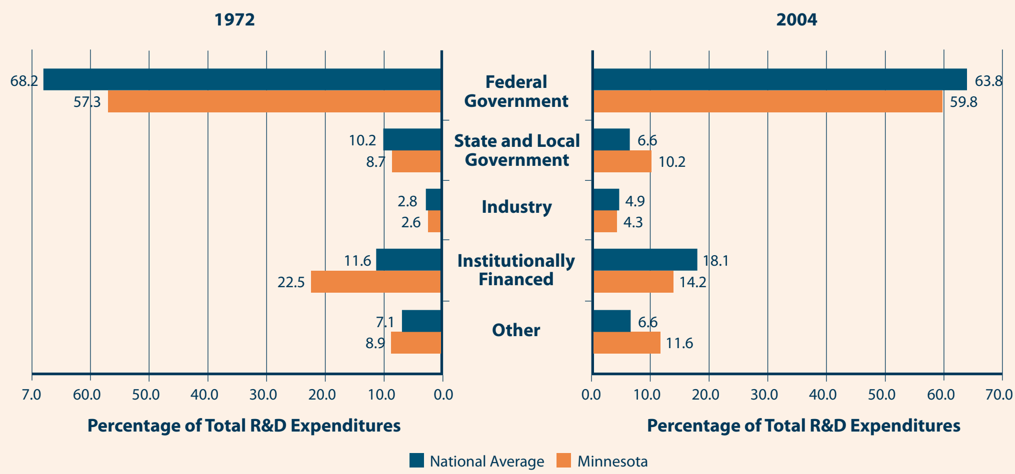
MINNESOTA TRENDS IN ACADEMIC R&D EXPENDITURES

Academic R&D within the state of Minnesota has also grown considerably over the past few decades, from $178.4 million in 1972 to $524.3 million in 2004. Notably, the University of Minnesota's $515.1 million accounts for more than 98 percent of the academic R&D in the state. However, if the Mayo Clinic and Foundation for Medical Education and Research expenditures were also included (currently, these are not classified as "academic" R&D), that would roughly add another $300 million dollars to the state total. This potential addition should be kept in mind when considering the state-by-state comparison tables presented below.

Keeping with the national trend, Minnesota's academic R&D spending is primarily sourced from the federal government (Figure 3.2). Dropping to a low of 49.1 percent in 1987, the federal share in 2004 is nearly the same as it was three decades ago, at 59.8 versus 57.3 percent, respectively. State and local government funding followed a different

rebound in 2003, although they still are less than the inflation-adjusted expenditures of 2000. However, industry funding of academic R&D has continued to slide since its peak in 2001.

Figure 3.2: Academic R&D Expenditure Shares by Source, 1972 and 2004



Source: National Science Foundation (2006c).

Notes: All expenditures are deflated (i.e., adjusted for inflation) using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006).

Table 3.1: Growth of Total U.S. Academic R&D Expenditures by Funding Source, 1972-2004

Funding Source	1972-2004	1972-1980	1980-1990	1990-2000	2000-2004	2004 R&D Expenditures	2004 Share
			(Average Percentage Per Year)			*(Millions of dollars)*	*(Percentage)*
Industry	6.8	7.4	12.3	4.6	-2.5	2,107	4.9
Institutionally Financed	6.4	5.5	9.1	4.9	5.0	7,771	18.1
Other	4.7	2.4	7.0	4.5	4.0	2,841	6.6
Federal Government	4.7	3.2	4.6	4.0	9.7	27,379	63.8
State and Local Government	3.5	0.3	6.1	3.1	4.6	2,847	6.6
Total	**4.9**	**3.2**	**6.0**	**4.2**	**7.2**	**42,945**	**100.0**

Source: National Science Foundation (2006c).

Notes: Average annual growth rates are calculated by taking the mean of the year-to-year growth rates calculated using the arithmetic growth formula. Growth rates are inflation adjusted using the U.S. GDP implicit price deflator (World Bank 2006).

Table 3.2: Growth Rates in State of Minnesota Academic R&D by Funding Source, 1972-2004

Funding Source	1972-2004	1972-1980	1980-1990	1990-2000	2000-2004	2004 R&D Expenditures	2004 Share
			(Average Percentage Per Year)			*(Millions of dollars)*	*(Percentage)*
Industry	5.8	8.9	11.9	2.2	-6.2	22.4	4.3
Other	5.5	2.5	8.4	0.5	16.9	60.7	11.6
State and Local Government	5.4	9.9	10.6	-0.8	-1.2	53.4	10.2
Federal Government	3.7	3.8	3.5	2.8	5.7	313.5	59.8
Institutionally Financed	3.2	5.8	4.2	1.8	-1.0	74.2	14.2
Total	**3.5**	**3.7**	**5.1**	**1.6**	**3.9**	**524.3**	**100.0**

Source: National Science Foundation (2006c).

Notes: Average annual growth rates are calculated by taking the mean of the year-to-year growth rates calculated using the arithmetic growth formula. Growth rates are inflation adjusted using the U.S. GDP implicit price deflator (World Bank 2006).

trajectory. The share of state and local funding has fluctuated, reaching a high of 17.1 percent of the total in 1976 (and peaking again in the late 1980s/early 1990s); however, by 2004, it stood at 10.2 percent of the total, slightly up from its 8.7 percent share in 1972. The share of industry funding has also bounced around, accounting for 4.3 percent of the share in 2004, up from 2.6 percent in 1972, but down from a high of 7.4 percent in 1994. In fact, industry's funding share has declined fairly steadily since 1994. The institutionally financed share of Minnesota's R&D has shown some volatility, but otherwise has steadily shrunk over the past three decades, down to 14.2 percent in 2004 from 22.5 percent in 1972. Much of this declining share seems to follow real declines in University of Minnesota endowment income.[6]

Over the long-haul, industry funding grew fastest during the 1972-2004 period, at an average real rate of 5.8 percent per year (Table 3.2). Growth in state and local government was close behind at 5.4 percent per year, and federal and institutional funds held up modestly at 3.7 and 3.2 percent per year, respectively. State and local government funding for academic research in Minnesota ramped up rapidly in the 1970s and 1980s, at rates well above the national average; after 1990, however, the trend is much different. Elsewhere in the country, state and local governments continued to increase their investments in academic R&D (albeit, at lower rates compared with the 1980s), but state and local government support for academic research in Minnesota has been cut back—dropping by 0.8 percent per year (on average) in the 1990s and declining even more rapidly (by 1.2 percent per year) since 2000. Conversely, there was a rebound in Minnesota's federal government funding growth in the last few years (but at a rate of increase lower than the national average).

MINNESOTA ACADEMIC R&D IN A NATIONAL CONTEXT

The state of Minnesota and its universities compete for research funding (mostly federal, but also industrial and philanthropic) with other states and institutions, many of which are also striving to improve the quality and local impact of the academic institutions hosted in their states. The comparative data below reveal how academic research in Minnesota has fared on a state-by-state basis. Across a variety of measures, we show that Minnesota has fallen relative to other states.

In 1972, the state of Minnesota ranked 19th in the nation in terms of total academic R&D expenditures with $178.4 million (2004 prices) of spending (Table 3.3). California and New York topped the list with a sizably larger $1.2 and $1.1 billion, respectively. Neighbors Michigan and Wisconsin came in at 6th and 7th, with $350.8 and $291.1 million, respectively, and Illinois was 5th with $442.8 million. By 2004, California and New York still topped the list with $5.7 and $3.4 billion in academic R&D, respectively, while the Midwestern states all slid down the rankings—to 7th for Illinois,

6 The notion that the decline in institutional funds arises from a contraction in endowment income stems from conversations with Peter Zetterberg of the University's Office of Institutional Research.

9th for Michigan, 13th for Wisconsin, and 26th for Minnesota. Notably, this period saw Minnesota slide from the top half of states in total academic R&D, to the bottom half.

Looking to long-term growth rates in total academic research spending, Minnesota ranked 47th in the nation over the 1972-2004 period, growing at an average annual rate of 3.5 percent per year (Table 3.4). This is well below the impressive average annual growth of 9.0 percent by Maryland. Neighbor North Dakota also makes the top five, growing annually by 7.4 percent, but this is from a much smaller base. Notably, Minnesota has growth rates comparable to 46th ranked New York and 48th ranked Massachusetts. However, these two states were able to maintain their high ranking in total academic spending (New York maintaining the number two spot

Table 3.3: Top 20 States in Total Academic R&D Expenditures, 1972 and 2004

Rank	1972 Expenditures		Rank	2004 Expenditures	
	(Millions of 2004 dollars)			*(Millions of 2004 dollars)*	
1	California	1,161.0	1	California	5,714.4
2	New York	1,108.2	2	New York	3,365.7
3	Massachusetts	677.5	3	Texas	2,880.8
4	Pennsylvania	464.7	4	Maryland	2,269.2
5	Illinois	442.8	5	Pennsylvania	2,206.0
6	Texas	426.3	6	Massachusetts	2,000.1
7	Michigan	350.8	7	Illinois	1,707.6
8	Wisconsin	291.1	8	North Carolina	1,442.9
9	Missouri	281.4	9	Michigan	1,397.0
10	Ohio	260.8	10	Ohio	1,318.4
11	Florida	234.7	11	Florida	1,306.8
12	North Carolina	232.2	12	Georgia	1,221.3
13	Maryland	227.3	13	Wisconsin	955.8
14	Washington	225.4	14	Washington	896.9
15	Colorado	213.0	15	Virginia	848.6
16	Connecticut	193.6	16	Missouri	841.6
17	Georgia	185.3	17	Indiana	841.0
18	Indiana	183.4	18	New Jersey	805.7
19	**Minnesota**	**178.4**	19	Colorado	771.8
20	New Jersey	166.6	20	Tennessee	658.0
			26	**Minnesota**	**524.3**

Source: National Science Foundation (2006c).

Notes: All expenditures are deflated (i.e., adjusted for inflation) using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006).

Table 3.4: Growth Rates in Total Academic R&D Spending by State, 1972-2004

Rank		1972-2004	1972-1980	1980-1990	1990-2000	2000-2004	2004 Expenditures
		(Average Percentage Per Year)					*(Millions of Dollars)*
1	Maryland	9.0	19.3	7.4	2.4	8.7	2,269.2
2	South Carolina	8.5	9.0	10.6	5.6	9.6	456.0
3	New Hampshire	8.0	5.6	9.2	6.1	14.4	277.2
4	North Dakota	7.4	7.2	2.1	7.8	20.3	151.7
5	Nevada	7.2	3.4	11.3	5.2	9.5	163.8
6	Kentucky	7.1	5.5	5.5	9.2	9.1	424.0
7	Virginia	6.8	6.2	10.1	3.1	9.3	848.6
8	Arizona	6.7	8.0	8.5	3.9	6.7	651.0
9	Alabama	6.6	5.7	11.0	3.4	5.5	571.0
10	Montana	6.3	6.1	3.0	8.5	9.7	154.7
41	Connecticut	3.9	2.7	5.5	2.4	6.5	649.7
42	Rhode Island	3.9	2.3	4.7	2.6	8.3	192.3
43	Wisconsin	3.9	1.4	4.4	3.9	7.5	955.8
44	Hawaii	3.9	0.0	2.3	6.4	9.1	241.3
45	Missouri	3.7	-2.3	5.5	5.6	6.2	841.6
46	New York	3.6	1.2	4.5	2.9	8.0	3,365.7
47	**Minnesota**	**3.5**	**3.7**	**5.1**	**1.6**	**3.9**	**524.3**
48	Massachusetts	3.5	1.7	4.5	3.0	5.7	2,000.1
49	Alaska	3.5	5.9	0.7	3.4	5.9	146.5
50	South Dakota	3.2	-1.7	-0.3	4.7	17.8	57.2
	National Average	*4.9*	*3.2*	*6.0*	*4.2*	*7.2*	*42,945.0*

Source: National Science Foundation (2006c).

Notes: Average annual growth rates are calculated by taking the mean of the year-to-year growth rates calculated using the arithmetic growth formula. Growth rates are inflation adjusted using the U.S. GDP implicit price deflator (World Bank 2006).

Table 3.5: Top 20 States in Total Academic R&D Expenditures Per Capita, 1972 and 2004

Rank	1972 Expenditures		Rank	2004 Expenditures	
	(2004 dollars per capita)			*(2004 dollars per capita)*	
1	Alaska	183.93	1	Maryland	416.96
2	Massachusetts	119.09	2	Massachusetts	311.95
3	Hawaii	109.52	3	North Dakota	239.45
4	Utah	108.32	4	Alaska	228.60
5	Colorado	96.38	5	New Hampshire	217.47
6	New Mexico	73.92	6	Hawaii	195.52
7	Rhode Island	66.62	7	Nebraska	187.95
8	Washington	66.03	8	Vermont	187.87
9	Wisconsin	65.89	9	Connecticut	187.85
10	Connecticut	63.86	10	Iowa	181.22
11	Wyoming	61.04	11	Rhode Island	179.99
12	New York	60.75	12	Pennsylvania	179.00
13	Missouri	60.16	13	Utah	177.32
14	California	58.13	14	Wisconsin	175.73
15	Maryland	57.92	15	New York	175.62
16	Oregon	55.20	16	North Carolina	173.57
17	Vermont	52.15	17	Colorado	171.58
18	Arizona	48.28	18	Montana	169.95
19	Nebraska	47.86	19	New Mexico	163.80
20	**Minnesota**	**46.88**	20	California	163.32
			40	**Minnesota**	**104.36**

Source: National Science Foundation (2006c); U.S. Census Bureau (2006a; 2006b).

Notes: All expenditures are deflated (i.e., adjusted for inflation) using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006).

and Massachusetts slipping from 3rd to 6th) given their large initial funding bases. In recent years, Minnesota picked up its rate of growth to 3.9 percent per year, moving ahead of its three decade average (3.5 percent per year). Even so, this rate of increase is well behind the national average of 7.2 percent per year since 2000.

RESEARCH INTENSITIES

Larger states are more likely to spend more on academic R&D (and on many other things as well) compared with smaller states. It is of little surprise, then, that large states like California, New York, and Texas top the list of state spending in academic research in 2004 (Table 3.3). In Table 3.5, we normalize the data regarding one important dimension of "largeness," expressing the state academic R&D spending relative to the size of a state's population.

In 1972, Minnesota ranked 20th in academic R&D expenditures per capita, at $46.88 per person. Given this normalization, Alaska was at the top of the list with $183.93 per person, due to its relatively small population.[7] However, Massachusetts, a state that hosts several prestigious academic research institutions, ranked second with $119.09 per capita. The top state in terms of total academic R&D spending, California, ranked 14th on this per capita measure. These data reveal no statistically significant link between the size of the state population and per-capita academic R&D expenditures.[8]

The right-hand panel in Table 3.5 shows Maryland asserting its preeminence in 2004, leading with $416.96 per person, followed by Massachusetts with $311.95 per capita. North Dakota ranks third, well up from their 36th place in 1972. Minnesota dropped precipitously in these rankings, from 20th in 1972 down to 40th in 2004 with $104.36 of academic R&D spending per capita. Notably, after

7 Alaska ranked 43rd in academic R&D expenditures but also was the 4th smallest state in terms of population, with just fewer than 664 thousand residents.

8 That is, a simple linear regression (using 2004 data) of state population onto academic R&D spending per capita yielded a surprisingly low coefficient of determination (R-squared) of less than 0.01 and a very small and statistically insignificant coefficient on state population as an explanatory variable.

Table 3.6: Top 20 States in Academic R&D Spending as a Share of Gross State Product, 1972 and 2004

Rank	1972 Intensity		Rank	2004 Intensity	
	(Dollars per $100 of GSP)			(Dollars per $100 of GSP)	
1	Alaska	0.59	1	Maryland	1.00
2	Utah	0.59	2	North Dakota	0.67
3	Massachusetts	0.57	3	Massachusetts	0.63
4	Colorado	0.44	4	Montana	0.56
5	Hawaii	0.44	5	New Hampshire	0.53
6	New Mexico	0.41	6	Vermont	0.53
7	Rhode Island	0.35	7	Utah	0.50
8	Wisconsin	0.34	8	New Mexico	0.50
9	Washington	0.32	9	Hawaii	0.48
10	Missouri	0.30	10	Iowa	0.48
11	Vermont	0.29	11	Nebraska	0.48
12	Maryland	0.29	12	Pennsylvania	0.47
13	Connecticut	0.28	13	Rhode Island	0.46
14	Oregon	0.26	14	Mississippi	0.46
15	New York	0.25	15	Wisconsin	0.45
16	California	0.24	16	Alaska	0.43
17	Wyoming	0.24	17	North Carolina	0.43
18	North Carolina	0.24	18	Missouri	0.41
19	Nebraska	0.24	19	Alabama	0.41
20	**Minnesota**	**0.23**	20	Oregon	0.39
			43	**Minnesota**	**0.23**

Source: National Science Foundation (2006c); Bureau of Economic Analysis (1988; 2005).

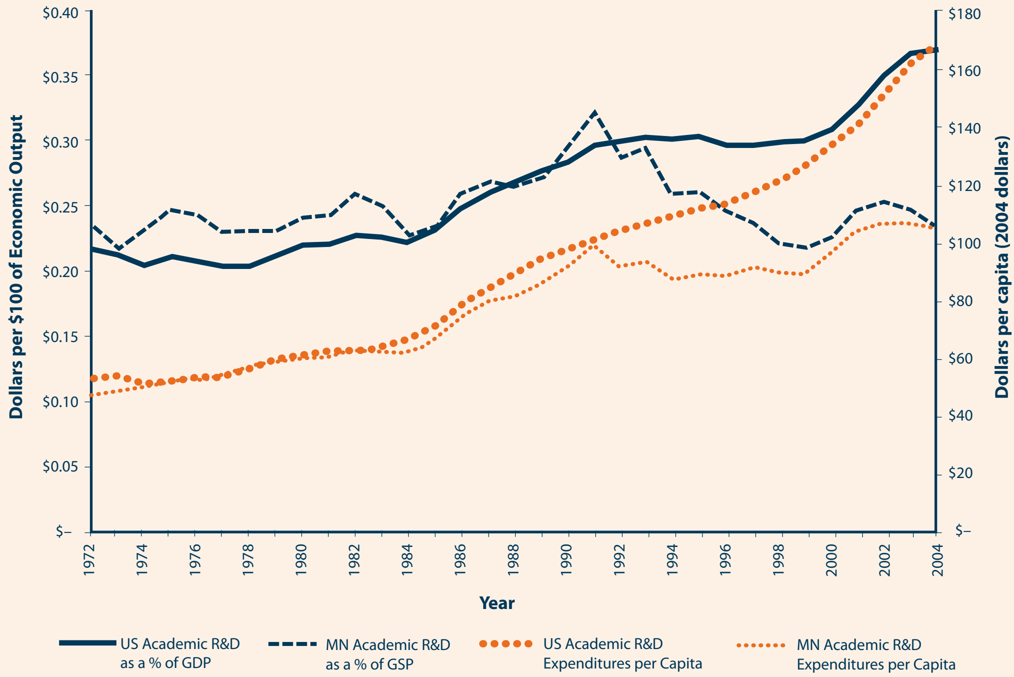
Notes: Gross state product (GSP) represents the value of the total economic output/production within a state. This concept is similar to gross domestic product (GDP) for a country.

adjusting for the effects of inflation, Minnesota's recent amounts of per capita spending intensities are less than those experienced by the leading states more than 30 year ago. Moreover, the spread in per capita spending between Minnesota and the top ranked state has widened considerably—in 1972 the differential was $137.05 per person, and by 2004 it had grown to $312.60. This widening gap in per capita spending does not appear to bode well for the University of Minnesota's aspirations to be a nationally top-ranked and world leading public academic research institution. Nor does it speak well for the state of Minnesota's position in an increasingly competitive economic landscape.

Another way to normalize state academic R&D expenditures is by the size of the local economy—here, using gross state product (GSP), a value-added measure of all the goods and services produced within a state. Table 3.6 once again illustrates a stark drop in Minnesota's relative standing from 1972 to 2004. In 1972, Minnesota ranked 20th, spending 23 cents in academic R&D for every $100 of the state's economic output. This expenditure intensity reached a high of 32 cents in 1991, thereafter falling precipitously back to 23 cents for every $100 of GSP in 2004. This moved Minnesota down to 43rd in the nation on this investment indicator, with Maryland leading the country at 1 dollar of R&D investment per $100 of economic output. On this score, Minnesota has substantially scaled back it's spending in academic R&D relative to the size of its economy in recent years, while at the same time most other states have moved towards investing larger shares of their economies in academic research. In 1972, only six states invested more than 40 cents per $100 of GSP; by 2004, that figure increased to 19 states.

These measures include funds (primarily federal) that are attracted from outside the states themselves. Considering just the state and local government share of academic R&D funding, relative to GSP, the national average increased from 2.2 cents per $100 of output in 1972 to 2.4 cents in 2004. By this measure, Minnesota was below average in 1972, spending 2.0 cents per $100 of GSP, but above average in 2004, spending 2.8 cents. Much of the industry financed research is also likely to be sourced from within a state. Here

Figure 3.3: U.S. versus Minnesota Research Intensities, 1972-2004



Source: National Science Foundation (2006c); Bureau of Economic Analysis (1988; 2005).

Notes: All expenditures are deflated (i.e., adjusted for inflation) using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006). Gross state product (GSP) represents the value of the total economic output/production within a state.

the national average intensity of industry funding increased from 0.6 cents to 1.8 cents per $100 of output from 1972 to 2004, respectively, while Minnesota's industry intensity only increased from 0.6 cents to 1.0 cents over this period.

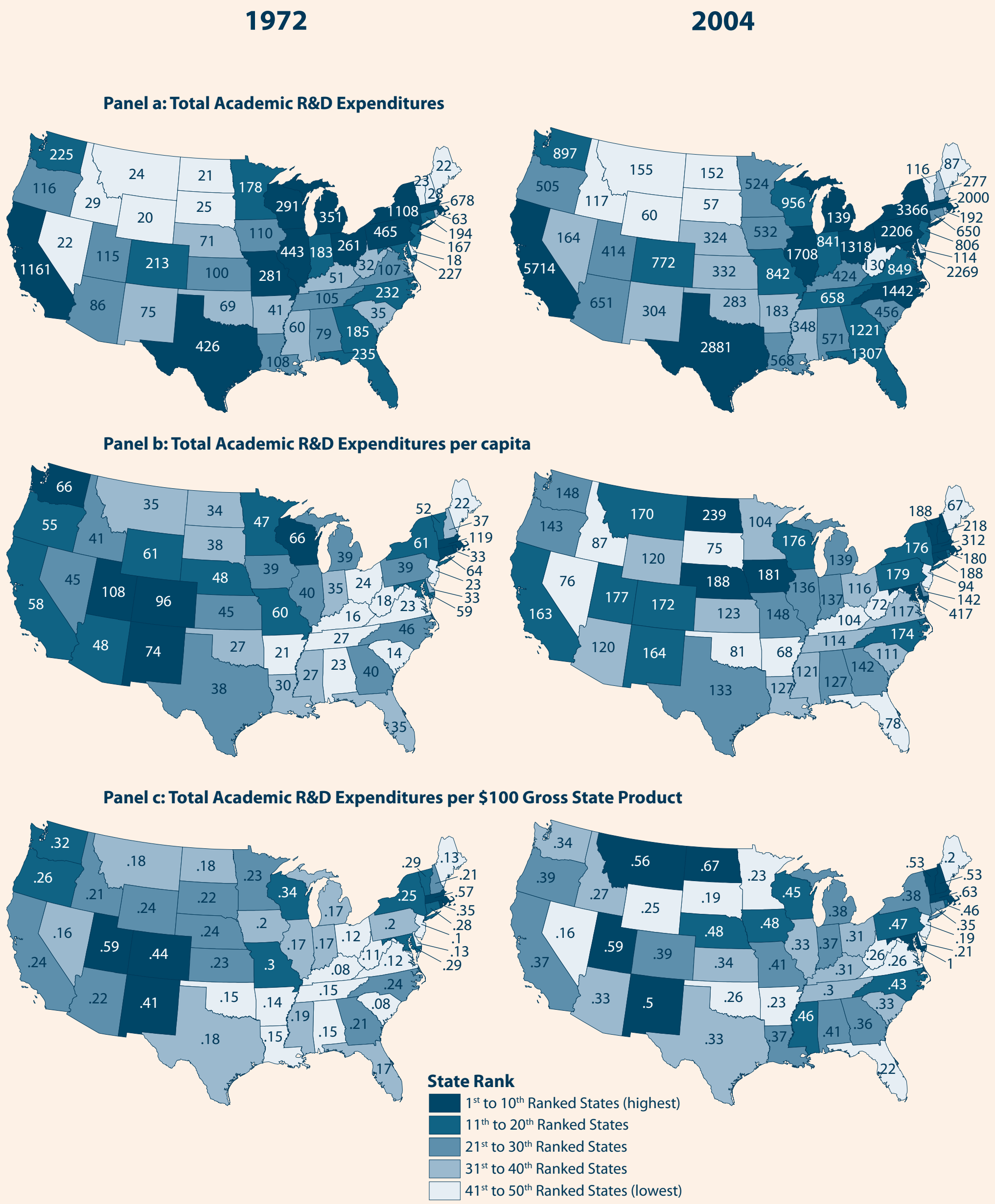
The solid blue line in Figure 3.3 shows the U.S. average intensity of academic R&D as a percentage of gross domestic product (GDP) while the dashed blue line shows the comparable Minnesota figure. In almost all years from 1972 through to 1991, Minnesota invested more of its gross state product in academic R&D than the national average. Thereafter, Minnesota's investment intensity fell precipitously as described above, while the national average figure continued trending upward, and at a generally accelerating rate. A similar story holds with expenditures per capita. The thick dotted orange line illustrates the national average and the thin dotted orange line illustrates Minnesota's investment intensity. Once again, Minnesota closely tracks the national trend to 1991, thereafter starkly diverging.

Figure 3.4 summarizes the trends discussed in this section, showing various academic R&D data for all states in 1972 and 2004. In that figure, lighter colored states had lower expenditures relative to other states. The figure clearly shows that Minnesota's ranking fell between 1972 and 2004 in terms of total academic R&D, academic R&D per capita, and academic R&D relative to GSP.

DIAGNOSTICS AND DISCUSSION

The four panels in Figure 3.5 illustrate the comparative growth rates of various Minnesota funding sources since 1972. The dashed 45 degree line in each panel represents the national average—meaning that points above the line are growing at an above average rate and points below the line are growing at rates below the

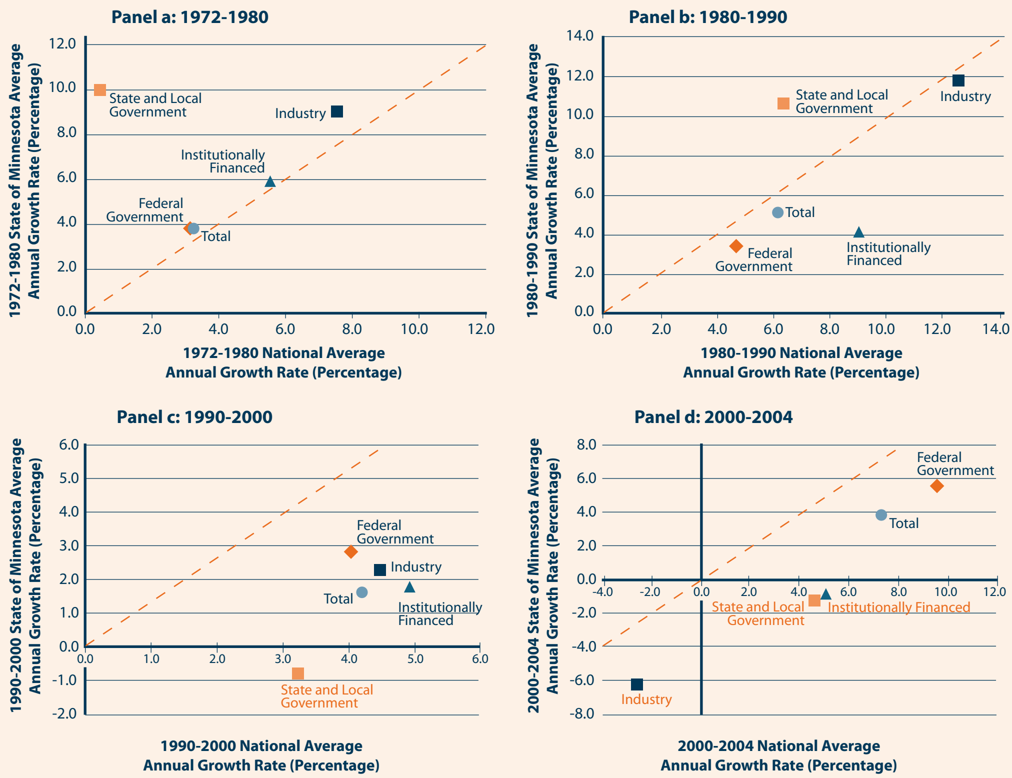
Figure 3.4: State Academic R&D Rankings, 1972 and 2004



Source: National Science Foundation (2006c); U.S. Census Bureau (2006); Bureau of Economic Analysis (1988;2005).

Notes: Numerical values in each state refer to the state's value for each respective data series.

Figure 3.5: U.S. versus Minnesota 1972-2004 Average Growth Rates by Funding Source



Source: National Science Foundation (2006c).

Notes: Average annual growth rates are calculated by taking the mean of the year-to-year growth rates calculated using the arithmetic growth formula. Growth rates are inflation adjusted using the U.S. GDP implicit price deflator (World Bank 2006). Orange labeled data points indicate negative rates of growth.

national average. Panel 3.5.a shows that during the 1970s, the growth rate in Minnesota's academic R&D funds from all sources—especially so with respect to state and local government—were above average.

However, by the 1980s, growth in funding from all sources other than state and local government had slipped below the national average (Panel 3.5.b). By the 1990s, funding from *all* sources, now including funds from state and local government, was growing at a below average rate (Panel 3.5.c). Moreover, not only had growth in state and local funding simply slowed and fallen well below the national average rate of growth, it had begun to decline. This below-average performance in Minnesota continued beyond 2000, with funding from state and local government, industry, and institutional sources all declining in inflation-adjusted terms (Panel 3.5.d). Given that Minnesota's long-run average growth rate in total spending is below the national average, the state's declining investment intensities noted above are almost inevitable.

The decline in state and local government support during the 1990s coincides with a marked slowdown in the growth of support from other sources, suggesting that a weakening of state support might lead to a reduction in funding from industry and federal sources thereby compounding the structural shift in support for Minnesota research evident in Figure 3.3. For example, strong state government support might be used to leverage support from elsewhere, as industry and federal funding agencies see cost sharing

Box 3.1: Data Sources and Methods

The academic R&D expenditure data reported in this and related briefs were obtained from the National Science Foundation's WebCASPAR Integrated Science and Engineering Resources Data System (See Box 2.1 in Brief 2 (p.17) for more details). Data for 805 academic institutions were aggregated by state across all years. In 2004, the average state total included data from 11.7 academic institutions (data from 9 institutions were included in Minnesota's 2004 total).

Other data came from the U.S. Census Bureau (for the time series of state population counts), the World Bank (for the U.S. GDP and GDP deflator time series), and the U.S. Bureau of Economic Analysis (BEA, for the time series of each state's gross state product, GSP). At the time of preparation, the BEA only published GSP data back to 1977. For the years 1972-1976, we constructed a time series from a historical BEA publication (BEA 1988).

Average annual growth rates for stated periods are calculated by taking the mean of the respective year-to-year growth rates obtained using the arithmetic growth formula.

opportunities on research of mutual interest. However, a statistical analysis of the funding-by-source data did not support the notion that strong state support "crowds in" or attracts additional support from elsewhere.[9] While the decline in state and local support surely did not boost the State's academic research investment rankings, there is no evidence that a lack of state government funding curtailed funding from others.

That said, just as there are reasons to believe that strong state and local (and institutional) funding may have complementary effects in attracting "outside" funding, there are also reasons to believe that increases in local funding could "crowd-out" federal and other external funding sources. That is, strong state support may induce complacency, causing research faculty to be less diligent in seeking federal or industry funds. Our analysis does not support the "crowding out" notion either. Hence, renewed growth in state, local, and institutional funding of academic R&D within Minnesota is unlikely to dampen growth in funding from elsewhere.

CONCLUSION

By nearly all measures, the state of Minnesota has lost ground in funding for academically performed R&D over the past three decades. Most of this relative decline has occurred since 1990. Even when adjusting for the varying "sizes" of U.S. states, Minnesota has slipped relative to other states. Overall academic R&D expenditures have continued to grow, even in inflation-adjusted terms, for the state of Minnesota, but these structural trends are of considerable concern in the context of the University of Minnesota's strategic goal to be among the top three public research universities in the world within the next decade.

9 We conducted a large number of statistical tests for Granger causality among all the University of Minnesota's funding sources, taking care to appropriately account for nonstationarity (i.e., trending tendencies that could give spurious causality results) and considering several lead-lag relationships. From this evidence we could not reject the null hypothesis of "no Granger causality."

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BRIEF 4

Falling Behind: An Institutional Comparison of Academic R&D Expenditures

STEVEN DEHMER AND PHILIP G. PARDEY

In March of 2005, the University of Minnesota Board of Regents unanimously approved a strategic plan (dubbed "Transforming the U") geared towards positioning the University among the top three public research institutions in the world within a decade. This is an ambitious goal, but many questions remain elusive. For instance, how do we know when the University has reached the top three, or is even closing in on that objective? Where is the University currently ranked? Anticipating the need for further specificity, President Robert Bruininks established more than 20 task forces charged with the goal of clarifying the new strategic vision. Of those, the Metrics and Measurements Task Force, identified more than 30 "scorecard" measures for quantitatively evaluating the University's performance vis-à-vis other top public research institutions. Here, we focus on one of the most important of these indicators: academic R&D expenditures.

TOTAL ACADEMIC R&D FUNDING TRENDS

Compared with its self-defined peer group of 14 universities, the University of Minnesota currently ranks 9th in total R&D expenditures with $515.1 million in 2004 (Table 4.1).[1] This compares to its 4th rank in 1972 with $173.5 million 2004.[2] This ground was lost to five universities that had lower relative research expenditures in 1972, including the leader in 2004, the University of California-Los Angeles, which grew from $161.2 million to $772.6 million over this period.

By this criterion, the University of Minnesota has slipped from immediate reach of the top three spot, even for this comparatively small comparison group. Indeed, ascending to the top three ranking among these peer schools would require an additional $250 million of research investment per year—an increase of nearly 50 percent over the current amount of spending.

Figure 4.1 shows an annual time profile of the University of Minnesota's R&D spending since 1972 relative to its peer institutions. The solid line plots

1 The University of Minnesota's peer group consists of the ten universities identified in the Final Report of the Metrics and Measurements Task Force (2006), which included: the University of California-Berkeley, University of California-Los Angeles, University of Florida, University of Illinois at Urbana-Champaign, University of Michigan-Ann Arbor, University of Texas at Austin, University of Washington-Seattle, University of Wisconsin-Madison, Ohio State University-Columbus, and Pennsylvania State University-University Park. Based on advice from the University's Vice President for Research, R. Timothy Mulcahy, the University of California-Davis, University of California-San Diego, and the University of North Carolina at Chapel Hill were also included in the peer group of institutions. Thus, the peer group includes some autonomous universities, universities that form part of a statewide system, and some multi-campus operations. For instance, in 2004, none of the individual campuses of the University of California system constituted more than 20 percent of the system's total academic R&D spending, while the University of California system accounted for 69 percent of the state's total academic R&D expenditures. In contrast, the University of Minnesota totals reported here include spending on five campuses (including the Waseca campus, which closed in 1992). The Twin Cities campus constituted about 96 percent of the University's entire academic R&D spending in 2004, while the University accounts for 98 percent of the state's total academic R&D spending. These institutional differences, including differences in the size and composition of R&D among institutions, must be borne in mind when making comparisons within this peer group.

2 For the remainder of this brief, unless otherwise specified, all dollar figures are deflated (i.e., adjusted for inflation) to base year 2004 prices. The U.S. GDP deflator (World Bank 2006) was used for this adjustment.

Table 4.1: Total Academic R&D Spending in Peer Universities, 1972 and 2004

	Peer University	1972 Federal	1972 State/Local	1972 Industry	1972 Institutionally Financed	1972 Other	1972 Total	2004 Federal	2004 State/Local	2004 Industry	2004 Institutionally Financed	2004 Other	2004 Total
		(Millions of 2004 dollars)						(Millions of 2004 dollars)					
1	University of California – Los Angeles	136.5	2.8	0.3	11.7	10.0	161.2	461.1	20.8	27.7	140.1	122.9	772.6
2	University of Michigan, All Campuses	162.9	2.2	11.1	53.4	13.1	242.6	521.3	16.2	32.2	156.5	42.8	769.1
3	University of Wisconsin – Madison	135.4	52.1	3.1	49.8	16.6	257.0	434.4	35.9	17.9	210.2	65.5	763.9
4	University of Washington – Seattle	141.2	7.9	1.3	0.4	10.9	161.7	625.2	10.5	46.5	15.2	16.5	714.0
5	University of California – San Diego	187.5	0.5	–	10.6	6.9	205.5	465.6	19.0	31.0	115.7	77.3	708.7
6	Pennsylvania State U, All Campuses	56.9	8.3	3.9	26.8	5.6	101.4	348.0	54.6	85.6	110.7	1.4	600.1
7	University of California – Berkeley	125.5	2.4	1.7	31.6	3.4	164.5	268.8	37.4	22.8	123.1	73.4	525.6
8	Ohio State University, All Campuses	64.0	27.4	2.9	5.8	1.1	101.1	284.7	61.8	42.8	97.5	31.3	518.1
9	**University of Minnesota, All Campuses**	**99.9**	**15.5**	**4.3**	**38.6**	**15.1**	**173.5**	**308.4**	**52.9**	**21.8**	**71.8**	**60.1**	**515.1**
10	University of California – Davis	51.4	3.3	3.1	34.9	1.8	94.4	221.9	42.0	24.2	172.9	50.6	511.8
11	University of Illinois at Urbana-Champaign	86.5	2.7	–	37.9	5.2	132.3	275.9	43.6	13.1	161.3	12.1	506.0
12	University of Florida	32.8	2.8	3.6	47.4	4.3	90.9	221.9	79.8	16.7	113.0	15.8	447.1
13	University of North Carolina at Chapel Hill	51.3	4.2	0.9	1.0	4.0	61.4	304.2	16.3	6.5	89.7	–	416.7
14	University of Texas at Austin	77.7	17.3	1.5	5.0	9.3	110.8	235.3	21.0	27.2	37.9	22.5	343.9

Source: National Science Foundation (2006).

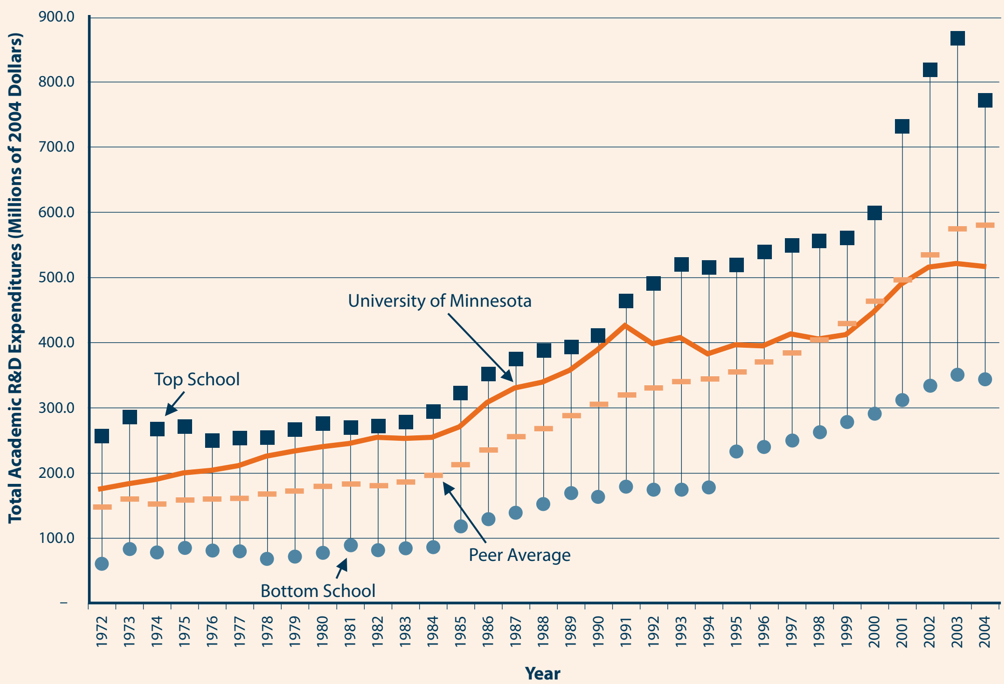
Notes: See Figure 4.1.

total academic research spending by the University after netting out the effects of inflation—i.e., it gives an indication of the real resources dedicated to research by the University over this time period. For each year we also plot the distribution of research spending among the 14 peer universities identified in Table 4.1. The solid square atop the distribution represents the top peer school in terms of total research for each year (e.g., the University of Wisconsin-Madison with $257.0 million in 1972); the solid round mark indicates the bottom ranked peer (e.g., $61.4 million by the University of North Carolina at Chapel Hill in 1972); the horizontal dash is the average R&D spending among the 14 peer universities for any given year.

This representation of the data is especially revealing. In 1972, the University of Minnesota invested slightly more than the peer average on R&D. Over the subsequent two decades, the University moved up the rankings and by 1990 was ranked 2nd in the terms of its R&D spending in this group, just behind the University of Wisconsin-Madison. Thereafter, Minnesota began losing ground, falling well down the rankings and by 1998 even slipped below the average of its peers. Since 2001, it has lost even more ground, not only falling well below the average of its peers but also well behind the top schools in this grouping.

Throughout this brief we emphasize the University of Minnesota's research investment performance relative to its self-defined peer group. However, there are several other groupings amongst which the University can be compared. TheCenter of the University of

Figure 4.1: Total Academic R&D Expenditures—University of Minnesota and Distribution of Peer Institutions, 1972-2004



Source: National Science Foundation (2006).

Notes: The University of Minnesota peer group is as identified by the final report of the Metrics and Measurements Task Force (2006). In addition, per advice we solicited from the Vice President for Research, R. Timothy Mulcahy, we also added the University of California-Davis, University of California-San Diego, and the University of North Carolina at Chapel Hill to the peer comparison grouping. All expenditures are deflated (i.e., adjusted for inflation) using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006).

Florida, a widely cited source for information on measuring and comparing university performance, provides two comparison lists—one for all U.S. universities and one for only public universities. In Appendix Tables 4.1 and 4.2, we provide similar rankings based on the top 25 universities that constitute TheCenter's Top American Research Universities and Top Public Research Universities groupings, respectively.[3]

When matched against *all* public and private universities in the United States, the University of Minnesota ranked 14th in terms of research expenditures in 2004, with Johns Hopkins University leading at $1.4 billion. Notably, the University of Minnesota ranks ahead of Harvard, Columbia, and Yale University on this metric, but still well behind the number three ranked University of Michigan.[4] Of course, the University's strategic goal is to be among the top *public* research universities, so the data in Appendix Table 4.2 are more relevant on that score. Among *all public* universities, the University ranks 11th, dropping two spots to the University of California-San Francisco and Texas A&M University which are not in the University's peer grouping. Importantly, these comparisons are only of U.S. based universities; the University ultimately seeks to be compared with the broader spectrum of all public universities in the world.[5]

3 The top 25 lists were drawn from TheCenter (2005, 28-30).

4 This comparison underscores the caveat that research R&D expenditures are only one criterion for evaluation and ranking. There are clearly other criteria that distinguish schools like Harvard.

5 Internationally, the Shanghai Jiao Tong University in China maintains rankings of the top 500 universities in the world. By their rankings, the University of Minnesota ranks 32nd in the

The amount spent on research is not the entire story, the efficiency and effectiveness with which these research dollars are spent matters too. In terms of achieving its strategic goals, the University's trend rates of growth (and volatility) of the spending is important. To that end, Table 4.2 shows that the University of Minnesota grew slowest among its peer group in total academic R&D expenditures. While the rather modest average growth rate of 1.5 percent per year picked up a bit in more recent years (to 3.8 percent), this is still well below most of the 13 other schools in the peer group (10 of which grew by at least 6 percent per year since 2000). Clearly, the University has been slipping behind its peers in research expenditures for at least the last decade (perhaps longer) and there is no evidence yet of it catching up.[6]

RESEARCH INTENSITIES

Universities vary in terms of their size and structure; thus, total spending amounts are only one useful (albeit, important) point of comparison. For instance, Table 4.3 gives a sense of the research orientation of the University's peer group while Appendix Table 4.3 provides more comparative information on the institutional make up of this group of universities. Regarding its research orientation, the University of Minnesota lies in the middle of this group, with about one in five dollars of the University's total operating budget going towards research and development. Like most of its peer institutions, the University of Minnesota has been directing a bigger share of its total spending to R&D related activities over the past three decades. By this measure, the University of Wisconsin-Madison is the most research intensive institution in the group, with more than one in three dollars of University spending going towards research in 2004. Ohio State, the least research intensive university of the group, spent slightly more than one in 10 dollars on research.

Expressing research spending on a per student or per faculty basis is also informative (Figure 4.2). The per student ratio provides an indication of the quality and depth of the research experience that both undergraduate and graduate students can embrace while attending university. For graduate students, access to adequate research resources affects the quality of their research training, thus directly affecting their future careers in research or its application (whether in academia or industry).

When considering all students (including undergraduate, graduate, and professional), the University of Minnesota ranked 10th among its peers, spending $8,309 per student on R&D in 2000—substantially less than the peer group leader, the University of California-San Diego, with $27,742 R&D per student (Figure 4.2, Panel a). The University drops one more spot when considering research expenditures per graduate student, where it ranks 11th with $39,575 per student—again behind the leading University of California-San Diego with $173,740 per graduate student (Figure 4.2, Panel b).[7]

Another relevant measure is to consider the quantity of research expenditures per faculty member. That is, a university is an institution engaged in the production of new knowledge, and so one can conceive of a "knowledge production function", wherein various inputs such as land, physical capital, and purchased inputs (e.g., energy, water, and communication services) and different types of human capital (faculty, research technicians, other support staff, and administrators) produce new knowledge (Pakes and Griliches 1980 and Pardey 1989).[8] From this perspective, the R&D spending per faculty ratios are an indication of the total cost of university research per unit of faculty input.

world and 25th in its region (the Americas) (Shanghai Jiao Tong University 2006). Shanghai's methodology is based mostly on "output" metrics, such as the number of alumni who have won Nobel prizes and publication counts. They do not consider research expenditures.

6 It should be noted, however, that our data series terminates prior to the formulation and implementation of the University's current "Transforming the U" strategic plan.

7 The University of California-San Diego has roughly the same amount of federal R&D funding as the University of California-Los Angeles, but half the number of students. The University of California-San Diego's super computing center and Scripps Institute of Oceanography, a (national) leader in oceanography and the climate sciences, likely attract a disproportionate amount of federal R&D dollars.

8 Note that the quantity of new knowledge produced is intrinsically difficult to quantify in any meaningful manner, although some gets embodied in measurable outputs such as scientific papers, books, patents, new crop varieties, new medical procedures, artistic performances, and so on. However, the inputs to this knowledge production process are more readily measured (either in cost or quantity units, or both).

Table 4.2: Growth Rates in Total Academic R&D Spending in Peer Universities, 1972-2004

	Peer University	1972-2004	1972-1980	1980-1990	1990-2000	2000-2004	2004 R&D Expenditures
			(Average Percentage Per Year)				*(Millions of dollars)*
1	University of North Carolina at Chapel Hill	6.6	3.9	8.2	6.0	9.6	416.7
2	Pennsylvania State U, All Campuses	6.1	5.5	9.3	3.2	6.8	600.1
3	University of California – Davis	5.6	5.0	6.8	4.3	6.9	511.8
4	Ohio State University, All Campuses	5.4	4.4	5.5	5.2	7.4	518.1
5	University of Florida	5.3	2.9	5.1	6.8	7.2	447.1
6	University of California – Los Angeles	5.3	1.5	6.3	5.9	8.6	772.6
7	University of Washington – Seattle	4.8	4.3	3.9	5.9	5.7	714.0
8	University of Illinois at Urbana-Champaign	4.5	3.1	6.2	3.2	6.0	506.0
9	University of California – San Diego	4.1	2.6	2.5	6.0	6.1	708.7
10	University of Michigan, All Campuses	4.0	-0.7	6.7	3.9	6.8	769.1
11	University of California – Berkeley	3.9	1.5	5.5	6.4	-1.2	525.6
12	University of Texas at Austin	3.8	4.6	6.9	-0.1	4.0	343.9
13	University of Wisconsin – Madison	3.6	1.1	4.1	3.9	6.3	763.9
14	**University of Minnesota, All Campuses**	**3.5**	**4.1**	**5.0**	**1.5**	**3.8**	**515.1**

Source: National Science Foundation (2006).

Notes: See Figure 4.1. Average annual growth rates are calculated by taking the mean of the year-to-year growth rates calculated using the arithmetic growth formula. Growth rates are inflation adjusted using the U.S. GDP implicit price deflator (World Bank 2006).

Table 4.3: Research Expenditures as Percentage of Total Operating Budget in Peer Universities, Various Years

	Peer University	1986	1990	2000	2004
			(Percentage of Operating Budget)		
1	University of Wisconsin – Madison	27.8	25.4	33.8	35.0
2	University of Florida	26.5	28.3	25.5	26.1
3	University of California – Berkeley	21.9	23.0	24.3	26.0
4	University of California – San Diego	22.5	21.6	26.5	25.6
5	University of Texas at Austin	26.0	24.3	20.5	23.1
6	University of Washington – Seattle	21.3	21.8	21.8	21.4
7	**University of Minnesota, All Campuses**	**15.3**	**18.6**	**18.5**	**21.1**
8	Pennsylvania State U, All Campuses	11.9	16.5	17.8	20.3
9	University of Illinois at Urbana-Champaign	25.4	24.6	25.7	20.2
10	University of California – Los Angeles	13.7	13.5	15.6	16.7
11	University of California – Davis	16.7	15.7	16.0	16.5
12	University of North Carolina at Chapel Hill	12.7	15.0	15.6	16.1
13	University of Michigan, All Campuses	9.5	13.4	10.9	13.0
14	Ohio State University, All Campuses	8.5	12.2	12.5	11.0

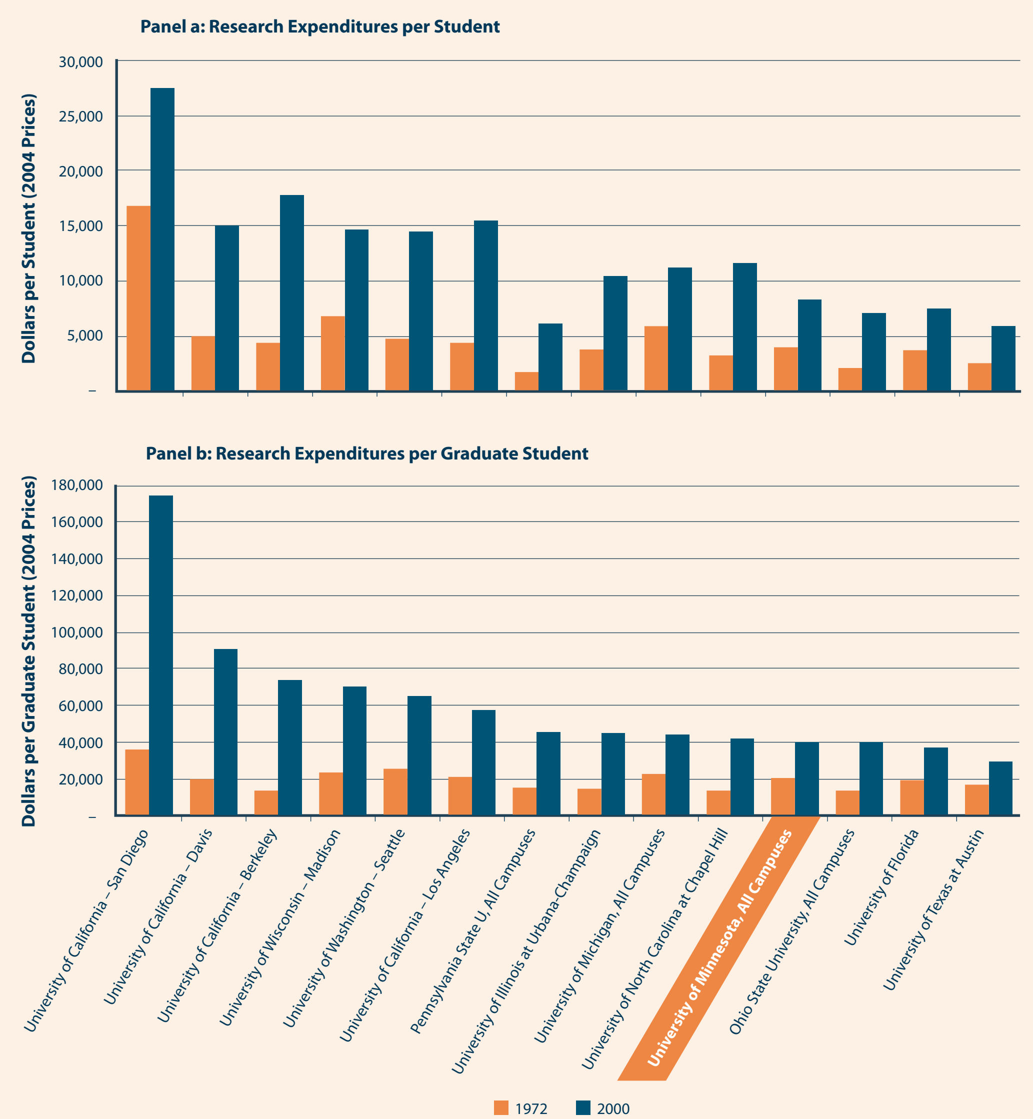
Source: National Science Foundation (2006).

Notes: See Figure 4.1. Average annual growth rates are calculated by taking the mean of the year-to-year growth rates calculated using the arithmetic growth formula. Growth rates are inflation adjusted using the U.S. GDP implicit price deflator (World Bank 2006).

By this measure, the University of Minnesota ranked 9th among its peer group in 1999, with $223,000 in research funds per (assistant, associate, or full) professor (Figure 4.3). The University of California-San Diego leads the cohort with $653,000 per faculty member. This means UC-San Diego invests roughly three times more in research resources per faculty member compared with the University of Minnesota.[9] Neighbor University of Wisconsin-Madison is second on the list with almost twice the resources per faculty member. These are large and significant disparities. In part, they may simply reflect a different mix of inputs among the

9 Or, by another token, the University of California-San Diego faculty attract three times as many research resources than their University of Minnesota counterparts.

Figure 4.2: Intensity of Research Spending per Student, 1972 and 2000



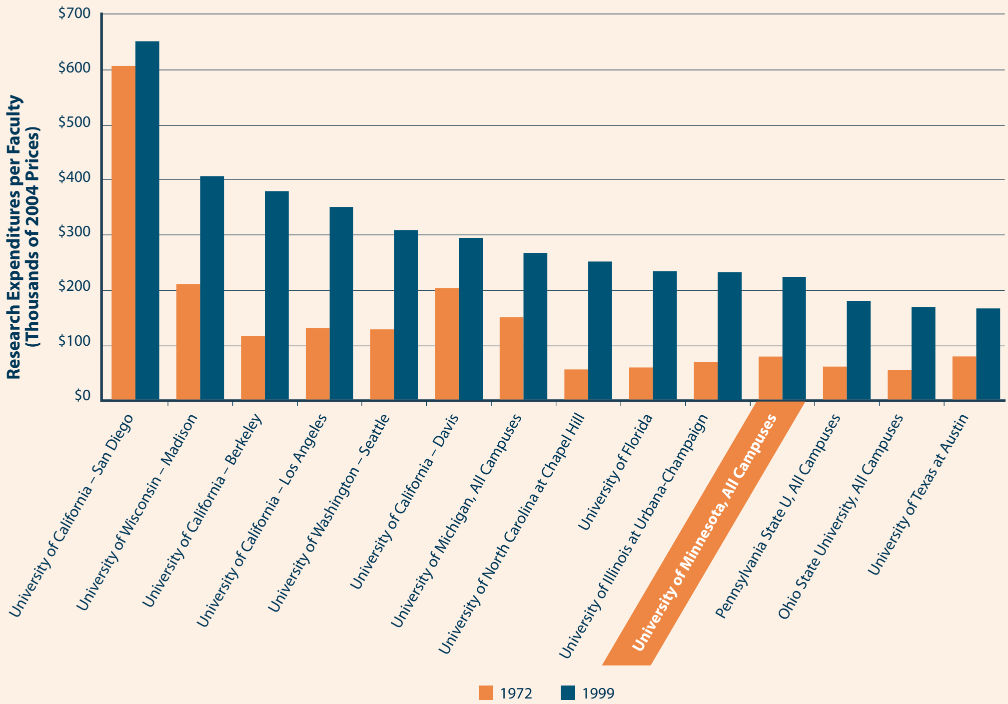
Source: National Science Foundation (2006); University of Minnesota, Office of Institutional Research (2003a; 2003b).

Notes: See Figure 4.1. Total student counts are based on fall enrollment of undergraduate, graduate, and professional students. Graduate student counts are based on fall enrollment of graduate students only. The University of Minnesota student counts (full-time equivalents) came from the Office of Institutional Research (2003a; 2003b). All expenditures are deflated (i.e., adjusted for inflation) using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006).

various universities, with Minnesota being more labor intensive in the conduct of it research than its cohorts (so that it employs more faculty per dollar spent).[10] However, it is also likely to reflect differences among universities in the salaries paid to recruit and retain world-class faculty, and the

10 It could also mean that University of Minnesota faculty are more productive, producing research at much lower costs. However, absent comparable research "output" data to do such analysis, there is no a priori reason to believe that University of Minnesota faculty are substantially more or less productive than, say the University of Wisconsin-Madison's. If so, then access to research inputs becomes an important determinate of the amount of research output.

Figure 4.3: Intensity of Research Spending per Faculty, 1972 and 1999



Source: National Science Foundation (2006).

Notes: See Figure 4.1. Faculty counts for the University of California schools are for 1971, not 1972. Faculty are defined as having rank of assistant professor or higher. All expenditures are deflated (i.e., adjusted for inflation) using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006).

commitment to provide sufficient funding support to facilitate world-class research.

AN ASSESSMENT

Notwithstanding a general growth in investment in University of Minnesota research over the past three decades, various metrics indicate the University has lost considerable ground, both in terms of its peer ranking and compared with other top (public) universities. Hence, while these spending metrics for the University of Minnesota have all been trending upward since 1972, they have been growing faster elsewhere, such that the University is falling behind its peers.

To explore the shifting structure of support that lies behind these research spending indicators, we decomposed the University's academic R&D expenditure into funds derived from federal government vs. state and local government vs. industry vs. institutional sources. Similar to the state of Minnesota's growth trend decomposed in Figure 3.5 of Brief 3, the University's slippage reflects below-average growth in funding from nearly all sources since the 1980s (Figure 4.4).[11]

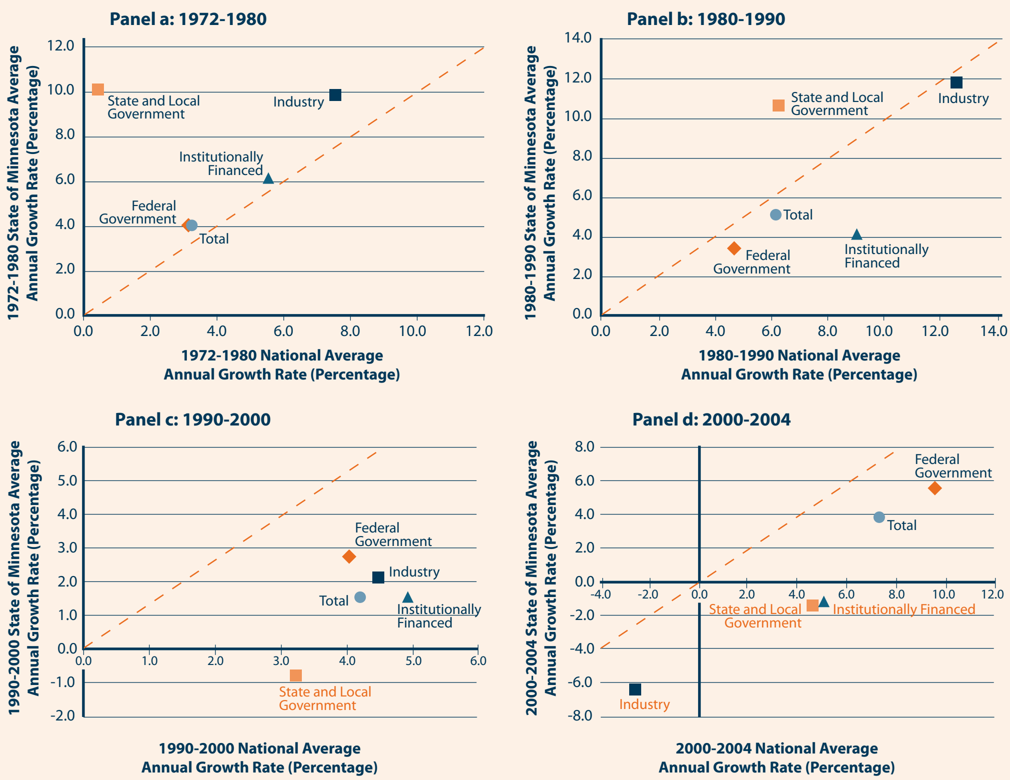
The dashed 45 degree line in each panel of Figure 4.4 represents the national average—meaning points above the line are above average and points below the line are below average. Research funding growth at the University was exceptionally strong during the 1970s, when funds from all sources were growing faster than the national average rate (Panel 4.4.a). By the 1980s, most of the University's funding sources grew below the national average, with the notable exception of

11 Indeed, since the University of Minnesota makes up for 98 percent of the state of Minnesota's academic R&D expenditures, Figures 3.5 and 4.4 appear to be nearly identical.

state and local government funding (Panel 4.4.b). Strong state and local support during the 1980s is one important contributor to the ascension of the University among its peers (where it peaked ranked second in 1991), as shown earlier in Figure 4.1.

However, by 1990, even the rate of growth in University of Minnesota funding from state and local government sources had also slipped behind the national average so that funding from *all* sources was growing more slowly at the University of Minnesota for the past decade and half compared with what was typical for other universities in other states (Panels 4.4.c and 4.4.d). It is then no small wonder the University of Minnesota has lost ground relative to its peers and aspirational institutions elsewhere in the country.

Figure 4.4: University of Minnesota Academic R&D Growth Rates Relative to National Average by Source, 1972-2004



Source: National Science Foundation (2006).

Notes: Average annual growth rates are calculated by taking the mean of the year-to-year growth rates calculated using the arithmetic growth formula. Growth rates are inflation adjusted using the U.S. GDP implicit price deflator (World Bank 2006). Red labeled data points indicate negative rates of growth.

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Appendix Table 4.1: Total Academic R&D Spending in Top American Research Universities, 1972 and 2004

	Top American Research Universities		1972 Federal	1972 State/Local	1972 Industry	1972 Institutionally Financed	1972 Other	1972 Total	2004 Federal	2004 State/Local	2004 Industry	2004 Institutionally Financed	2004 Other	2004 Total
			(Millions of 2004 dollars)						(Millions of 2004 dollars)					
1	Johns Hopkins University	(6)	107.1	1.4	2.7	9.9	15.3	136.3	1,229.4	5.4	19.8	67.1	53.3	1,375.0
2	University of California – Los Angeles	(13)	136.5	2.8	0.3	11.7	10.0	161.2	461.1	20.8	27.7	140.1	122.9	772.6
3	University of Michigan, All Campuses	(9)	162.9	2.2	11.1	53.4	13.1	242.6	521.3	16.2	32.2	156.5	42.8	769.1
4	University of Wisconsin – Madison	(16)	135.4	52.1	3.1	49.8	16.6	257.0	434.4	35.9	17.9	210.2	65.5	763.9
5	University of California – San Francisco	(17)	68.9	4.5	1.1	3.1	6.2	83.8	418.9	27.9	31.5	128.8	121.2	728.3
6	University of Washington – Seattle	(11)	141.2	7.9	1.3	0.4	10.9	161.7	625.2	10.5	46.5	15.2	16.5	714.0
7	University of California – San Diego	(20)	187.5	0.5	–	10.6	6.9	205.5	465.6	19.0	31.0	115.7	77.3	708.7
8	Stanford University	(2)	168.9	0.9	1.7	9.2	6.6	186.2	541.7	5.0	34.3	41.6	48.5	671.0
9	University of Pennsylvania	(3)	106.0	6.9	6.2	12.2	7.4	138.7	435.3	3.6	27.7	47.9	82.2	596.8
10	Cornell University, All Campuses	(18)	108.6	40.4	6.5	10.5	15.9	182.0	339.1	59.9	23.0	107.4	46.1	575.6
11	Massachusetts Institute of Technology	(1)	216.6	2.2	7.1	3.1	27.2	256.2	427.6	0.2	72.2	11.9	31.6	543.4
12	University of California – Berkeley	(8)	125.5	2.4	1.7	31.6	3.4	164.5	268.8	37.4	22.8	123.1	73.4	525.6
13	Duke University	(70)	70.0	0.2	0.9	0.1	4.8	76.0	347.9	17.2	94.4	29.5	31.9	520.9
14	**University of Minnesota, All Campuses**	**(15)**	**99.9**	**15.5**	**4.3**	**38.6**	**15.1**	**173.5**	**308.4**	**52.9**	**21.8**	**71.8**	**60.1**	**515.1**
15	University of Illinois at Urbana-Champaign	(21)	86.5	2.7	–	37.9	5.2	132.3	275.9	43.6	13.1	161.3	12.1	506.0
16	Washington University	(12)	67.4	0.4	3.1	–	6.5	77.3	371.0	12.4	13.1	60.2	32.8	489.6
17	Columbia University in the City of New York	(4)	143.3	0.9	0.5	7.6	33.3	185.6	406.6	2.9	7.4	30.7	21.0	468.5
18	Harvard University	(5)	154.7	0.7	2.3	24.7	42.8	228.2	399.8	1.9	5.9	–	47.0	454.5
19	University of Southern California	(14)	58.0	0.9	1.3	–	6.0	66.3	312.6	8.5	20.0	85.6	–	426.7
20	Yale University	(10)	103.3	7.2	0.4	0.6	15.5	127.0	330.8	0.6	14.4	26.1	50.9	422.8
21	University of North Carolina at Chapel Hill	(19)	51.3	4.2	0.9	1.0	4.0	61.4	304.2	16.3	6.5	89.7	–	416.7
22	Northwestern University	(23)	41.6	0.1	1.6	13.4	8.8	65.5	230.6	2.2	9.2	86.1	30.9	358.9
23	University of Texas at Austin	(22)	77.7	17.3	1.5	5.0	9.3	110.8	235.3	21.0	27.2	37.9	22.5	343.9
24	California Institute of Technology	(24)	59.1	0.0	1.0	2.5	2.9	65.5	244.2	1.6	3.9	6.8	4.6	261.1
25	Princeton University	(25)	45.7	–	1.7	11.8	2.5	61.7	111.4	2.2	8.0	54.8	12.0	188.4

Source: National Science Foundation (2006).

Notes: Top American Research Universities list is from the TheCenter of the University of Florida (2005). The number in parentheses represents the (2005 edition) "ordering" based on TheCenter's scoring system. All expenditures are deflated (i.e., adjusted for inflation) using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006).

Appendix Table 4.2: Total Academic R&D Spending in Top Public Research Universities, 1972 and 2004

	Top Public Research Universities		1972 Federal	1972 State/Local	1972 Industry	1972 Institutionally Financed	1972 Other	1972 Total	2004 Federal	2004 State/Local	2004 Industry	2004 Institutionally Financed	2004 Other	2004 Total
			(Millions of 2004 dollars)						*(Millions of 2004 dollars)*					
1	University of California – Los Angeles	(2)	136.5	2.8	0.3	11.7	10.0	161.2	461.1	20.8	27.7	140.1	122.9	772.6
2	University of Michigan, All Campuses	(3)	162.9	2.2	11.1	53.4	13.1	242.6	521.3	16.2	32.2	156.5	42.8	769.1
3	University of Wisconsin – Madison	(5)	135.4	52.1	3.1	49.8	16.6	257.0	434.4	35.9	17.9	210.2	65.5	763.9
4	University of California – San Francisco	(20)	68.9	4.5	1.1	3.1	6.2	83.8	418.9	27.9	31.5	128.8	121.2	728.3
5	University of Washington – Seattle	(10)	141.2	7.9	1.3	0.4	10.9	161.7	625.2	10.5	46.5	15.2	16.5	714.0
6	University of California – San Diego	(16)	187.5	0.5	–	10.6	6.9	205.5	465.6	19.0	31.0	115.7	77.3	708.7
7	Pennsylvania State U, All Campuses	(12)	56.9	8.3	3.9	26.8	5.6	101.4	348.0	54.6	85.6	110.7	1.4	600.1
8	University of California – Berkeley	(1)	125.5	2.4	1.7	31.6	3.4	164.5	268.8	37.4	22.8	123.1	73.4	525.6
9	Texas A&M University, All Campuses	(21)	44.6	49.3	12.4	–	4.7	111.0	204.0	119.7	35.0	142.1	20.3	521.0
10	Ohio State University, All Campuses	(11)	64.0	27.4	2.9	5.8	1.1	101.1	284.7	61.8	42.8	97.5	31.3	518.1
11	**University of Minnesota, All Campuses**	**(8)**	**99.9**	**15.5**	**4.3**	**38.6**	**15.1**	**173.5**	**308.4**	**52.9**	**21.8**	**71.8**	**60.1**	**515.1**
12	University of California – Davis	(19)	51.4	3.3	3.1	34.9	1.8	94.4	221.9	42.0	24.2	172.9	50.6	511.8
13	University of Illinois at Urbana-Champaign	(7)	86.5	2.7	–	37.9	5.2	132.3	275.9	43.6	13.1	161.3	12.1	506.0
14	University of Arizona	(15)	38.3	22.3	1.8	9.7	6.5	78.7	284.0	6.4	29.6	138.5	20.2	478.7
15	University of Pittsburgh, All Campuses	(13)	45.8	0.5	0.2	4.0	3.3	53.8	394.4	10.0	6.6	25.3	25.3	461.7
16	University of Florida	(6)	32.8	2.8	3.6	47.4	4.3	90.9	221.9	79.8	16.7	113.0	15.8	447.1
17	University of North Carolina at Chapel Hill	(4)	51.3	4.2	0.9	1.0	4.0	61.4	304.2	16.3	6.5	89.7	–	416.7
18	Georgia Institute of Technology, All Campuses	(18)	21.1	1.2	4.4	15.0	1.3	43.1	237.5	10.5	29.5	127.2	6.1	410.8
19	Purdue University, All Campuses	(25)	53.3	2.7	4.2	32.6	0.7	93.6	144.1	46.9	37.9	136.6	0.3	365.8
20	University of Texas at Austin	(9)	77.7	17.3	1.5	5.0	9.3	110.8	235.3	21.0	27.2	37.9	22.5	343.9
21	University of Maryland at College Park	(17)	40.6	20.4	1.6	2.2	0.2	65.0	180.9	17.2	9.2	108.3	10.1	325.6
22	Michigan State University	(22)	60.9	3.1	4.4	–	7.7	76.1	143.5	48.6	8.6	109.2	15.6	325.4
23	University of Texas Southwestern Med Ctr Dallas	(23)	15.7	–	0.9	0.0	3.1	19.7	200.9	23.3	12.5	7.1	70.6	314.4
24	University of Iowa	(24)	42.7	0.4	0.8	5.7	3.5	53.0	209.9	10.7	14.1	66.8	11.5	312.9
25	University of Virginia, All Campuses	(14)	26.9	0.5	0.6	5.6	2.0	35.6	188.1	2.3	7.5	21.7	9.0	228.5

Source: National Science Foundation (2006).

Notes: See Appendix Table 4.1.

Appendix Table 4.3: Structural Composition of Academic R&D Budgets by Field of Science Among Peer Universities, 1973 and 2004

	Disciplinary Shares								Students		
1973	Engineering	Physical Sciences	Geo-sciences	Math and Computer Sciences	Life Sciences	Psychology	Social Sciences	Inter-disciplinary or Other Sciences	Under-graduate	Graduate & Professional	Total R&D Expenditures
	(Percentage of Total Research Budget)										(Millions of 2004 dollars)
Ohio State University, All Campuses	19.2	7.0	5.1	1.6	49.5	0.8	15.1	1.7	40,537	10,954	104.5
Pennsylvania State U, All Campuses	15.0	10.8	13.7	0.4	33.6	2.2	15.8	8.5	57,623	7,853	102.8
Unversity of California – Berkeley	18.8	16.8	1.2	2.7	42.0	3.8	12.6	2.1	25,170	10,380	192.5
University of California – Davis	8.0	3.3	0.5	0.3	82.0	0.2	5.6	0.0	12,796	4,241	112.9
University of California – Los Angeles	9.7	8.5	7.9	3.1	58.5	5.3	5.8	1.3	26,574	11,283	177.6
University of California – San Diego	1.1	14.6	41.9	0.5	40.5	0.7	0.4	0.3	7,434	1,760	226.8
University of Florida	14.8	5.1	2.4	2.2	70.9	1.5	3.0	0.0	20,286	5,337	92.5
University of Illinois at Urbana-Champaign	26.1	11.6	6.6	8.7	26.2	3.6	10.3	6.9	26,080	10,171	142.0
University of Michigan, All Campuses	25.2	4.6	4.7	2.3	38.2	6.5	18.5	0.0	26,933	16,227	235.1
University of Minnesota, All Campuses	**8.9**	**7.3**	**1.7**	**1.7**	**63.5**	**1.9**	**9.4**	**5.5**	**35,258**	**8,720**	**181.5**
University of North Carolina at Chapel Hill	8.5	4.1	0.3	1.2	57.6	1.2	1.6	25.7	14,099	5,384	83.7
University of Texas at Austin	15.4	21.2	3.6	4.4	16.2	5.9	13.7	19.7	35,747	8,106	106.6
University of Washington – Seattle	7.9	7.7	15.1	0.7	65.4	1.1	1.8	0.3	27,133	7,809	181.4
University of Wisconsin – Madison	4.7	12.0	13.6	3.8	37.2	5.2	15.5	8.0	27,564	10,751	285.9
2004											
Ohio State University, All Campuses	21.4	6.0	2.2	5.8	55.8	1.3	6.3	1.1	42,314	12,729	518.1
Pennsylvania State U, All Campuses	35.0	10.0	6.8	6.7	33.1	3.1	4.3	1.0	64,655	10,748	600.1
Unversity of California – Berkeley	28.8	18.6	1.7	1.7	33.9	2.2	9.5	3.5	22,678	8,599	525.6
University of California – Davis	9.9	4.8	5.3	1.2	74.6	0.3	3.5	0.5	20,388	5,706	511.8
University of California – Los Angeles	7.5	7.7	2.0	2.9	72.8	1.6	4.7	0.8	25,011	11,879	772.6
University of California – San Diego	10.0	6.5	17.3	12.5	50.8	1.0	1.8	0.1	16,496	3,701	708.7
University of Florida	15.0	7.6	1.8	1.6	69.7	2.0	2.3	0.0	32,680	12,434	447.1
University of Illinois at Urbana-Champaign	23.7	9.9	8.1	23.2	26.0	2.8	5.4	0.8	28,414	10,051	506.0
University of Michigan, All Campuses	21.2	5.0	1.1	1.8	57.4	1.4	12.0	0.1	36,813	16,006	769.1
University of Minnesota, All Campuses	**10.2**	**5.0**	**2.4**	**3.7**	**72.3**	**2.5**	**3.9**	**0.0**	**38,216**	**15,284**	**515.1**
University of North Carolina at Chapel Hill	0.0	5.2	5.7	2.5	77.0	1.5	8.2	0.0	15,608	9,284	416.7
University of Texas at Austin	34.7	21.9	9.0	12.7	12.9	2.2	5.3	1.3	38,162	11,834	343.9
University of Washington – Seattle	9.8	4.9	11.0	0.7	67.5	1.2	4.8	0.0	28,691	10,559	714.0
University of Wisconsin – Madison	12.4	6.8	7.1	2.4	62.0	3.8	5.5	0.0	29,697	10,961	763.9

Source: National Science Foundation (2006); University of Minnesota, Office of Institutional Research (2003a; 2003b).

Notes: Student counts for 2004 are from 2000. The University of Minnesota student counts (full-time equivalents) came from the Office of Institutional Research (2003a; 2003b). All expenditures are deflated (i.e., adjusted for inflation) using the U.S. GDP implicit price deflator with base year 2004 prices (World Bank 2006).

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