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THE COLD WAR, TECHNOLOGY AND THE AMERICAN UNIVERSITY

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The nation's ascendance as the major military and economic power in the post-World War II period made the cult of the sciences pervasive in American society. Science and technology, explained Daniel Yankelovich, "were almost universally credited with a decisive role in gaining victory in war, prosperity in peace, enhancing national security, improving our health, and enriching the quality of life."[1] In the late 1950s, Americans took comfort in the fact that they were the champions of this rational and mechanical art. Even with the Soviet attainment of the bomb in 1949, America remained confident of its technological, and moral, superiority and had built its Cold War foreign policy on the notion of containing the communist menace – in essence, a policy reliant on perpetual technological superiority. The 1957 launching of Sputnik shattered the sense of comfort in America's scientific prowess, not only creating the image of an enemy capable of launching missiles of massive destruction, but a widespread fear that America had failed to nurture the sciences and build advanced technologies, with potentially horrifying implications.

To a large degree, American popular opinion credited the Soviet educational system with Sputnik's success. Here was the source for its scientists and engineers – the labor pool required to pursue technology related research and for conceiving and constructing the rockets that propelled Sputnik. Conversely, the reason for America's apparent second place position in both the arms and space races was its faltering schools and universities. Among the American public, the correlation seemed obvious.

Supporters of a stronger federal role in education united with critics of America's schools systems, running roughshod over the long-standing reluctance to expand the influence of Washington in policy areas traditionally reserved to the states. "For several years independent observers have been warning us about what the Soviets were doing in education, especially in science education," explained Thomas N. Bonner in the *Journal of Higher Education*, "but they were crying in the wilderness until October 4, 1957, when the Russians punctured our magnificent conceit by making it clear that in a number of related areas of basic research and applied technology they have already outdistanced us . . . Science and education have now become the main battleground of the Cold War."[2]

Bonner was not alone when he pronounced his belief that "It is upon education that the fate of our way of life depends."[3] The quick conclusion of many was that America's system of education was disorganized, that it failed to provide sufficient training and research in the sciences, that it catered to mediocrity at the expense of the promising student. Higher education bore the brunt of a national failure. The elementary school and the high school nurtured the pool of talent necessary for technological advancement. But higher education, and the research university in particular, was the primary institution for creating the next generation of scientists and engineers, and for producing basic research – the basis for most major technological innovations, from the computer to the bomb. Not only was there a perceived "missile gap." There also was a "education and technology gap."

The translation of Sputnik from a scientific into a political event changed the dynamics of federal science and technology policy, and elevated to new heights the American research university as a pivotal tool for winning the Cold War. This paper discusses this significant shift in federal policy, its impact on America's research universities and scientific community, and its influence on the contemporary economy. Sputnik prompted a significant expansion in the training of scientists and engineers, and acted as a catalyst for large scale federal funding for higher education. It also resulted in the federal government becoming the nation's primary source of R&D investment. The result was a greatly accelerated shift in scientific research increasingly toward a multi-disciplinary model and the creation of new knowledge that form the foundation for today's technological innovations that may well exceed in importance the trials and tribulations of the Cold War itself.

The Beginning of the Cold War

In the immediate post-World War II era, federal support of science and engineering had already become a central means to maintain technological superiority in domestic and international markets, and to support the nation's relatively new military dominance. Within the context of a general rejection of New Deal politics and a celebrated return to a free-market economy, the federal government would enlarge its role in basic and applied research assumed vital to the economy and national defense. But this expansion of federal support and the development of a national science and technology policy would come slowly, awaiting the jolt provided by Sputnik.

As the director of the wartime Office of Scientific Research and Development, Vannevar Bush provided a blueprint for a post-war science policy – essentially a public and private sector model for promoting science that remains the focus of debate over future federal R&D policy. Bush argued for continuing the flow of federal funds to universities, and to the university managed federal laboratories.[4] In 1945, the federal government was already funding 83 percent of all research in the natural sciences. Should this dominant role continue? Bush recognized the predilection of the private sector to invest in research that promised quick returns as commercial products, and argued that America's research universities should remain the primary engine for basic research. The generation of new knowledge vital to technological change could be nurtured best in an environment that supported the free-market of ideas, with or without recognized commercial application. The seemingly impossible invention of the atomic bomb, the development of jet engines, and other innovations reinforced the notion that basic research would drive new and unforeseen revolutions in products and manufacturing processes. The emergence of the Cold War and the subsequent race for technological superiority made any other model obsolete. America simply could not afford to leave basic research to the private sector.

Two years later, the President's Scientific Research Board reiterated many of Bush's recommendations. Bush had advocated a single federal agency to set science policy and distribute funding. While this grand and overarching agency was never created, the pragmatic argument regarding the primary role of the federal government in promoting basic research took hold. Both Bush's report and that of the Scientific Research Board led to the organization of the Office of Naval Research in the Department of the Navy, and later the establishment in 1950 of the National Science Foundation. The resulting proliferation of federal agencies created to fund and manage the nation's scientific advancement provided a new source of influence on American higher education. In 1950, over a dozen federal agencies funneled over $150 million to a select group of universities for contract research. Some 13 institutions garnered over 85 percent of the federal research contracts, and creating the semblance of a network of national research universities that has remained dominant in securing federal research funds.[5]

The assumed importance of higher education to national security and to economic growth would translate into relatively new forms of federal involvement in higher education. In 1942, the Roosevelt administration was already making plans for what would become known as the G.I. Bill of Rights. Legislation to benefit veterans had long been a political tradition. Yet added to the mix of pensions, medical benefits, and subsidies for housing, was a new commitment to support and encourage veterans to attend college. The motivation was not only the welfare of veterans. The surge of veterans returning to a peace-time economy, it was feared, would likely drive up unemployment and exacerbate the likelihood of a severe post-war recession – and possibly depression. Training in postsecondary institutions, from vocational schools to research universities, promised to reduce unemployment rolls, and train a new army of laborers suited to an increasingly technologically driven economy.

Reflecting the traditional role of the federal government regarding education, the G.I. Bill purposely provided no direct funds for supporting postsecondary institutions. Instead, financial support went to the individual for the payment of tuition and fees at an accredited school, college or university. The contemporary system of self-accreditation of higher education institutions was created in the post-war period specifically in reaction to the G.I. Bill. The result of this relatively new intervention in higher education was a huge surge in enrollment in both public and private colleges and universities that peaked in 1947. In California, for example, just over half of all students enrolled at the University of California were veterans, while 70 percent of students at the state colleges and 36 percent of junior college enrollment were veterans.

In the aftermath of the war, the federal government also provided the first infusion of property and funds for the capital needs of higher education. Previous federal legislation, including the Morrill Act, stipulated that federal funding be reserved for operating costs. The Surplus Act of 1944 donated federal lands and buildings, primarily former military bases, for expanding the infrastructure of colleges and universities. By 1950, Congress also authorized the Housing and Home Finance Agency to provide $300 million in loans to pubic and private colleges for the building of dorms.

A post-war structure of support for higher education had emerged, linked to a growing faith in America's colleges and universities as a determiner of socio-economic mobility, economic prosperity, and as a key component in winning the Cold War. A major federal study commissioned by President Truman, and issued in December, 1947, articulated the national needs in higher education, and argued for the continued expansion of federal support. *Higher Education for American Democracy* argued for a doubling of higher education enrollment in ten years. The study, completed by a 26 member commission, boldly stated that at least 49 percent of our population has the mental ability to complete 14 years of schooling. At the time, only 20 percent of the nation's high school graduates went on to a postsecondary institution. Further, the study insisted that "at least 32 percent of our population has the mental ability to complete an advanced liberal arts or specialized professional education." Estimating the mental ability of an entire nation is, to say the least, problematic. Yet the faith in scientism and desire to expand access to higher education overrode such methodological questions.

How could the nation encourage these levels of access? For one, the commission urged state and local governments to expand the number of public institutions, and primarily the number of junior colleges. The major role of the federal government, it was explained, should be a significant expansion of its scholarship programs beyond veterans. Both state and federal government, it was argued, needed to help remove not only economic barriers to access, but geographic, racial and religious barriers primarily by providing financial support to needy students.

Yet the push for a larger federal role in higher education essentially stalled by the mid-1950s. The G.I. Bill and a second bill to benefit veterans of the conflict in Korea kept the U.S. government in the business of providing scholarships. The net effect was an indirect subsidy to both public and private higher education through the collection of tuition and fees. Despite the lobbying by higher education leaders, Congress refused any expansion of the federal government's scholarship program. In 1956, some 50 bills where proposed that would either grant loans or scholarships to students. All where defeated or killed in subcommittees as inappropriate forays into state control and responsibility for higher education. The American Council on Education proposed the creation of federal tax credits, one of numerous schemes that failed to gain significant support among lawmakers.[6] The enrollment bulge of veterans, and the flow of federal dollars for tuition, had dissipated.

Federal loans for dormitories had proven of great benefit to public and private colleges and universities; but advocates for higher education had failed to convince Congress to expand this program to include loans, and perhaps even direct support, for the construction of buildings for academic programs. Funding was also needed for equipment. Expanding enrollment and research activity required a significant expansion in infrastructure – a burden that federal officials claimed was not the responsibility of the federal government.

The one area of federal funding for higher education that continued to grow was related to supporting basic research. In 1955, federally funded organized research at American universities and a select number of colleges had climbed to $169 million. Another $180 million went to university managed laboratories, such as Los Alamos. By early 1957, federal contracts for research had climbed to $229 million, with university managed laboratories consuming an additional $240 million. The result was the first phase of significant transformation in the activities and perceived purpose of higher education, and research universities specifically. In 1939, organized research consumed only 4.8 percent of all expenditures in American higher education, both public and private. By 1945, that number increased to 9.4 percent, and by 1955 to 15 percent.[7]

The search for agricultural advancements had dominated the pre-war research activities of universities.[8] The increase in post-war research was primarily in state of the art technologies like micro-electronics, pharmaceuticals, and engineering fields with strong relationships to national defense needs. Despite these significant changes, the greatest period of federal investment in R&D and in American higher education was yet to come.

Sputnik's Arrival

The seventeen year period between the end of World War II and the launching of Sputnik represents the first phase of a growing federal relationship with and dependence on higher education in the Cold War era. A general framework of policy had been created, funneling federal resources to institutions. The majority of these funds, some 45 percent (not including the university managed federal laboratories) went to faculty directed projects in research universities, reflecting the federal government's continued post-war investment in basic research.

The arrival of Sputnik did not revolutionize the post-war pattern of federal engagement in higher education. The dependence on higher education for training scientists and engineers, for creating new technologies and investigating their applications, had already been formed, and precedents set, such as the GI Bill. But the event of Sputnik did provide a tremendous spark for enlarging federal investment in America's colleges and universities on an unprecedented scale, and with tremendous implications for hastening the development of new modes of scientific research. No other Cold War event, including the Soviet attainment of the atomic bomb, so shocked and galvanized American lawmakers and the public in their joint resolve to invest in and reposition higher education. Sputnik created an urgency for further investment and introspection, heightening the sense among the public that education, and specifically the academy, provided the key ingredient for beating the Soviet's space age war machine. Promoting scientific knowledge now become a main stream issue of lawmakers, not just the personal interest of academics and a select number of government officials.

In September of 1957, a national recession and a court order to desegregate schools in Little Rock, Arkansas, dominated the national news. The pressures of the Cold War, while ever-present and ingrained in American political culture, seemed sufficiently distant. Soviet ideology had been the largest concern of Americans. A vast ocean and a continent separated the nation from the Soviet empire and battlegrounds such as Korea. In the public eye, the thought of communist subversives at home appeared the most salient component of the Soviet threat. Political careers were built on the fear of communist infiltrators.

The announcement on October 4, 1957 by Tass of the launch of Sputnik jolted the public and caught Congress and the President by surprise. President Eisenhower knew of the Soviet bid to beat the U.S. in launching a satellite. In the midst of racial strife, a recession, and plans for discussion with Khrushchev, however, the political ramifications of such an event were not well assessed. The president was ill-prepared for the onslaught that followed. Democrats and Republicans embraced the "devastating blow" of

Sputnik to blame each other for what appeared to be a colossal failure to beat the Russians into space and, ultimately. to invest in technology. "The big significance for the U.S. is not the object itself, but the power of the rockets used," explained one national magazine: "The Soviet Union today possess rockets capable of launching missiles with hydrogen-bomb warheads that – if guided accurately – can strike the U.S. sixteen minutes after being launched from Soviet soil."[9] Although the communist enemy had the bomb, Americans were confident of their technological superiority. Sputnik changed that. Suddenly, there was the threat of Soviet technology and possibly military superiority.

President Eisenhower had long doubted the validity of the so-called missile gap. Even with the news of Sputnik, he remained skeptical about the scientific accomplishment of the Soviets. Eisenhower at first attempted to deny that America was now in second place in missile technology. He also defended his administration's policies that had separated the development of missiles for military use from that of scientific experiments, including the plan to launch America's first satellite as part of the International Geophysical Year. But the lack of a seemingly coherent attempt to beat the Soviets drowned his pronouncements. Eisenhower's sparse defense budgets and lame duck status provided fodder for both the right and left of the political spectrum. Democratic Senator Henry Jackson professed Sputnik as a symbol of a national failure of leadership, a "devastating blow" and a "week of shame and danger" that, implicitly, could be traced to the White House. Senator Styles Bridges, a Republican from New Hampshire, admonished Americans to "be prepared to shed blood, sweat and tears if this country and the free world are to survive."[10]

The political stakes required a strong response from the administration, and made federal resolve and legislation inevitable. But what form would it take? Eisenhower resisted calls for a massive infusion of funds for the military: "The American people," he would state before Congress, "could make no more tragic mistake than merely to concentrate on military strength." On October 15th, Eisenhower met with his Science Advisory Committee on Defense Mobilization. Two major recommendations came out of that meeting that inextricably linked winning the Cold War with the educational establishment.

First, Eisenhower agreed to a full-time science adviser in the executive branch. The President would later appoint MIT president James R. Killian to the post, who then chaired the newly formed President's Science Advisory Committee (PSAC). From this group would come proposals for reorganizing the federal governments funding of R&D, for disentangling the military service rivalries that, it appeared, had been one major explanation for coming in second in the space race, and the creation of new agencies, notably NASA which would manage a new and concerted space program. And second, the federal government would need to invest immediately in education, from the elementary school to the research university, to expand the number of scientists and engineers, and to substantially increase America's research prowess.

The Soviet success brought an unprecedented desire in American society to analyze the purpose and functions of education, and to seek its reform – a desire magnified by the launch of Sputnik II just six months later. Both "shocked our citizens and our government out of their complacent faith," noted one observer, "in our ability to maintain a scientific and military lead over the Russians and in the superiority of our educational program."[11] The impulse was to compare the competing Soviet educational system to our own. Sputnik has "imparted a sense of urgency and, indeed, at times almost an atmosphere of panic to a searching examination of the techniques, methods, and philosophy which have enabled the Soviet Union to achieve so dramatic a sequence of achievements and, at the same time, have aroused a widespread demand for an equally comprehensive reevaluation of American education."[12]

Nicholas DeWitt had warned of the Soviet Union's massive investment in education for Cold War purposes, and his study of their education system became the source of popular sentiment: reduced to its fundamentals, he explained, the Soviets had realized that the "Advancement of science and technology is best promoted through central planning of education and research . . . that scientific and educational efforts are primarily a means for the advancement of the social, economic, political and military interests of the nation."[13] "What the Russians have done is nothing very mysterious," claimed Bonner, "they simply prized brains . . . opened [the educational system] to all who could profit from it, and provided mammoth incentives to excel. America had simply produced a curriculum made for the norm, and our society lacked respect for learning and the teaching profession."[14] The Russians made their "tremendous leap forward in science and technology," explained Clarence Hilsberry, president of Wayne State University, by making almost everything subservient to this end within the education system: "they have given student-in-training and teachers of science and technology the prestige of both position and salary."[15]

While there were indeed lessons to be learned from the Soviets, noted one congressional advisory committee under its "Proposed Program of Federal Action to Strengthen Higher Education in the Service of the Nation," an "unwise imitation of Russian education could be as disastrous for the United States as imitation of our educational system would certainly be for the ruling clique in the Kremlin." Composed of professional educators and administrators, this special committee noted openly its fear of wholesale reform and federal intervention in higher education. The committee contended that federal and state government needed to bolster the existing system and encourage curriculum development in the sciences. "The fundamental problem facing the American people is how to improve and strengthen our educational structure, not how to remake it in blind admiration of the Russian model."[16]

Others warned against the demand for vocational and professional instruction at the cost of a liberal education, particularly at the postsecondary level. The political reaction to Sputnik, it appeared, promised to convert much of higher education "toward training people to make bombs and carriers and television sets and automobiles," according to Alex Bedrosian and Bruce Jackson. But such a reorientation, already begun in the post-World War II era, would not give students "the maturity to determine the place and relative importance of these devices in society . . . Too little accent is being put on the position of the sciences in relation to other disciplines."[17] C. P. Snow wrote about the growing cultural and resource divide between humanists and scientists, and argued for mitigation. Yet the saliency of this concern seemed rather remote to lawmakers caught in the frenzy of bolstering the science and technology abilities of the nation. The two general non-science areas that did seem to deserve greater financial support again related directly to national defense needs: political scientists and others studying the nature and predilections of the Soviet bloc and vulnerable countries, and the study of foreign languages necessary for such understanding.

The Soviet's success was not the only event that set the stage for lawmakers returning to Washington in early 1958. The Naval Research Laboratory's attempt to launch a Vanguard rocket carrying America's IGF satellite in December, 1957, lifted off only to come crashing down in a plume of smoke and fire. The successful launch of America's first satellite by the Army a little over a month later made little difference in the political environment. For the public and lawmakers, the Vanguard's failure reinforced the resolve for a bill that would alter the landscape of American science and research. "Congress has repeatedly turned down educational assistance," remarked Congresswoman Martha W. Griffith at a meeting of the American Association of Land Grant Colleges and State Universities. "Now, for the first time, it will undoubtedly be one of the first matters on the agenda."[18]

Wholesale reform of the nation's education system was virtually impossible in light of decentralized state and local control of educational policy. Though some advocated it, centralized authority and planning, one of the espoused secrets of the Soviet system, was not a politically or operationally viable option in the United States.[19] State governments, not Washington, retained control over the chartering and organization of higher education in the United States. Centralized control threatened the sense and reality of institutional autonomy crucial to the very idea of the academy. But most importantly, a blatant embracement of Soviet style central planning was anathema to the public and lawmakers. Yet the Soviet example provided a new focus for the federal government, creating a crucial impulse to use the federal largess toward a national purpose and in ways that promoted the nation's scientific and technological prowess. The future of America's decentralized education system engulfed the discussion on domestic policy to such an extent that the nationwide interest in education was perhaps at its peak in the twentieth century.

At the federal level, a consensus formed, shaped in large part by the science and education community empowered by the spectacle of Sputnik. Funding was needed to increase support for our most promising students. Curricula in the sciences and in applied fields needed to be promoted, and data needed to be collected and analyzed on the activities and performance of America's education system. Federal policy, it was decided, would promote state level planning of higher education, and create the semblance of a national policy. And finally, Congress agreed to substantially increase the flow of federal research dollars to primarily higher education. The federal government was going to shift substantial resources and influence toward education in the name of defense.

The result was the most important federal bills related to education since the 1862 Morrill Act: the National Defense Education Act of 1958 (NDEA).[20] The general provisions of the act stated the Cold War motives of Congress: "an educational emergency exists and requires action by the federal government. Assistance will come from Washington to help develop as rapidly as possible those skills essential to the national security." Federal expenditures for education more than doubled. For higher education, this included funding for federal student loan programs, graduate fellowships in the sciences and engineering, institutional aid for teacher education, funding for capital construction, and a surge of funds for curriculum development in the sciences, math and foreign languages.

"A careful reading of the Act," wrote Philip Coombs, the director of the Fund for the Advancement of Education in 1960, "makes it obvious that Congress knowingly took positions on issues which the educators themselves are still debating. Congress," he explained, "took a stand in favor of differential programming for abler students in the schools and colleges; it took a stand on debatable curriculum questions by giving special attention to foreign languages, science, and mathematics . . . . And it also took the stand, with which many educators do not yet agree, that modern communications such as films and television should be given a much larger role in the learning process."[21]

<u>R&D and the University</u>

The NDEA was only one part of the reaction to Sputnik. While new funds for science curricula, for graduate fellowships and the like flowed through the Department of Health, Education and Welfare, and the Office of Education, other agencies received large infusions of funds specifically aimed toward expanding the nation's R&D effort. In the name of defense, congressional allocations provided a flood of taxpayer money to existing agencies such as the Department of Defense (DOD), the Atomic Energy Commission, and the National Science Foundation (NSF) to fund basic and applied research. The establishment of NASA 5 months after the launching of Sputnik united the federal government effort to develop its space program, and brought a new and substantial source of funding for America's scientific community.

The NDEA and the establishment of NASA provided the gateway to a new role for the federal government in R&D. A dramatic transformation quickly occurred in both the amount and in the source of the nation's R&D investment. Federal expenditures for R&D swelled from $2.7 billion to more than $15 billion between 1955 and 1965. And while the vast majority of funding flowed under the rubric of developing the nation's defense and space capabilities, two important forces spread the wealth and created a much broader and complex national research engine. Each involved and benefited America's research universities and expanded the role of basic research.

First, the very nature of technological innovation, both in military hardware and space travel, required an ever expanding base of scientific knowledge. The serendipitous nature of scientific research and its growing relevance to technological innovation required a diffusion of funding for basic research that was substantially different from earlier decades. It also required a new model for managing federal R&D efforts that would reallocate power to new civilian led agencies such as NASA and the NSF, and direct the nation's resources in a way that would promote new fields of science. "The technological revolution that is now fully upon us involves all areas and disciplines," stated James Webb, NASA's aggressive and second director appointed in 1961 by President Kennedy. "No nation that aspires to greatness, or to use its power for good, can continue to rely on the methods of the past" he pronounced. "Unless a nation purposefully and systematically stimulates and regulates its technological advances and builds the fruits of those advances into the sinews of the system, it will surely drop behind."[22]

And second, the political realities of American government required spreading the surge of funds among competing constituents that were not directly part of the expanding military-industrial complex. Program research such as the Manhattan Project had dominated the federal allocations thus far. A philosophical shift placed greater emphasis on providing funding for research by individuals that might have direct or indirect relationships to agencies such as NASA or specific defense programs. Agencies such as NASA were literally awash in funds and sought mechanisms to not only spend money, but to broaden the purpose of the agency and expand political support.[23] "Unless the United States [was] to transmogrify into a high-tech military economy while civilian industries went begging," explains Walter McDougall in his political history of the Space Age, "the beneficiaries of the boom [needed] to demonstrate that R&D for space and defense also energized the larger economy."[24]

The new, post-Sputnik structure for R&D investment wrested, in effect, policymaking from the traditional military services, and articulated a larger vision of how science and technology might be promoted and sustained. The military and space objectives remained dominant; but they also provided a platform for the creation of a relatively new scientific community. And as a result, the post-World War II tendency toward large, monolithic organizations funded by a single federal agency, and focused on the research and production aspects of a project, such as the national laboratories, gave way to a relatively new framework: multiple federal agencies funding individual scientists within their existing institutions. The federal government focused less on investing in research that might lead to a product useful for military purposes – such as the computer – to a more holistic approach of supporting a broad range of scientific endeavors.

The size of expenditures in federally funded R&D rose spectacularly, and the wealth was spread to a degree unimaginable before October, 1957. With its primary and celebrated objective to transport a human to the moon, NASA employed this diffusion of workload as an essential ingredient in its operations. NASA, explained Webb, was spreading "all of the problems, scientific and technical, over a very large number of able minds in educational institutions . . . and throughout industry," and sought to "do all [we] can to build up the university research, teaching, and graduate and postgraduate quality and quantity of education."[25]

James Killian and the PSAC had pushed hard to have the federal government increase funding for basic research, and more generally to expand federal support for research universities. Killian's advisory committee appointed a panel chaired by UC Berkeley chancellor, Nobel laureate, and PSAC member Glenn Seaborg, also argued that federal funds support a greater share of direct costs for contract research projects.[26] The vested interests of public and private universities had long been relatively powerless to influence federal research policy. But the sense of crisis now transformed the politics of federal aid to higher education. Prior to Sputnik, university presidents found that the increase in federal allocations for basic research projects failed to cover the full and indirect costs of research. Each time a university accepted a new federally-funded project, institutional funds from other sources needed to be found to support the development of appropriate facilities, the hiring of administrative staff and other costs. The result was a growing drain on university resources. Yet opposition in Congress and the Eisenhower administration's persistent efforts to limit the growth of the federal budget made any change in federal policy unlikely.

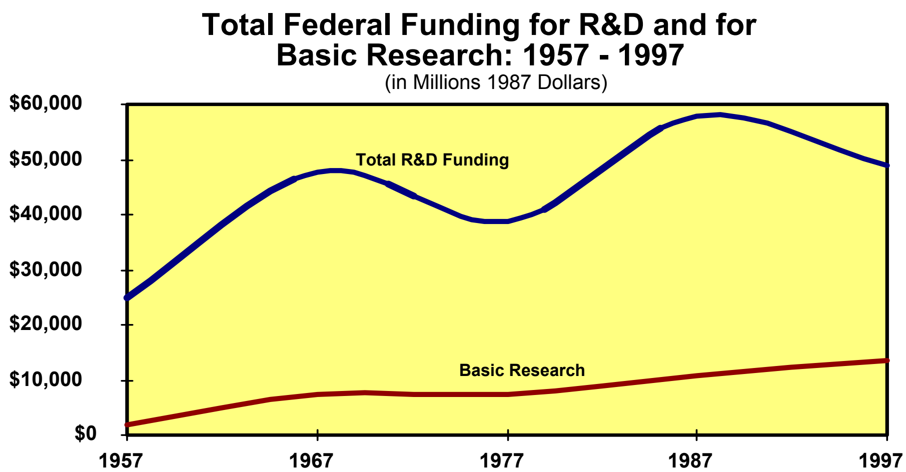
The centrality of the research university in the Cold War era accentuated by Sputnik offered a unique opportunity for the scientific community to lobby for an expanded notion of federal obligations. The Seaborg Report, in particular, argued that federal funding support the entire research-related infrastructure of universities, from scientific buildings, laboratories and equipment, to graduate fellowships. Without an increase in federal support for indirect costs, research universities would discourage federal grant projects proposed by faculty. Seaborg's panel also linked graduate education as part and parcel of any legitimate research enterprise in the sciences and engineering. The NDEA's support of approximately 4,000 graduate students per year was not enough. "Whether the quantity and quality of basic research and graduate education in the United States will be adequate," stated the report, "depends primarily upon the government of the United States. From this responsibility the Federal Government has no escape."[27]

Sputnik helped to create a consensus within both government and industry regarding the role of basic research. "We might liken our pool of basic scientific knowledge to a savings account," explained Crawford H. Greenewalt, the president of DuPont in 1959, "from which we make withdrawals as we convert that knowledge through applied research to new products and processes . . . . Applied research and development are concerned primarily with the present. For the future, we must place our reliance on basic research."[28] While Greenewalt and others in business advocated greater basic research investment by industry, the dominant role of the federal government and research universities was both rationalized as critical to national security, and welcomed by the private sector. It was work and an investment that the private sector would never fully fund.

DuPont had created one of the first industry based research laboratories and pioneered cooperative relationships with university researchers. Yet some twenty-years later, Greenewalt's successor reiterated the value of university based research. "While we at DuPont consider research collaboration to be important," he explained, "we consider as much more important the university as the principal source of basic research and of future leaders."[29]

The immediate post-Sputnik years mark a major transition for the expanding business of research. The majority of new federal funds for R&D continued to go to programmatic research and development for defense purposes and the space program, feeding America's growing and massive defense and aeronautics industry. Adjusting for inflation, total R&D funding grew by 200 percent between 1955 to 1965 – the largest single period of increase in this century. Outlays for research had grown from 5 percent to 15 percent of the federal budget. Some 70 percent of the nation's entire research effort now came from federal coffers. Since Sputnik, an estimated 75 percent of all engineers and scientists who entered the field of scientific research had gone into federally subsidized undertakings in both public and private sectors. *Fortune* magazine stated the obvious, "science and technology have become the wards of the federal government."[30]

Figure 1



As shown in Figure 1 above, post-Vietnam budgets and a national recession caused a reduction in federal investment in the early and mid-1970s in real dollars, a recovery in the 1980s buttressed by President's Reagan's "Star Wars" program, and since then a significant decline. Federal R&D policy was profoundly shaped by Cold War fears; in the opening years of the post-Cold War, demilitarization and fiscal constraints now appear the primary influence on federal policymaking. The net effect has been a substantial erosion in the federally funded military-industrial complex, and a difficult period of transformation for defense dependent industries and federal research laboratories.

Yet federal investment in basic research has largely avoided the vacillations found in overall federal R&D funding. Reflecting the centrality of basic research to technological innovation, and Vannever Bush's proclaimed paradigm government role in promoting and sustaining basic research, this sector of the federal investment in R&D has steadily grown. Funding for basic research quickly increased by some 320 percent between the same ten year period beginning in 1955, and grew as a percentage of federal expenditures on R&D from 9 to 14 percent. NASA provided the single largest investor in basic research in 1965, funding $790 million. The second largest source, the Atomic Energy Commission, spent $268 million, HEW $237 million, the DOD $220 million, and NSF $143 million.[31]

At the same time, and influenced by the Seaborg Report, federal agencies substantially increased their funding for indirect costs. Prior to 1957 the overhead rate that federal agencies would fund was around 12 percent above the proposal budget for a research project. By the mid-1960s, more elaborate formulas for overhead rates had been developed, with each university campus negotiating the final rate with federal officials. At major research universities such as Harvard and Columbia, overhead rates had reached 36 percent – a rate that higher education leaders still argued was insufficient.[32]

By 1995 basic research accounted for 28 percent of all federal R&D funding. Overhead agreements at some research universities had climbed to 60 to 70 percent, reflecting not only increased federal support for indirect costs of institutions, but also the increased costs of laboratory science. In the decades after Sputnik the federal government emerged as the major source of basic research investment on a scale few thought imaginable in the immediate post-war years. As shown in Figure 2, while federal funding surged, industry investment in basic research remained at the same level for twenty years following the launch of Sputnik. By the 1980s, however, private sector investment would grow with the arrival of relatively new industries focused on high-tech areas such as computers, pharmaceuticals, biotechnology, and medical diagnostic devices – commercial applications of technologies fostered and benefited by the federal basic science investment.

Figure 2

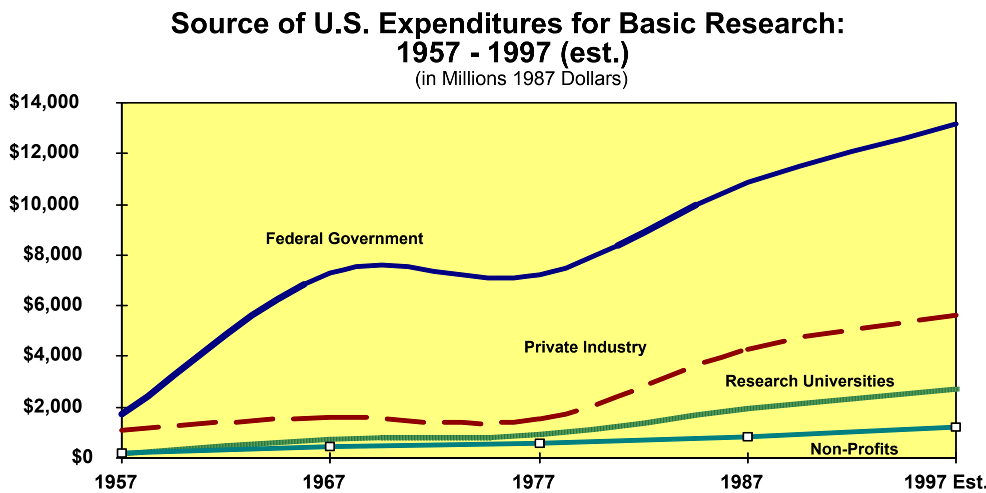
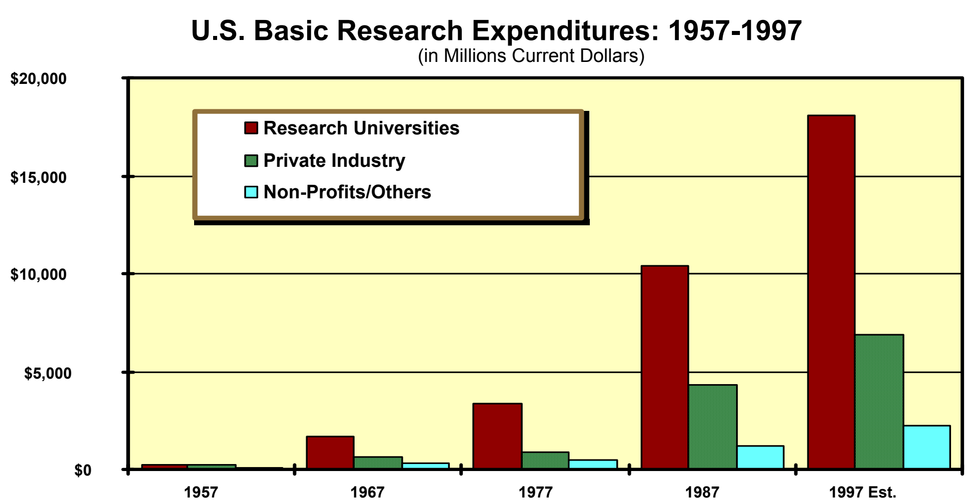


Figure 3



The majority of this large and growing federal investment in basic research, not surprisingly, went to research universities. Prior to Sputnik, federal and private sector investment in basic research was approximately the same. In addition the amount of basic research being conducted by research universities and non-profit agencies versus private industry was also about the same (as measured in actual expenditures). However, by 1967, expenditures for basic research in research universities outpaced those in the private sector by a ratio of 3 to 1. As shown in Figure 3, this ratio would be maintained throughout the 1980s and into the 1990s.

A Federal and State Government Symbiosis

In the aftermath of Sputnik the federal interest in higher education was driven largely by national security interests. Here was the rational for intruding into the affairs of state governments and public and private institutions. State and local support for higher education tended to focus on socio-economic mobility and economic development. The marriage of these interests created a powerful force that would not only expand access to higher education, but also buttress the growth of the sciences and engineering within the academy.

Supported by federal grants and loans, states began a massive expansion of public colleges and universities. With the rapid expansion of the Cold War economy, access to higher education increasingly became a matter of economic competitiveness. In states such as California, approximately 50 percent of the state's economic growth from 1945 to 1960 was tied directly and indirectly to the defense industry and federal outlays for research. The labor needs for engineers, technicians and others in rapidly growing, and federal subsidized industries such as electronics and aeronautics alone provided a tremendous catalyst for state investment in higher education.

Post-Sputnik federal policy encouraged larger state expenditures on higher education, particularly in areas that related to science education and basic research. Portions of the 1958 NDEA required matching funding from states, and stipulated that state governments establish agencies for coordinating the dispersal of federal funds, for reporting back to Congress, and for creating a new national data base on educational expenditures and programs. In California the single largest benefactor of federal aid to higher education, the Bureau of National Defense Education, was established for this purpose. Similar agencies where created in all other states. And because the allocation of federal funds was correlated to the number of students enrolled, colleges and universities gained an added incentive to increase student numbers, as well as acquiring subsidies for expanding access.

State governments, while still wary of federal controls over education competed for the new federal largess. California's Bureau of National Defense Education was not only established to meet federal guidelines, but, as stated in its charge by the state legislature, to insure that "schools and colleges of the state exploit every opportunity to qualify for the funds afforded."[33]

The post-Sputnik surge of federal interest which helped to finance the nation's expanding network of college and universities, culminated in the passage of the 1965 Higher Education Act by Congress. Passed at the height of President Johnson's Great Society program, the Act expanded the federal government's subsidization of college and university operating costs. Grants were provided for university community services programs, college library assistance, instructional equipment, and enlarged the student loan program even further. The Act, however, added a new aspect to federal support. Growing concern that the new wave of federal assistance and contract research benefited largely a few select research universities provided the basis for grants to "developing institutions." Studies on the dispersal of federal funds among states and institutions also led to changes in the allocation of contract research. In 1963, 20 universities received nearly 80 percent of all federal research funding allocated to higher education – including university managed national laboratories.

Despite the attempt to democratize the dispersal of federal funds, the institutions that benefited the most from post-Sputnik legislation continued to be a select group of public and private universities. Within the context of a relatively new world of federal funding to higher education, private research universities gained the most from the post-Sputnik policy changes. On average, and benefiting from both the surge in federal support for research and student loan programs and high tuition rates, by 1965 the national government provided 35 percent of the operating budgets of private research universities – up from a total of around 20 percent in 1957.

At public institutions such as the University of California the surge of federal funds proved decisive in both expanding access, and increasing the quantity and quality of scientific research (see Figures 4 and 5). In the 1960s, the largest period of enrollment and programmatic growth for California's land-grant university, federal funds for research, student scholarships, and capital construction, helped to build six new campuses. By 1965, $95 million, or some 22 percent of the university's budget (excluding the federal laboratories at Los Alamos, Livermore and Berkeley) came from federal coffers. At campuses such as Berkeley and UCLA, the percentage of their operating budget from Washington was closer to 35 percent.

Figure 4

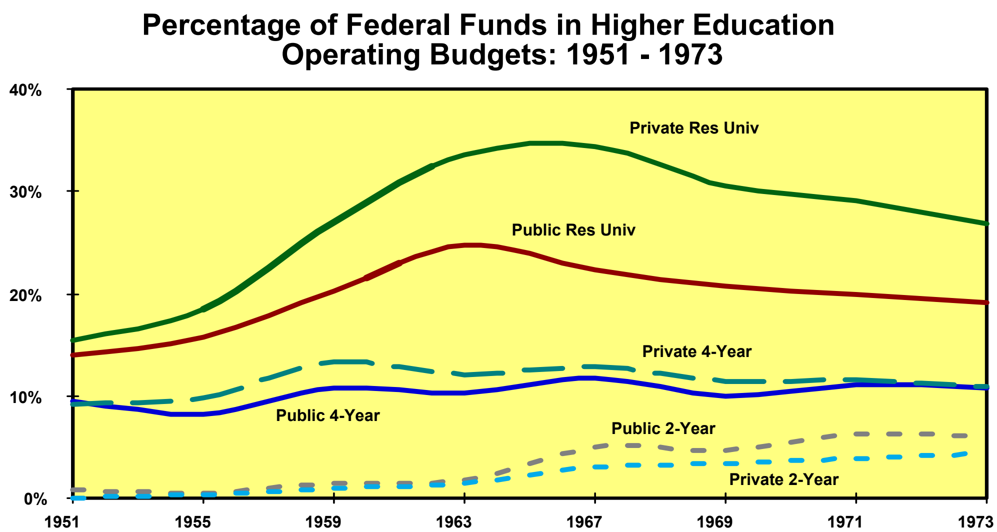
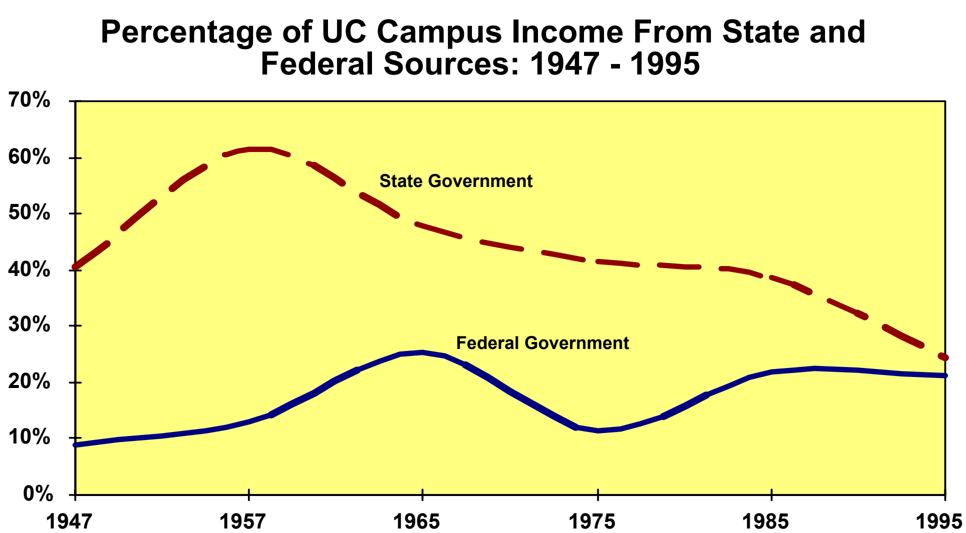


Figure 5



The decline in the percentage of funds coming from the federal government to the University of California in the 1970s, and its subsequent growth in the 1980s reflects national trends. By 1972, Congress had not renewed those aspects of the 1965 Higher Education Act that provided funds for capital construction, and began a shift away from scholarships administered by higher education institutions to a program of loans to students. Direct aid to higher education declined. Yet the eventual growth in the student aid program, and the continuing increase in federally funded research at the University would once again bring federal support to approximately 25 percent of the institution’s operating budget. Within the context of a continuing decline in state funding for higher education – a national phenomenon – federal funds have provided a key source of support.

The Production of Knowledge

Born out of the fear of a rival foreign power, federal funds flowed to American research universities in the early 1960s, in large part, to expand the labor pool of scientists and engineers and to increase the quantity and quality of scientific research. What was the impact of the surge in federal funds and influence on the academy, and more generally on the production of knowledge?

The explosion of federal funding had been largely embraced, indeed encouraged, by the academic community. At perhaps no other time in the nation’s history had higher education, and the research university in specific, been elevated to such a pivotal place in the society. And the studious avoidance of centralized planning and federal control over higher education institutions provided the semblance of independence for the academy. Indeed, the NDEA explicitly stated that “Nothing in this act shall be construed to authorize any agency or employee of the United States to exercise any direction, supervision, or control over the curriculum, program of instruction, administration, or personnel of any educational institution . . . .” Federal funds were dispersed to encourage science education, to promote and expand scientific research.

Yet the surreptitious influence of federal grants particularly for research once again raised important question regarding the purpose of the academy. With the emergence of the Cold War research university, the president of the University of California, Clark Kerr, remarked it was perhaps ironic that America's universities, "which pride themselves on their autonomy . . . which identify themselves either as `private' or as `state' should have found their greatest stimulus in federal initiative . . . that institutions which had their historical origins in the training of `gentlemen' should have committed themselves so fully to the service of brute technology."[34] A number of academicians lamented the transition was not a conscious decision of the educational community. "Powerful precedents have been set,” remarked Ross L. Mooney, "the universities have been by-passed as agencies adequate in their own right to determine what research to do.”[35]

With the federal presence at its height in the mid-1960s – funding not only research and a growing federal scholarship and loan program for students, but a significant portion of capital construction in private and public institutions – there was some conjecture that the post-Sputnik era would eventually lead to greater federal control and authority over higher education, creating a national system analogous to those found in Britain and France.

The concept of academic freedom, of free inquiry, appeared on the wane, particularly in the select major research universities which garnered the vast bulk of federal grants. While substantial sums were now “available to support scientific investigation in higher education,” remarked Richard J. Barber in an analysis of the politics of research in 1966, “it has been bought at a high price.” For one, noted Barber, with project or field of inquiry set by a federal agency, the choice of the investigator is limited, and the development of new areas of research restricted. “The result has been to favor certain fields of science, particularly the physical sciences, at the expense of others, especially the psychological and social sciences. The medical schools, benefiting from the largess of the NIH, have become much more attractive to students than, say, biology, so that those who might have embarked on graduate work in biology troop off to medical school instead.”[36]

The servitude of the sciences and engineering to the national security agenda of Washington, however, did not lead to any serious opposition to federal funding of higher education. The windfall of funds helped major research university’s expand in the sciences and increase the quality of programs at a time of large scale enrollment growth – expansion that could have significantly eroded academic quality. The subsequent growth of the sciences and engineering at university campuses also created a constituency not only dependent on the grant structure in Washington, but deeply involved in influencing the flow of funds. Sputnik launched a movement that had disenfranchised the military leadership in allocating R&D funds. The creation of NASA was the first major break. The plans of Robert McNamara and other members of the Kennedy administration to improve the management and shape the direction of America's R&D effort included increasing civilian control over DOD allocations.[37]

The decentralized and multi-agency approach to funding R&D not only fed the scientific community, it infiltrated and controlled much of the research agenda. The concern by academics, often non-scientists, regarding the influence of the federal government and compromises over academic freedom was accompanied by another worry that came from outside of the academy. Eisenhower's reflection on the rise of the military industrial complex also included a fear that federal R&D increases would lead to the "domination of the nation's scholars." Shortly after leaving the presidency, Eisenhower noted not only the great importance of scientific research, but also urged awareness of the "equal and opposite danger that public policy could itself become the captive of a scientific-technology elite."[38] Barber, a persistent critic of federal R&D policy, noted that the post-Sputnik rush of Congress to more than triple federal outlays for research had neglected to establish a structure for analyzing and shaping national research policy. "We continue to leave science to the scientists and engineers. To me this makes no more sense than leaving war to the generals."[39]

The specter of a national system of federally controlled and funded research universities would never arrive. The decentralized framework for allocating federal funds for research solidified by the Cold War and critical events like Sputnik remains largely intact. The heavy bent toward military needs and space inextricably shaped the course of research in America and in ways that, ultimately, fed a research industry that was and remains redundant and perhaps wasteful. A 1991 government, university and industry research roundtable, and in the midst of a national recession, reiterated the criticism that university research has tended to "focus on the source of funds" such as the National Institute of Health, and "de-emphasized interaction with the users of the output of research."[40]

Yet the explosion of new knowledge supported largely by the federal investment in R&D had a perhaps unexpected result. A crowded, federally subsidized, and, ultimately, more productive research engine emerged, which in turn hastened important changes in how scientific research is conducted. Buttressed by a series of post-Sputnik bills, including the 1963 Higher Education Facilities Act, scientists and engineers gained access to new laboratories with state of the art equipment. Scholarship funds provided support for graduate students and a growing cadre of professional researchers and support technicians. Team research began to replace the single scientist working in a laboratory. The number and variety of research consortiums at University campuses grew, enhancing communication between scholars and forming one basis for the expansion of multi-disciplinary research. The speed in which new discoveries might lead to new areas of research also increased considerably.

The influx of federal funds sparked by Sputnik brought opportunities for inquiry in basic research that simply would not have existed otherwise. The very nature of basic research, with only tangential relationships to immediate military, energy, health and other needs of federal agencies, created a platform for scientists to not only capture financial support. But it also provided a mechanism for public sector scientists to create research agendas often distant from the objective provided by a federal granting agency – a process of subterfuge that has not been fully recognized.

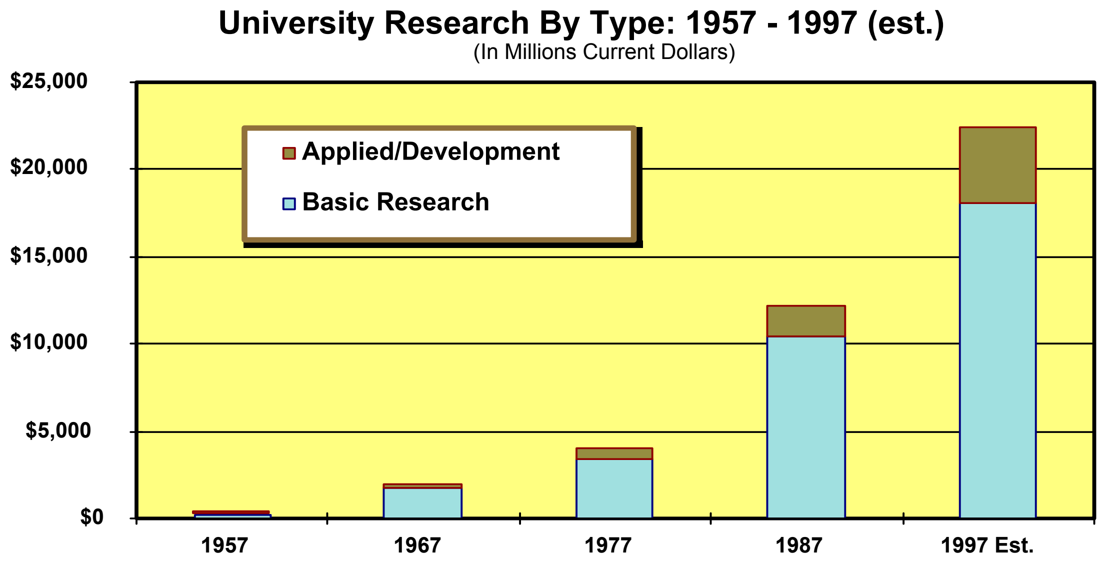
While shaped by the international science community, America's rapid emergence as the leading scientific state fast-tracked the production of knowledge toward a multidisciplinary, transdiciplinary and collaborative model that, today, is increasingly obscuring the distinction between basic and applied research in fields such as biotechnology and communications. "While knowledge production within traditional disciplinary structures remains valid," explains Michael Gibbons, Martin Trow and other co-authors of *The New Production of Knowledge*, a relatively new mode of research "is growing out of these structures and now exists alongside them." The burst of new knowledge subsidized and encouraged by federal outlays to research universities and industry has, in turn, created new technologies such as the internet which, in turn, have fed this new mode. "In transdisciplinary contexts, disciplinary boundaries, distinctions between pure and applied research, and institutional differences between, say, university and industry, seem to be less and less relevant," state the authors. "Instead, attention is focused primarily on the problem area, or the hot topic, preference given to collaborative rather than individual performance and excellence judged by the ability of individuals to make a sustained contribution in open, flexible types of organizations. . ."[41]

The market for scientific research has expanded considerably since the early 1960s. Private sector investment in both industry and university basic research has increased dramatically in the last two decades. The melding of basic and applied research has also been encouraged by changes in federal policy, providing funding and tax incentives for the establishment of Industry-University Cooperative Research Centers in areas such as engineering, and in 1984 giving universities patent rights for discoveries connected to federal subsidized research. In 1986, the NSF funded the first Engineering Research Centers (ERCs) with private industry and which focused on team research in areas that promise the next generation of technological advances. There are now twenty-five such centers all located on major research university campuses.

The 1986 Federal Technology Transfer Act permitted, for the first time, federally funded researchers to collaborate with industry to develop commercial patents. "In effect, the federal government was limping toward a sort of industrial policy," claims Norman E. Bowie. "Since American industry was failing to invest in sufficient research and development to bring new products to market that could compete internationally, especially with the Japanese, the government provided public funds to universities to help move the fruits of basic research in to the marketplace."[42] The federal government had created a tremendous national infrastructure for science and innovation in the post-World War II era. In the mid-1980s and reflecting international trends, it now created new mechanisms to tempt the academy and industry into a closer alliance.[43] In attempting to gain a greater understanding of the role of basic and applied research in the economy, NSF director Richard Atkinson funded a series of studies on the link of R&D investment with economic growth. "As late as the mid-1970s, there was no substantial economic data, no reliable economic analysis of the relationship between investments in R&D and economic development," Atkinson recently explained. He and others at the NSF realized that the lack of such information made it more difficult to gain support for research in Congress.[44] Atkinson's successor, Erich Bloch, proceeded to make economic competitiveness a part of the NSF's mission.

Reflecting the evolving nature of technological innovation, and the development of university and industry based consortiums and partnerships, American research universities are now engaged in more applied and developmental research than in any other time in their history (see Figure 6). Fields such as engineering and agriculture have long had applied and industry subsidized research components. The greatest expansion in applied research is in relatively new fields such as biotechnology that are, by their very nature, transdisciplinary and rooted in the hard sciences. As Roger Geiger has noted, the philosophical opposition to applied research in the academy, and the concerns of leaders such as Clark Kerr and later Derek Bok at Harvard, gave way to a new era dominated by new fields of scientific inquiry.[45] "The deadlock between pro- and anti-business forces was broken," writes Geiger: In no small part, the fast-paced development in biotechnology "overwhelmed the innate resistance of the universities to closer industrial ties." Geiger concludes.[46]

Figure 6



In one sense, the fact that research universities are increasingly relevant to the nation's economy is a reflection of an increasingly technology dependent private sector that needs both basic and applied research to remain competitive. In another sense, America's research universities are returning to the role they were anointed to by the Morrill Act of 1862: to be major sources of new knowledge and trained labor for dominant sectors of the economy. Agriculture and mechanical arts have been replaced by semi-conductors and communications, by biotechnology and space exploration. It is a role in the economy for American higher education that never went away, but it has become more active, more complicated, and more essential to the private sector. In his study of technology transfer at four major research universities, Gary Matkin has noted a number of trends that illustrate this shift: for one, every major research university, he predicts, will "eventually become a financial partner in start-up companies." As long as there is a balance of activity that is largely basic research in nature, and a balance of sources for funding academic research from both public and private coffers, than the academy can be preserved. Defining this balance of activity, and hence keeping at bay a dominating subservience to the commercial world, will continue to be a challenge – despite its contemporary relegation as an issue of seemingly marginal importance.[47]

<u>The Sputnik Legacy and a New Era</u>

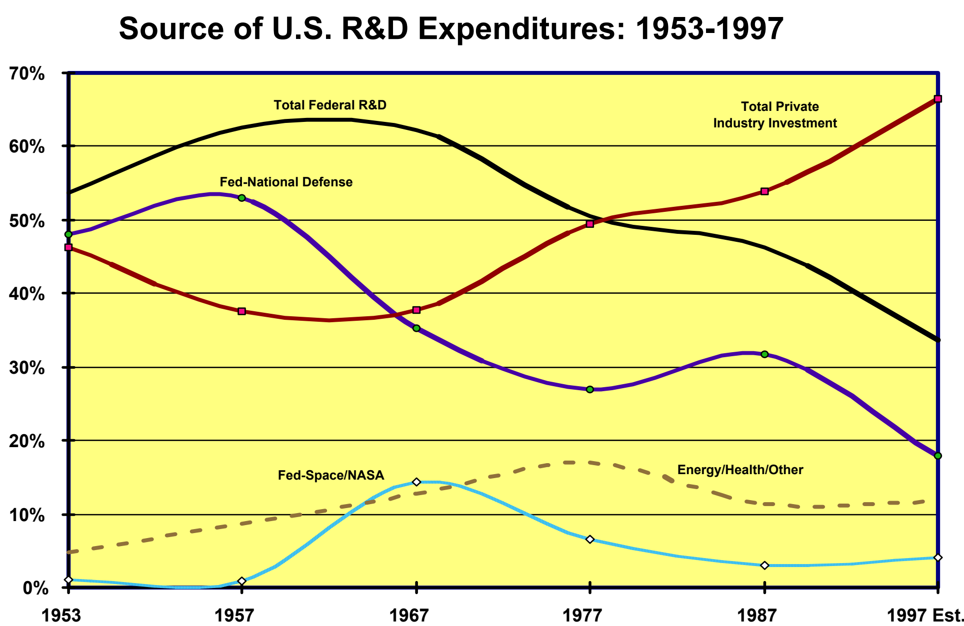
Sputnik provided the political currency for the federal government to inject money into the nation's education system, and to take on the burden of funding the nation's lagging applied and basic research effort. The race for technological superiority, essentially, made any other model obsolete.

Forty years later, a cadre of economists project that perhaps 50 percent of America's post-World War II economic growth is directly or indirectly related to private and federal R&D investment. A 1995 report of the Council of Economic Advisors to the president linked increasing productivity of America's workforce to future economic growth, and then stating that "Investments in research and development are the key to increasing productivity. The social rates of return, noted that report, "exceed the high private rates of return, of 20 and 30 percent, by a considerable amount because of 'spillovers' – benefits that accrue as other researchers make use of new findings, often in applications far beyond what the original researchers imagined."[48] Reflecting on some twenty-five years of studies, many through the NSF, Richard Atkinson, now the president at the University of California, notes that there is now real evidence that as investments in university research increase, a corresponding increase in private-sector investment results – but often with a time lag of five to fifteen years.[49]

The percentage of return is debatable, particularly since so much of the nation's R&D effort has gone toward military hardware with only indirect benefits to the economy and new industries. The bridge between new scientific discoveries to the actual reiterative process of design, and then commercial production and, finally, economic growth is also a topic of significant debate among economists: for example, the role of commercial development, argue scholars such as Terence Kealey, is the most important part of the story, not basic science.[50] Yet it is clear that there is a strong relationship between R&D investment, including the funding of basic research, and economic growth – a relationship that will only get stronger.

The Sputnik legacy remains, but the world has changed. The post-Cold War era has brought with it an overall decline in federal support for both higher education and the nation's R&D effort. At the same time, and as noted previously, the private sector has significantly expanded its R&D investment, essentially replacing declining federal dollars. As shown in Figure 7, in 1977 the private sector become the primary investor in R&D for the first time since the early 1950s. Continuing this shift, it is now the private sector that funds approximately 70 percent of all R&D activity in the U.S. It is exactly those industries that have benefited most from government funded basic research – high tech businesses focused on, for example, computers, communications, biotechnology and pharmaceuticals, even aeronautics – that are investing their own dollars on research. Biotechnology and digital communication industries owe their very existence to university based research and the scientists produced in the academy. In a sense, the federal government primed the pump, helping to create new market opportunities for the private sector, and now encouraging the evolution of university and business partnerships.

Figure 7



Yet is America investing enough in R&D? Between World War II and 1957, America's investment in R&D as a percentage of GDP averaged about 1 percent. In the post-Sputnik era it averaged about 2.6 percent. Total investment in R&D as a percentage of GDP, however, is now nearly a quarter less than the peak in the mid-1960s. While other industrial nations are increasing investment in R&D as a percentage of GDP, in the U.S. it may decline. In the post-Cold War era, it would be folly for the United States not to pursue some level of increased investment in R&D, and perhaps most importantly, in basic research.

At the same time, America's investment in basic research is stagnant, with growth at or barely above the rate of inflation.[51] As a percentage of GDP, R&D investment may actually decline in the next several years unless there is a marked and long-term change in public and private funding patterns – not simply a one-year boost. Despite the increase in privately funded R&D, most of the investment is in applied areas, with only a small percentage funneled to basic research. The vast majority of America's basic research activity, including the training of the nation's scientists and engineers, is still dependent on federal funding and carried out by the nation's research universities – confirming Bush's earlier contention that the private sector might never adequately fund or conduct basic research. The linear model outlined by Bush of public sector basic research and private sector applied and development research is frayed and perhaps metamorphosizing, but remains valid.

The path of new knowledge and the seeds for technological innovation still flow largely from the academy to industry, not the other way around – although collaborative modes between public and private sectors are expanding and new structures for promoting scientific research are developing. Most of the businesses engaged in both applied and basic research are still dependent on the findings and trained personnel that come from the academy. Indeed, many of the new high tech companies are closely linked with research universities, often started by academics, and purposely located at the perimeter of university campuses.

With nearly two-thirds of all new patents in the United States based on public sector basic research, the pace and mechanisms for encouraging the transfer of new knowledge from the academy to the private sector is growing in importance.[52] For the immediate future, the health and growth of a significant portion of the American economy relates directly to the activity level in basic research, and in turn the financial support of research in universities – what remains America's market advantage for technological innovation. Federal belt tightening intended to balance the budget, however, and the rising cost of hard science research present serious problems for universities in sustaining their research mission – reduction in funds and rising costs that private-public consortiums and patent income can not, thus far, compensate for. In mega-states such as California, where a quarter of all federal R&D funds flow to industry and universities, the potential impact on the academy and high tech businesses could be significant.[53]

While the modes, mix and quality of research is extremely important, one might conjecture that overall R&D investment in the United States will need to increase by a full 1 percent of GDP over the next decade, up from the current rate of 2.4 percent to approximately 3.5 percent. This would be an increase of about one third over current investment, and is simply an extrapolation of previous investment trends. More of the R&D pie should also go to basic research, both in public and private sectors of the economy. If past history is any indicator, society and our economy will become more technologically bound, not less. New industries will rely even more on R&D, not less. The development of new modes of collaborative research will increasingly disregard national borders, and the globalization of the economy provides new perameters for developing national research policy. There may also be declining rates of research productivity and technological innovation as the level of R&D investment rises. However, some sizable increase in R&D is inevitable. The question is when and how.

Sputnik the political event made it relatively easy: a sense of urgency jolted Washington and the public into action. The results have been dramatic. The new era is less sanguine, less directed and, ultimately, more complacent. The pattern of investment today, however, may have an even larger impact on the quality of life, the environment, and the economy of tomorrow. While the federal government no longer plays the dominant role in applied R&D, there is a great need for a general discussion of the future pattern of investment, and the appropriate role of the private and federal sectors – in applied and basic research. Science and technology are no panacea. Yet it is clear that the jobs and prosperity of the next century will depend in no small part on today's level of investment in R&D.

FOOTNOTES

[1] Daniel Yankelovich, "Science and the Public Process," *Issues in Science and Technology*, 1:1 (Fall 1984) pp. 6-12.

[2] Thomas N. Bonner, "Sputniks and the Educational Crisis in America," *Journal of Higher Education*, 29:4 (April 1958) pp. 177-84.

[3] *Ibid.*

[4] Vannevar Bush, *Science: The Endless Frontier* (Office of Scientific Research and Development, Washington D.C., 1945); see also Pascal G. Zachary, *Vannevar Bush: Engineer of the American Century* (New York: Free Press, 1997).

[5] See Roger Geiger, *Research and Relevant Knowledge: American Research Universities since World War II* (New York: Oxford University Press, 1993).

[6] Seymour E. Harris, *Higher Education: Resources and Finance* (New York: McGraw-Hill Book Company, Inc., 1962) 316.
[7] June O'Neal, *Resource Use in Higher Education* (Berkeley: Carnegie Commission on Higher Education) p. 22.
[8] See Roger Geiger, *To Advance Knowledge: The Growth of American Research Universities, 1900-1940* (New York: Oxford University Press, 1986).
[9] "Around the World in 96 Minutes -- What Does It Really Mean?" *U.S. News and World Report*, 43:16 (October 18, 1957).
[10] Quoted in Barbara Barksdale Clowse, *Brainpower for the Cold War* (Westport, Conn.: Greenwood Press, 1981) 9.
[11] "A Time for Greatness," *Journal of Higher Education*, 29:2 (February 1958) p. 105.
[12] H. E. Salisbury, "The Soviet Educational System," *Journal of Higher Education* 29:8 (November 1958) pp. 462-64.
[13] Nicholas DeWitt, *Soviet Professional Manpower* (Washington, D.C.: U.S. Government Printing Office, 1955) pp. 3-4; DeWitt's study was made before Sputnik but was highly influential. The dearth of other studies and reports included such books as George S. Counts, *The Challenge of Soviet Education* (New York: McGraw-Hill Book Company, Inc., 1957); Division of International Education, U.S. Department of Health, Education, and Welfare, *Education in the USSR* (Washington, D.C.: U.S. Government Printing Office, 1957); Alexander G. Korol *Soviet Education for Science and Technology* (New York: Technology Press of MIT and John Wiley and Sons, Inc., 1957).
[14] Bonner, "Sputniks and the Educational Crisis in America," pp. 177-84.
[15] Clarence B. Hilsberry, "Sputnik and the Universities," *Journal of Higher Education* 29:7 (October 1958) pp. 375-80.
[16] Committee on Relationships of Higher Education to the Federal Government, "A Proposed Program of Federal Action to Strengthen Higher Education in the Service of the Nation," *Higher Education and National Affairs*, 11:3 (January 1958) pp. 1-2; see also David D. Henry, *Challenges Past, Challenges Present* (San Francisco: Jossey-Bass Publishers, 1975), pp. 118-122, for a description of the concerns of university presidents regarding the growing federal role in higher education prior to Sputnik.
[17] Alex Bedrosian and Bruce Jackson, "Intellectual Conformity: Not the Answer," *Journal of Higher Education*, 29:7 (October 1958) pp. 381-85.
[18] Martha W. Griffith, "As I See it From Here," Proceedings of the Seventy-First Annual Convention of the American Association of Land-Grant Colleges and Universities, November, 1955; E.W. Kelley, *Policy and Politics in the United States: The Limits of Localism* (Philadelphia: Temple University Press, 1987) discusses the shift in federal policy toward education, and its impact regarding increased appropriations.
[19] As Percival M. Symonds, "The Organization of Educational Research in the United States," *Harvard Educational Review*, 27 (Summer 1957) pp. 159-167 noted: "One outstanding characteristic of education in this country, presumably, is that it lacks organization, or at least, that whatever organization it has is determined at the local level and is not imposed from above by the central government."
[20] National Defense Education Act, passed September 3, 1958. James Conant and Eliot Richardson helped to craft the bill which was carried in congress by Democrats Carl Elliot and Senator Lister Hill, and gained the votes of twenty-four Republicans who had previously voted against similar legislation.
[21] Philip H. Coombs, "Some Issues Raised by Recent Legislation," in Seymour E. Harris (ed.), *Higher Education in the United States: The Economic Problems* (Cambridge, Mass.: Harvard University Press, 1960) p.83-87.
[22] James Webb, *Space Age Management: The Large Scale Approach* (New York, 1969) 117.
[23] Roger D. Launius, *NASA: A History of the U.S. Civil Space* Program (Malabar, Florida: Krieger Publishing Company, 1994) 65.
[24] Walter A. McDougall, *The Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, Inc., 1985) 385.
[25] Cited in McDougall, *The Heavens and the Earth*, 385.
[26] President's Science Advisory Committee, *Scientific Progress, the Universities, and the Federal Government*, (Washington, DC: US Government Printing Office, 1960) p. 10-11.
[27] *Ibid.*
[28] Crawford H. Greenewalt, "Basic Research: A Technological Savings Account," in Dael Wolfle (ed.) *Symposium on Basic* Research (Washington, D.C.: American Association for the Advancement of Science, 1959) 130.
[29] W.G. Simeral, "The Evolution of Research and Development Policy in a Corporation: A Case Study," in Langfit et. al. (ed.), *Partners in the Research Enterprise: University Corporate Relations in Science and Technology* (University of Pennsylvania Press, 1983).
[30] "The Nationalization of U.S. Science," *Fortune* (September 1976) 158.
[31] Budget of the United States, Fiscal 1965.
[32] Harris, *Higher Education: Resources and Finance*, 649.
[33] California Legislature, "Report of the Senate Fact Finding Commission on Education, 1961, CSA."
[34] Clark Kerr, *The Uses of the University* (Cambridge, MA: Harvard University Press, 1964) p. 49.
[35] Ross L. Mooney, "The Problem of Leadership in the University," *Harvard Education Review*, 33:1 (Winter 1963) pp. 42-57.
[36] Richard J. Barber, *The Politics of Research* (Washington, D.C.: Public Affairs Press, 1966) 60.
[37] See McDougall, *The Heavens and the Earth*, 332.
[38]Quoted in *New York Times*, January 18, 1961.
[39] Barber, *The Politics of Research,* v.

[40] "Government-University-Industry Research Roundtable: Industrial Perspectives on Innovation and Interactions with Universities," National Academy of Sciences, 1991.

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