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CHAPTER 1

Academic Science as an Economic Engine

On 4 October 1961, the president of the University of Illinois received a letter from Illinois governor Otto Kerner. In the letter, Governor Kerner asked the flagship institution to study the impact of universities on economic growth, with an eye toward "insur[ing] that Illinois secures a favorable percentage of the highly desirable growth industries that will lead the economy of the future."[1]

In response, the university convened a committee that met for the next eighteen months to discuss the subject. But despite the university's top-ten departments in industrially relevant fields like chemistry, physics, and various kinds of engineering, the committee was somewhat baffled by its mission.[2] How, it asked, could the university contribute to economic growth? Illinois faculty could act as consultants to companies, as they had done for decades. The university could provide additional training for industrial scientists and engineers. Scholars could undertake research on the economy. But, the committee's final report insisted, "certain basic factors are far more important in attracting industry and in plant location decisions, and therefore in stimulating regional economic growth, than the advantages offered by universities."[3] In 1963, the University of Illinois—like almost every university in the United States—had no way of thinking systematically about its role in the economy.

In 1999, thirty-six years later, the university faced a similar request. The Illinois Board of Higher Education declared that its number-one goal was to "help Illinois business and industry sustain strong economic growth."[4] This time, though, the university knew how to respond. It quickly created a Vice President for Economic Development and Corporate Relations and a Board of Trustees Committee on Economic Development.[5] It titled its annual State of the University report "The University of Illinois: Engine of Economic Development."[6] It expanded its program for patenting and licensing faculty inventions, launched IllinoisVENTURES to provide services to startup companies based on university technologies, and substantially enlarged its research parks in Chicago and Urbana-Champaign.[7] It planned to pour tens of millions of dollars into a Post-Genomics Institute and tens more into the National Center for Supercomputing Applications.[8]

What changed during this period that caused the university to react so differently to similar situations? That question is the puzzle driving this book. It has become common knowledge, at least on university campuses, that academic science is much more closely linked with the market today than it was a

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few decades ago. In the United States, a university research dollar is now twice as likely to come from industry as it was in the early 1970s, and industry funding has increased ninefold in real terms since then.[9] The patenting of university inventions, a practice that was once rare and sometimes banned, has become routine. About 3,000 U.S. patents are issued to universities each year—eight times the number in 1980 and more than thirty times that in the 1960s—and universities now bring in more than $2 billion in licensing revenue annually.[10] In some fields, it has become common for faculty to also be entrepreneurs; in others, it is a lack of consulting ties that is now looked on askance.[11] Universities once self-consciously held themselves apart from the economic world. How and why did they begin to integrate themselves into it?

This book attempts to answer these questions. The conventional wisdom about why universities become more involved in the marketplace emphasizes two factors. First, the move is seen as the predictable result of universities' ongoing search for new resources. After two decades of rapid growth in government funding for academic science, budgets stopped increasing in the late 1960s and stagnated through most of the 1970s.[12] When this happened, universities, which had grown accustomed to constant expansion, turned to the market as a way of acquiring additional resources. A second argument focuses on the role of industry in pulling universities toward the market. During the 1970s, many cash-strapped firms cut back on doing research—particularly basic research—themselves.[13] Industry, it is presumed, looked to universities to replace the basic research it was no longer conducting internally.

I argue that while there are elements of truth to these explanations, the main reason academic science moved toward the market was not a search for new resources or the changing needs of industry. Instead, I make two central claims about why universities' behavior changed. The first is that it was government that encouraged universities to treat academic science as an economically valuable product—though not by reducing resources so that universities were forced to try to make money off their research. The second is that the spread of a new idea, that scientific and technological innovation serve as engines of economic growth, was critical to this process, transforming first the policy arena and eventually universities' own understanding of their mission.

Despite the perception that universities were secluded ivory towers in the 1950s and 1960s, even this period saw regular experiments with practices that tied science to the marketplace, including the creation of research parks, industrial affiliates programs, and industrial extension offices. But in these decades, there were many barriers—financial, legal, and normative—to the spread of such activities. This situation persisted through the mid-1970s. In the late 1970s, however, policy decisions began to change universities' environment in ways that removed many of these barriers and in some cases replaced them with incentives. The result was the rapid growth of activities like patenting, entrepreneurship, and research collaboration with industry, which by the mid-1980s were becoming widespread in academic science.

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These government decisions were made because policymakers became enamored with the idea that technological innovation helps drive the economy. Though the idea itself was not new, historically it had had little political impact. But by the late 1970s, the conjunction of a growing body of economic research, the concerns of industry, and a favorable political situation led to its embrace. For years, the United States had faced an extended period of economic stagnation, including high unemployment, high inflation, low productivity growth, and an energy crisis. Policymakers, desperate for a way out, began arguing that this was, at least in part, an innovation problem, and that policies that explicitly connected science and technology with the economy could help close a growing "innovation gap" with countries like Japan. This led to a variety of policy decisions meant to strengthen innovation as a means of achieving economic goals. These decisions came from diverse locations and reflected a whole spectrum of political and economic philosophies. Many of them were not even aimed at universities. Collectively, however, they changed the environment of academic science in a way that stimulated and legitimized the spread of market-focused activities within it.

This policy-driven change in universities' resource and regulatory environment was critical in encouraging their turn toward the market. But the idea behind the decisions mattered, too, as universities, perceiving the political success of arguments about the economic impact of innovation, began to seize upon this new way of thinking about science. Universities had always been more open to taking an active economic role than the ivory-tower stereotype would imply. But, as the University of Illinois example suggests, before the 1970s universities had a different *way* of thinking about their impact on the economic world. They saw universities as providing the fundamental science that firms would draw upon as needed to solve industrial problems and make technical advances. That is, universities saw academic science primarily as an economic *resource*.

By the early 1980s, though, universities were starting to follow policymakers' lead in seeing science as more than just a resource. Increasingly, universities also saw science as having the potential to actively drive economic growth by serving as a fount of innovation that could launch new industries or transform old ones beyond recognition. Science, universities came to believe, could actually serve as an economic *engine*.

The shift from a "science-as-resource" to "science-as-engine" model had a major impact on the university. It changed the calculus through which universities made decisions about what kinds of activities were appropriate to pursue. It gave universities a new mission: to facilitate economic growth by making sure their research reached the marketplace. It encouraged universities to move away from a passive role in which they simply created the knowledge that industry would draw on—or not—as needed. Instead, they would start working actively to turn scientific innovation into economic activity through technology transfer, faculty entrepreneurship, spinoff firms, and research partnerships with industry. The assimilation of new ideas about the impact of innovation on

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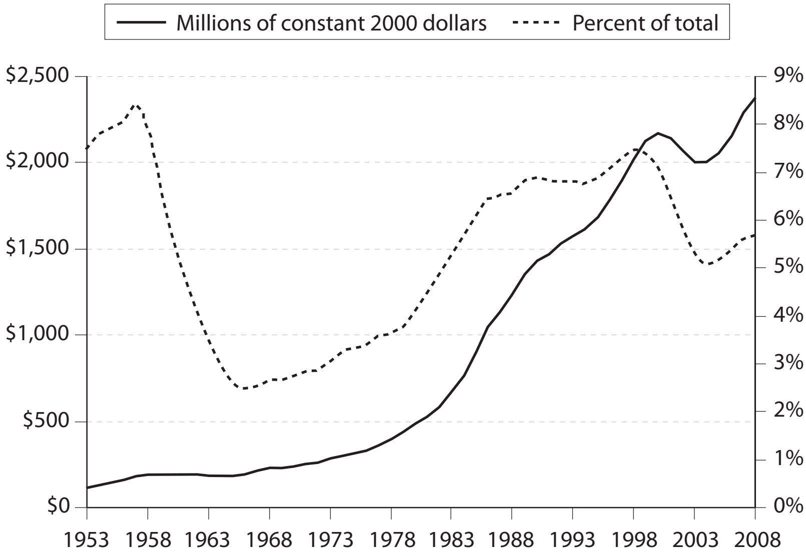

Figure 1.1. University R&D spending provided by industry, 1953–2008 (in millions of constant 2000 dollars and as a percentage of total spending). Adapted from NSB (2010:appendix table 4–3).

the economy led logically enough to other new ideas about what the relationship between academic science and the commercial world should be, and the changed environment policymakers had created made such ideas easier to put into practice. By the time the University of Illinois was asked again how it could help the state's economic growth, it had both a new way of thinking about the question and the surroundings that made it possible to turn those thoughts into action.

The Changing Nature of Academic Science

No single indicator can capture all the ways the relationship between academic science and the market has changed over the decades. But one number at least captures some part of these changes, and helps to highlight when they were taking place: the proportion of academic research and development (R&D) funded by industry, which has risen and fallen over time. Always a small fraction of the total, this number nevertheless tripled between its historical low in 1966 and its 1999 peak (see figure 1.1). (Since then it has declined significantly, a trend returned to in chapter 8.) The total amount of industry funding increased even more dramatically during that period, by an order of magnitude in real terms.

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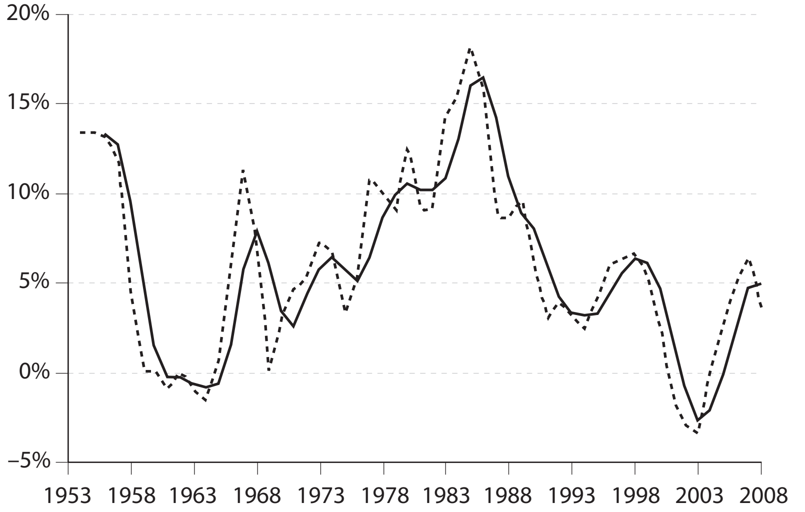

Figure 1.2. University R&D spending provided by industry, percent real change from previous year, 1954–2008. (Dashed line represents annual data; heavy line is three-year moving average.) Adapted from NSB (2010:appendix table 4-3).

The pace of this change shows when the move toward the market was at its fastest. Industry funding plummeted as a *percentage* of total academic R&D spending in the 1950s and early 1960s as the result of a sevenfold increase (in real terms) in federal funding, even though industry support for university research actually rose during this period.[14] But the fraction of funding coming from industry started to increase steadily again during the late 1960s as federal support leveled off. Starting around 1977, increases in industry funding accelerated, and real growth averaged more than 12% a year for the following decade. Between 1985 and 1986, industry funding grew by 18% in inflation-adjusted dollars, the largest jump on record; after that, funding continued to climb but at sharply decelerating rates (see figure 1.2).[15]

Other, more qualitative measures capture some of the flavor of this shift. For example, university attitudes toward patenting evolved dramatically during this time period. Traditionally, universities rarely patented faculty inventions. Most universities felt that since faculty were already being paid to do research, they didn't need additional incentives to invent. And patenting was widely seen as incompatible with the scientific ideals of open communication, disinterestedness, and service of the public good. When Jonas Salk, bacteriology professor at the University of Pittsburgh, invented the vaccine for polio, Edward R. Murrow asked him who owned the patent. Salk replied, famously, "Well, the people, I would say. There is no patent. Could you patent the sun?"[16]

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The idea that patents were at odds with the nature of science as well as the public interest can be found in many university patent policies of the 1950s and 1960s.[17] By no means were all universities categorically opposed to patenting. But many emphasized the university's aversion to financially benefiting from faculty research, and limited patenting to cases in which it was necessary to prevent a private party from appropriating an invention.[18] Johns Hopkins' policy summed up this attitude: "The ownership and administration of patents by the University is believed undesirable. . . . Consistent with its general policy, the University makes no claim to royalties growing out of University research."[19]

But over time, universities' perspective on patenting changed. Patenting and licensing are now almost universally encouraged, and seen as a key mechanism through which scientific advances reach the public. Today, more than 150 U.S. universities have technology transfer offices, or TTOs, employing some 2,000 people and filing well over 10,000 new patent applications a year.[20] A statement by the Council on Governmental Relations, an association of research universities, reflects this new understanding:

> The ability to retain title to and license their inventions has been a healthy incentive for universities. . . . It is important to recognize that without such incentives, many inventions may not get carried through the necessary steps and a commercial opportunity will be wasted. This wasting of ideas is a drain on the economy, irrespective of whether it was public or private funding which led to the initial invention.[21]

As the Association of University Technology Managers emphasizes, "These activities can be pursued without disrupting the core values of publication and sharing of information, research results, materials, and know-how."[22]

This change in belief may have aligned with what universities saw as their financial self-interest, but that makes it no less sincere. It goes hand in hand with the idea of science as an economic engine, a source of innovation that can create new products, firms, or even industries. From this point of view, the market is the best way of getting university breakthroughs into the hands of the public, and patents create the incentive that makes this happen. As a university administrator interviewed by Leland Glenna and his colleagues stated, "The truth of the matter is that if things get created at the university and they never get pushed out into the industry sector and turned into a product, they really don't benefit the public good other than for the knowledge of their having existed."[23]

As the university itself has come to focus on the commercial impact of science, so have individual scientists. In the 1950s, academic scientists were supposed to be indifferent to worldly goods. As Steven Shapin has pointed out, in 1953 a letter-writer to *Science* was able to argue that the American scientist

> is not properly concerned with hours of work, wages, fame or fortune. For him an adequate salary is one that provides decent living without frills or

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> furbelows. No true scientist wants more, for possessions distract him from doing his beloved work. He is content with an Austin instead of a Packard; with a table model TV set instead of a console; with factory- rather than tailor-made suits, with dollar rather than hand-painted neckties, etc., etc. To boil it down, he is primarily interested in what he can do for science, not in what science can do for him.[24]

While it seems certain that such asceticism was never completely the norm, the fact that such a claim could even be seriously made suggests that a change in ideals has taken place. Ever since Genentech's 1980 initial public offering (IPO) made University of California, San Francisco (UCSF) biochemist Herbert Boyer worth $65 million overnight, the possibility of owning the Packard—or a garage full of them—has not been lost on ambitious scientists.[25] Academic scientists still hold a range of attitudes toward the appropriate role of commercial activity in the university. But a large number join the belief that science has value because it expands human knowledge with the belief that the market is key to maximizing the impact of that knowledge—and that financial rewards are completely appropriate for those who facilitate that process.[26] As one entrepreneurial academic has said, "If there is some gold in the hills, and you happen to get a chunk, well, there is no point in leaving it in the ground if somebody is going to pay you for it."[27]

All these changes have been a part of a gradual shift in values and beliefs, not a wholesale transformation. But they have led to tensions within the university about its proper role in society and where, or if, a boundary between university and industry should be drawn. Critics of this move toward the market see it as posing a threat to science in service of goals that should be secondary, at least for universities, to the pursuit of knowledge. One prominent biochemist expressed concern about "almost a get-rich-quick attitude that is contrary to everything that science and the university stand for, which is knowledge for its own sake, not knowledge that is lucrative."[28] Others worry that these developments distort research agendas, create problematic conflicts of interest, and encourage a secrecy that is detrimental to the progress of science.[29]

Proponents, on the other hand, emphasize the benefits of these changes, pointing to the role of the market in getting science into broader use, the contribution of university inventions to economic development, and the importance of rewarding scientists whose work has a real-world impact.[30] As one academic-turned-entrepreneur said of scientists who criticize patenting, "They don't understand what it takes. They get their money from public funds. They owe it to the public or to the government or to wherever they get their money from, to try to capitalize on that investment as well as they can."[31] From this perspective, the positive effects of this shift far outweigh any new problems it might create.[32]

While universities themselves have moved decisively toward the market, debate between these points of view persists. A few years ago, Berkeley found it-

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self under fire for accepting a $500 million grant from energy firm BP to pursue research on biofuels and other alternative energy sources.[33] Many saw the deal as win-win, leveraging public and private resources to launch a major research effort in a vitally important field.[34] But it was also criticized precisely *because* the research was so socially relevant: critical new technologies developed with public resources might be controlled by a private firm, and research might focus on areas most likely to be commercially viable, not necessarily those with the largest potential impact on climate change.

The nature of such debates has changed remarkably little over time. In 1974, Harvard and chemical firm Monsanto formed a large-scale university-industry research partnership—a then-unheard-of $23 million collaboration to study a substance thought to regulate tumor development. Headlines about the Harvard-Monsanto deal emphasized the project's potential to fight cancer. But concerns came up as well. "Would it undermine peer review? Would it lock the university into business deals it ultimately might not like? If one such arrangement is acceptable, would many subtly work against academic freedom in ways no public interest committee could fully guard against?"[35] These issues have been raised many times since then, and the very same questions continue to be asked today.

Studying the Changes in Academic Science

The purpose of this book, however, is not to resolve such debates, but to explain *why* these changes took place. I do that by comparing the historical development of three different practices closely associated with this shift: faculty entrepreneurship in the biosciences, the patenting of university inventions, and the creation of university-industry research centers (UIRCs). Each of these activities is frequently referred to in discussions of how academic science has changed, and based on their scale and divergence from past practice, they are among the most significant reflections of this trend.[36] But in order to explain why I chose this particular approach and how I came to my conclusions, I will first take a step back and briefly introduce a concept that grounds the larger argument.

The changes in academic science can be seen as one instance of a more general pattern. In the last thirty years, the logic of the marketplace—of property rights and free exchange as the best way to maximize both the individual and collective good—has expanded in a number of fields where it once played a minor role. Domains as diverse as healthcare, the military, water systems, highways and ports, and K–12 education have all been reorganized to some extent around market ideals.

Scholars who study organizations have developed a concept that is useful for thinking about these moves toward the market: that of the *institutional logic*.

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An institutional logic is a set of organizing principles for a major social order, such as the market, the state, the family, religion, or science.[37] These principles explain the purpose of social action and serve as a basis for making decisions about how to behave. Different institutional logics frequently conflict with one another. The institutional logic of the family, for example, emphasizes community, loyalty, and support for its members. It would prescribe actions in the interest of the family as a whole, even if they come at a personal cost. The logic of religion, by contrast, suggests action in accordance with a transcendental set of principles. The biblical story of Abraham's anguish over God's demand that he sacrifice his son, Isaac, can be seen as a case of intense conflict between these two logics.

More mundanely, the new practices in academic science that I examine are consistent with the logic of the market, or capitalism. This logic views science as a useful tool for affecting the world. Its success is ultimately measured by whether its results have value in the marketplace, a metric that is the norm in the world of business. But in the field of academic science, another institutional logic has also traditionally been strong: the logic of science.[38] This other logic sees the search for truth as having intrinsic value. Science is fundamentally the pursuit of knowledge, in which practical results are an agreeable but secondary benefit. The ivory-tower stereotype, in which isolated scholars pursue their intellectual agendas without regard to "real-world" relevance, is compatible with this logic.

The story of academic science over the past several decades, then, can be recast as one in which market logic has gained strength relative to the logic of science. Of course these two logics are not the only grounds upon which scientists can act. Science has also been driven by the desire to achieve other goals, like improving human health or contributing to the nation's defense, that do not map neatly onto these two logics. But even these other goals have often been seen through the lens of science or market logic. While scientists once argued that the best way to achieve medical breakthroughs was by following the internal logic of science, they now emphasize the role of the market in getting medical breakthroughs into use. As a shorthand for talking about what has changed, the idea of a shift from science logic to market logic captures a lot.

But how does an institutional logic gain strength in a particular field? Here, organization theory gives us fewer tools to work with.[39] On the one hand, a particular logic may become stronger across a field as a whole. The new logic starts to seem more appropriate and legitimate to people within the field, it more frequently occurs to those people to deploy it, and action based on it becomes more likely to succeed. Some of the changes in academic science have been of this relatively diffuse nature, as people within universities have developed a greater familiarity and comfort with the idea that science's value is realized through the marketplace.

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These diffuse changes, however, are difficult to pinpoint and thus to explain. I suggest that in addition to such distributed change, the strength of a new logic also becomes visible because it grounds particular practices that become widespread. In academic science, while there has certainly been a shift in the typical attitude toward the economic role of science, a lot of what has changed is that specific practices grounded in market logic have become more common. The practices I examine here, biotech entrepreneurship, university patenting, and university-industry research centers, each reflect the idea that science matters, and has an impact, because people are willing to pay for its results.

Examining the emergence of specific market-logic practices has two advantages. One is that it provides a focal point that is not available when looking at changes in academic science as a whole. The other, and more important, advantage is that it provides comparative leverage. The trajectories of the three practices I look at are very different. The practices emerged from a variety of disciplines and were initiated by a variety of actors. If they all developed in response to reduced resources, or were all the outcome of industry efforts, or if upper-level administrators championed each one, that should tell us something about why market logic gained strength in the field as a whole.

This approach has limitations, too, of course. It does not examine every market-logic practice that has emerged in academic science. Other practices may have had different causes. It assumes that an explanation of why these particular practices spread tells us something about why market logic gained strength across academic science as a whole, even in other parts of the field. And in its effort to explain the emergence of these specific practices, it cannot account for the possibility that similar factors may have been present and yet not led to the spread of market-logic practices in other parts of academic science. Nevertheless, if these limitations are kept in mind, I believe this research strategy can contribute to our understanding of how academic science moved toward the market.

The initial phase of research, then, involved developing histories of these three practices. To do this, I drew on a variety of sources, ranging from archival records and Congressional hearings, to oral histories and interviews, to contemporary media accounts and published statistics. In each case, I tried to identify reasons each practice spread, looking for evidence along the way that would support or disconfirm any emerging explanations, and to evaluate the relative importance of these reasons. While I tried to remain open to a variety of possible causes, I paid particular attention to the roles of the university itself (including those played by both faculty and administrators), of government, and of industry in encouraging the spread of these practices.

This led to a deeper understanding of each practice, but not to any easy answers about why universities moved toward the market. The practices had very different origins and reasons for their spread, to the extent that their differences initially seemed to outweigh their similarities.

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Two commonalities, however, stood out. First, government, more than universities or industry, played an important role in promoting the growth of each practice. While all three practices were initiated in universities prior to and independent of government action, each encountered a variety of barriers that limited its spread until specific policy decisions had been made. Second, all but one of these critical policy decisions were made within a relatively narrow time window in the late 1970s and early 1980s.

The problem, though, was that while government action seemed to be key, the actual policy decisions that contributed to the practices' growth initially appeared to have little in common. The decisions had different supporters with different political philosophies and a variety of goals. A number of them were not even targeted at universities. So simply attributing the shift to government action was not, by itself, a very satisfying answer.

But the temporal overlap of these policy decisions suggested that they might have something in common despite their superficial dissimilarity. This observation led to a second round of research focused specifically on the politics behind ten significant policy decisions. Here, a pattern quickly jumped out. While the important decisions were not initiated by the same groups or for the same reasons, in every case but one new arguments about the economic impact of scientific and technological innovation were very visible as they were being made. During the late 1970s, in the context of a stagnating economy and growing pessimism about the nation's future, arguments that innovation was key to economic growth and that government needed to strengthen innovation became newly popular among policymakers. These arguments gave a political boost to policy proposals that could be framed as improving innovation, whether that was the proposals' original intent or not.

In six of the ten policy decisions I examined, the deployment of such arguments seemed crucial to the decision's being made. In one, these arguments played a role but were probably not decisive, and in two more innovation arguments were visible, but I did not find enough evidence to draw conclusions about how important their role was. The final decision took place before the innovation frame became prominent, and innovation arguments were not visible in that decision. The fact that in nine of ten cases innovation arguments were very visible, and that in six of those they appeared to be critical, suggested that claims about the economic impact of innovation, newly salient in the political sphere, significantly reshaped the environment surrounding academic science.

At this point, then, I had a working argument about why market logic had gained strength in academic science. Universities had already been experimenting with market-logic practices, but until the late 1970s those experiments remained limited in scope because the cultural, resource, and regulatory environment was unfavorable to them. In the late 1970s and early 1980s, however, policy decisions—driven by the idea that innovation spurs economic growth—changed that environment in ways that removed regulatory barriers

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to such practices and provided new resources for them. In this new environment, market-logic practices grew and spread, and market logic became stronger throughout the field.

A final comparative strategy helped test this argument. Here, the insights of institutional theory were again useful. Friedland and Alford emphasized that the major institutional logics—market, family, state, religion, science, and so on—are available for individuals to use and elaborate across various fields, even though some fields may be dominated by one particular logic.[40] So the idea that people in universities were experimenting with market logic even before it became common is compatible with their conception.

If this is the case, one should expect to find experiments with market logic in the 1950s and 1960s, during the peak years of science logic, as well as in the 1970s, just before the shift began. If the changed policy environment of the late 1970s was critical to the takeoff of contemporaneous market-logic experiments, one would make two predictions about earlier market-logic experiments. First, one should see earlier experiments running into barriers similar to those initially encountered by the practices of the 1970s. Second, one should be able to argue plausibly that earlier experiments also could have grown and spread, had they encountered a policy environment similar to that of the late 1970s.

This turned out to be the case. Three experiments with market logic were initiated during the 1950s and 1960s and experienced some modest success but did not become widespread at the time: industrial affiliates programs, industrial extension offices, and research parks. A look at their development suggested that they ran into barriers quite similar to those initially encountered by the 1970s practices. Furthermore, in each case it seemed plausible that a policy environment focused on encouraging innovation for economic reasons could have led to policies that would have encouraged them. In fact, research parks actually did eventually take off in the 1980s with the intervention of government, after enduring a bust during the 1970s. This last round of comparison reinforced the core argument, which I will now present as a chronological narrative.

Explaining the Rise of Market Logic in Academic Science

The central question this book is trying to answer is why, over a period of several decades, market logic became more influential in academic science. Empirically, I argue that market logic gained strength for two reasons. First, government policies encouraged the growth of small-scale market-logic activities. Second, the reason those government policies changed was because policymakers embraced a new idea: that scientific and technological innovation drive the economy.

Theoretically, I propose a new way of thinking about how an institutional logic can gain influence in a particular field. Individual actors in a field are con-

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tinually experimenting with innovative activities, most—but not all—of which will draw on the field's dominant logic. Some of these experiments will eventually spread and become institutionalized. But for such practices to thrive and grow, they must be reproducible. That is, those carrying them out must be able to secure whatever resources they need to continue to enact them.

Most of the time, local innovations based on the dominant logic will find it easier to acquire the resources needed to perpetuate themselves than will practices based on other institutional logics. A restaurant based on family loyalty rather than commitment to the bottom line will on average be outcompeted by restaurants focused primarily on profit. But sometimes the broader environment may change in ways that start to favor innovations based on an alternative logic. As these alternative-logic practices themselves start to spread and become institutionalized, the alternative logic gains strength in the field as a whole.

This is what happened in academic science. Multiple logics have always been at play in academic science. But in the decades following World War II, the logic of science—that scientific knowledge should be pursued for its own sake, and that scientists should be free to direct that pursuit—was especially strong. During that period, some people did experiment with practices grounded in market logic—that is, that saw science in terms of its economic value—initiating activities like research parks, industrial affiliates programs, and industrial extension offices. But while such activities spread to a modest extent, they also encountered barriers that limited their growth. In particular, a university-industry culture gap made them difficult to sustain, and they had trouble securing the financial resources they needed to reproduce themselves more broadly.

In the late 1970s, a shift began in the policy realm that changed the environment of academic science in ways that encouraged the growth of market-logic practices. That shift took place because policymakers seized upon a new theory. Economists had explored the idea that technological innovation was a crucial source of economic growth for several decades. But until the 1970s, few policymakers focused on the economic impact of science and technology. As the stagflation of the 1970s dragged on, however, policymakers were looking for new solutions to the nation's economic problems, and by about 1977 they were reaching consensus that encouraging innovation was one such solution. For the next few years, this "innovation economy" frame was particularly strong, and policies that could be argued to strengthen innovation received a political boost.

The result was a variety of policy decisions made claiming to help innovation. Some were new policies created specifically to pursue that goal. Others had long been on the agenda, but were now reframed in innovation terms. The policies were diverse, and represented a range of economic philosophies. Some were free-market-oriented, while others aligned with industrial policy. They were promoted by a variety of individuals and groups with very different inter-

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ests, and did not reflect a coherent political project. Collectively, however, they would change the environment of academic science in ways that had long-term consequences.

In universities, the 1970s saw several new experiments with market-logic activities, including faculty entrepreneurship in the biosciences, increased patenting efforts, and the creation of university-industry research centers. In many ways, these experiments were no different from the market-logic experiments of the 1950s and 1960s, which had such limited success. In fact, these new experiments ran into very similar difficulties to those the older ones had, and as late as 1977 it seemed unlikely that any of them was on the verge of takeoff. But the new political environment changed in ways that removed limits to the spread of these new practices and created new resources to sustain them. By the end of the decade, all were growing rapidly and were on their way to broader institutionalization.

The modern era of biotech entrepreneurship began in 1976 with the founding of Genentech by an academic and a venture capitalist. The invention of recombinant DNA (rDNA) technology in 1973 had opened new doors for the practical application of biology, and Genentech hoped to capitalize on it. In the next few years, a handful of other biotech firms were started. But there were significant drags on the spread of biotech entrepreneurship. In addition to disapproval within the academic community, there were fears about the hazards of rDNA, and the availability of venture capital was extremely low. Between 1977 and 1979, though, three policy decisions were made that changed that situation.

First, though Congressional regulation of rDNA research looked inevitable as late as August 1977, by the end of the year the tide had turned, and by the spring of 1978 legislation restricting rDNA was permanently off the table. Second, though a few other startups had been created on the Genentech model by 1978, the limited availability of venture capital made funding them a struggle. This was particularly critical since even optimists believed the startups were years away from having rDNA products to sell. In 1978, however, two policy decisions were set into motion that changed the venture capital situation dramatically. The Revenue Act of 1978 was signed into law in November, reducing the top tax rate on capital gains from 49% to 28%. And around the same time, the Department of Labor initiated a regulatory clarification that would allow pension funds, with their massive holdings, to invest some of their money in venture capital. These two actions helped set off a rush of venture capital investment and dramatically changed the resource environment for biotech startups. As a result, not only did more money become available for the handful of firms that had already been founded, but incentives to start new firms also increased dramatically. This was followed by a 1980 Supreme Court decision, *Diamond v. Chakrabarty*, that affirmed that microorganisms could be patented and reassured investors that it would be possible to realize profits on the products of

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biotechnology. By the early 1980s, over a hundred biotech startups, typically founded by academics and venture capitalists, had been established, and entrepreneurship was becoming common in the bioscience disciplines.

University patenting had taken place on a small scale for many decades. Federal patent policy, however, effectively limited the extent of university patenting, as many agencies restricted it or made it hard to do. But starting in the late 1960s, as the scale of research funding grew, the number of patents being issued to universities gradually began to increase. One important reason for this was that in the late 1960s the National Institutes of Health (NIH) began using institutional patent agreements (IPAs), which made it somewhat easier for universities to patent research supported by the agency. By the early 1970s, the National Science Foundation (NSF) was signing IPAs as well. But an abrupt reversal of this policy at NIH in 1977 suddenly halted the patenting of NIH-funded research and made it clear that the practice was on shaky legal foundations.

Three policy decisions made in the early 1980s changed the resource and regulatory environment in ways that encouraged the growth and spread of university patenting. The most important was the 1980 passage of the Bayh-Dole Act, which gave universities the clear right to patent all government-funded inventions and the obligation to encourage the commercialization of such research. The 1980 *Chakrabarty* decision also helped by expanding the scope of patentability in an area that was particularly significant to universities. And the 1982 creation of the Court of Appeals for the Federal Circuit, a specialized patent court that is widely attributed with having strengthened intellectual property rights in the United States, also played an important role by making patents more valuable to universities as well as other patent holders. The legitimation of university patenting provided by Bayh-Dole, in conjunction with this general fortification of the patent system, helped increase the frequency of university patenting.

University-industry research centers, modeled on the organizational research units that became widespread on campuses in the 1960s, were a new way of organizing ongoing university-industry partnerships. A few schools experimented with them in the 1970s, but they did not spread quickly, in part because they encountered familiar barriers: a university-industry culture gap, and trouble convincing industry that they were worth supporting at levels of ongoing sustainability.

Between about 1978 and 1984, however, federal and state policy decisions changed the environment for UIRCs as well, making them viable by subsidizing them heavily. In 1978, NSF initiated the Industry/University Cooperative Research Centers (I/UCRC) program, a modest effort to support UIRCs. Then in 1983, it established a related—but much larger—Engineering Research Centers (ERC) program that would provide further support. Collectively, NSF programs invested more than $100 million in UIRCs by the end of the 1980s.

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At the same time, individual states were also becoming interested in UIRCs. While states had played a major role in funding higher education, historically they had not focused their efforts on scientific research, and they certainly had not tried to leverage science for the purposes of economic development. Beginning around 1979, however, a handful of states began to do just that, and one of the most common forms their efforts took was support for UIRCs. In the early 1980s, such policies spread rapidly across state governments, and during that decade states invested hundreds of millions of dollars in such programs. Thus the spread of UIRCs was facilitated not by making university research more valuable and easier to sell on the market, as the changes in patent policy and in the venture capital environment did, but by actively subsidizing activities that focused on the economic value of science. The UIRC programs supported the spread of market-logic practices even though they were interventionist, not free-market, in nature.

The policy decisions that facilitated the growth of market-logic practices superficially had little in common. They were not promoted by a single group of people working to transform the innovation landscape in the United States. Instead, they resulted from a variety of political projects undertaken by a variety of political actors holding a variety of political and economic philosophies. But in almost every case, policymakers' level of concern with the economic impact of innovation was an important factor in the decision. The way that concern had its effects varied considerably. In some cases, like the passage of Bayh-Dole, policy entrepreneurs reframed a preexisting political effort in innovation terms. In others, the frame was used strategically to defend an agency's autonomy, as when NSF created its I/UCRC program so that Congress did not force it to start supporting industry research directly. In yet others, policy proposals were made politically unviable by being portrayed as stifling innovation, as happened during debates over the regulation of rDNA research. But in each case, the increased political salience of innovation as an economic issue gave a boost to a policy that aligned well with the goal of improving innovation.

Despite the diversity of these policies, and despite the fact that a number of them did not even target universities, collectively they had a consistent effect on academic science. They tended to encourage activities that treated science as an economic input, which effectively meant that they promoted the growth of market-logic practices. While this did not mean that all new efforts to capitalize on the economic value of science would succeed, it did allow a variety of market-logic activities to grow, spread, and begin to institutionalize throughout universities by the mid-1980s.

The practices of biotech entrepreneurship, university patenting, and university-industry research centers did not originate with university leaders, but with faculty and mid-level administrators. But as these activities became visibly successful, others within the university, including upper-level administrators, also became more oriented toward realizing the economic value of

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science. New experiments with market logic were initiated, like a wave of large-scale biotech research partnerships announced in the early 1980s, and older activities that had not been on a growth trajectory, like research parks, suddenly took off. And increasingly, as the political effectiveness of innovation arguments became visible, representatives of the university began framing both existing activities and new ones in terms of their economic impact, even if they had originally been conceived of in terms other than those of market logic.

These developments all led market logic to gain further strength across academic science. It did not replace the logic of science, though the latter certainly ceded some ground. But by the mid-1980s, market logic had become much better established in universities, and since then it has remained a central way of thinking about the value of science and the best path to realizing that value. The uneasy coexistence of market logic and the logic of science continues to be at the root of some of our most serious debates about the purpose and future of science in the university.

Overview of the Book

The rest of this book is divided into three parts. Chapters 2 and 3 provide background, looking at the state of academic science, and market logic within it, up to the late 1970s. Chapter 4, 5, and 6 contain case studies of the emergence and growth of three market-logic practices in the 1970s and 1980s. And chapters 7 and 8 explore the consolidation of market logic in the 1980s and beyond, and examine its broader implications for the university.

I will begin in chapter 2 with a survey of the postwar golden era, when the logic of science was strong and increases in federal funding were large and steady. Yet even in this period, market logic was present. I look at records from the early 1960s that suggest that universities were not as unfriendly to market logic as one might assume, and describe several experiments made with market-logic practices during this era. But while such activities were not unheard of, sustaining them was difficult, and they did not have a large impact on the university at the time. By the late 1960s, however, changes were starting to undermine the system of federal funding that had supported the logic of science, and these would eventually open the door to other ways of thinking.

Chapter 3 begins by introducing another round of market-logic experiments, this time ones being undertaken in the mid-1970s. Like earlier efforts, these practices encountered limitations and did not, at the time, look poised to take off. But this time, things would be different, as a new idea started to gain influence in the policy realm. While economists had been looking seriously at the impact of innovation since the 1950s, policymakers' attention to the issue was limited before 1970. A spurt of interest in innovation in the early 1970s fizzled out when the economy rebounded briefly, but as the economy

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lost steam mid-decade, industry leaders, concerned with indicators suggesting that the United States was losing its technological leadership, began to push the idea that government needed to act to strengthen innovation. In the latter part of the decade, the innovation issue would become politically salient and influential, and would shape a variety of policies meant to strengthen the U.S. economy.

Chapters 4, 5, and 6 are the empirical heart of the book. Each looks at the development of a specific new market-logic practice in academic science: faculty entrepreneurship in the biosciences, the patenting of university inventions, and the creation of university-industry research centers. The chapters begin by reviewing the origins of one of these practices, then track its early development as well as limits to its growth and spread. They go on to examine policy decisions that removed these limits and replaced them with incentives, and consider how political concern with the economic impact of innovation contributed to these decisions. The chapters conclude with a look at the subsequent takeoff of each practice, followed by a discussion of the conditions that appear to have been necessary for this takeoff to occur.

Chapter 7 returns the focus to the university as a whole. It asks how the spread of these three practices contributed to a larger shift toward market logic in academic science during the 1980s. This chapter shows how the success of biotech entrepreneurship, university patenting, and university-industry research centers encouraged additional experiments with and expansions of market-logic activity, as well as pushing university leaders to recast much of what academic science did in terms of its economic impact.

The book's conclusion develops two points. First, it reviews how the evidence presented in earlier chapters supports my overall argument, as well as evaluating other possible explanations for the changes that have taken place in academic science. Second, it considers what the story told here has to say to larger conversations—about how institutional logics gain strength, about the role of the state in creating markets, and about how thinking about activities in terms of their economic role can eventually change them.