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Not Just Neoliberalism: Economization in US Science and Technology Policy

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Abstract

Recent scholarship in science, technology, and society has emphasized the neoliberal character of science today. This article draws on the history of US science and technology (S&T) policy to argue against thinking of recent changes in science as fundamentally neoliberal, and for thinking of them instead as reflecting a process of "economization." The policies that changed the organization of science in the United States included some that intervened in markets and others that expanded their reach, and were promoted by some groups who were skeptical of free markets and others who embraced them. In both cases, however, new policies reflected (1) growing political concern with "the economy" and related abstractions (e.g., growth, productivity, balance of trade) and (2) a new understanding of S&T as inputs into a larger economic system that government could manipulate through policy. Understanding trends in US S&T policy as

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resulting from economization, not just neoliberalism, has implications for thinking about the present and likely future of science and S&T policy.

Keywords
S&T policy, neoliberalism, economics, economization, rationalization

Science, technology, and society (STS) scholars widely agree that the organization of scientific research has shifted over the past forty years. This change has been characterized as a move from mode 1 to mode 2 science (Gibbons et al. 1994), toward a triple helix of university–industry–government relations (Leydesdorff and Etzkowitz 1996), in the direction of asymmetric convergence (Kleinman and Vallas 2001), toward a regime of globalized privatization (Mirowski and Sent 2008), and toward market logic (Berman 2012a, 2012b). It has also been described repeatedly as neoliberal (Atkinson-Grosjean 2006; Canaan and Shumar 2008; Slaughter and Rhoades 2004), and recently efforts to understand it have been placed more explicitly within larger debates over neoliberalism (Abraham and Ballinger 2012; Fisher 2009; Lave, Mirowski, and Randalls 2010; Mirowski 2011; Moore et al. 2011).

If we accept as a first-order approximation that neoliberalism is some combination of belief in the desirability of free markets in organizing human activity and in a strong but limited government focused on securing property rights and promoting free trade, there is clearly a story to be told about science that lines up with a narrative about neoliberalism. The expansion of intellectual property rights, the idealization of entrepreneurship, and the reorientation of academic science toward work with commercial value can all be seen in this light.

But at least in the United States, the history of science and technology (S&T) policy tells a more complex story about the interest groups and ideologies behind these changes. While some US policy decisions can reasonably be called neoliberal, either because of the beliefs underlying them or the groups that supported them, others were predicated on the assumption that government should intervene to solve problems of market failure in science (Block 2008; Berman 2012a). This latter group of policies, and the policy makers and interest groups who supported them, fit uncomfortably with the label "neoliberal." Yet these efforts, too, encouraged a more market-oriented science.

The relationship between science and the market has changed. But if some of the policies that led to this change did not idealize markets, nor

were their proponents skeptical of active government involvement in the development of science, calling this transformation "neoliberal" obscures more than it enlightens. This article argues that while there is a strand of S&T policy in the United States that can accurately be called neoliberal, the broader trend in S&T policy is better described as one of "economization" (Callon 1998).

If neoliberalism is about the idealization of the market and a belief that the main role of government should be to create and uphold markets, economization is about a shift toward thinking in terms of the economy. The process of economization as it plays out in US S&T policy has two components. First, it involves increased political concern with "the economy" and related economic abstractions (e.g., growth, productivity, the balance of trade) as objects of knowledge that government can act upon. This attention is grounded in the epistemic authority of the economics discipline, but is also made possible by the proliferation of calculative devices (e.g., gross national product/gross domestic product [GDP], research and development [R&D] expenditures, productivity measures) that enable empirical analysis of these abstractions (Callon and Muniesa 2005).

Second, it involves coming to see more activities as inputs into this system—inputs that government can potentially manipulate in order to affect the economy. This perceptual shift is grounded in the expanding knowledge base of the economics discipline, which incorporates an increasing number of factors into its framework—in this case, coming to see technological innovation as a source of economic growth and exports (Godin 2009; Berman 2012a). The exact relation between inputs and outputs is almost always contested among policy makers and often within the economics profession as well. And policy makers are more likely to adopt such arguments in broad strokes than to dive too deeply into their technical details. But the economization of policy is always linked to the idea that the main purpose of government is to affect positively the larger economy.

Economization is completely compatible with both neoliberal and state-interventionist approaches to governance, in S&T policy and elsewhere. Neoliberalism's view of the state as existing to encourage the free play of markets by upholding property rights, establishing the conditions for free trade, and so forth, necessarily implies an abstract conception of the economy and can easily accommodate the assumption that technological innovation is an important input into it. A neoliberal approach to S&T policy, as scholars have pointed out, will emphasize strong intellectual property rights, a large role for the private sector, and the encouragement of market mechanisms within science.

But economization does not require the belief that a strong but limited free market–oriented state is the best way to achieve desirable economic outcomes. Most members of the political left in the United States and elsewhere also believe that the public interest is best served by a growing economy, and that the state should try to create such an economy. They may also assume, however, that some markets are prone to failure and that the state should intervene to solve problems that markets cannot. For example, many believe that the state should support scientific research directly because markets will, on their own, underinvest in R&D, and R&D investment increases productivity and economic growth. This economic justification for funding science differentiates economization from other ways of thinking about S&T policy, which might support science because it will improve medicine, serve military needs, or address climate change.

Distinguishing between a narrower trend toward neoliberalism and a broader move toward economization resolves the historical puzzle of how, in the United States, policies that were not neoliberal and that were advanced by people without a neoliberal political agenda could, nevertheless, end up encouraging more attention to the economic value of science. It also offers a better diagnosis of the current state of S&T policy and its likely future. Neoliberal efforts to reduce the role of government in science, or to increase the use of market mechanisms within it, are politically polarizing. But economization, which simply suggests that we should use the economic input of S&T to improve the economy, is popular across the political spectrum, and is typically perceived as technocratic and politically neutral.

Few would argue against efforts to improve our collective material well-being. But an ongoing move toward economization will likely have unintended consequences. At bottom, economization rests on the assumption that we actually understand the relationship between S&T and the economy well enough to inform policy. But our understanding of the economic effects of S&T policy is quite limited, and recent decades have shown that a larger GDP and higher productivity do not necessarily benefit the average person. Since our knowledge about what kinds of S&T policies will actually have desirable economic effects is limited, efforts to redirect S&T toward economic purposes tend to lead to policy decisions that sound like they have some connection to the economy, and that advance some group's interests.

But channeling resources to efforts that sound like they might have an economic impact means channeling them away from efforts to achieve other goals directly. Economization thus pulls S&T policy away from a focus on solving scientific and technological puzzles and meeting other

national needs, yet without evidence that doing so will have the desired economic results.

Ultimately, S&T policy should aim to improve human well-being, which is not identical with improving the economy. The good news is that the former goal may actually be more achievable. But when overly optimistic beliefs about our capacity to use science to affect the economy displace other efforts to improve human well-being with S&T, they can do more harm than good.

The rest of the article will develop this argument in several parts. First, it briefly reviews the neoliberalism literature. Second, it makes competing predictions about what we should see in the recent history of US S&T policy if it is better characterized by neoliberalism or by economization. Next, it will describe the major shift in US S&T policy that took place in the late 1970s and early 1980s, and use this empirical evidence to adjudicate between the two explanations, arguing that economization is the better fit. Finally, it will discuss the broader implications of this claim for understanding recent changes in science and S&T policy.

Neoliberals All the Way Down?

While conversations about neoliberalism have been going on for a long time in the social sciences (Foucault [1979] 2008; Rose and Miller 1992), "neoliberalism" has not, for the most part, been the dominant way of talking about the changes that have taken place in science. Recently, however, several authors have made a more programmatic argument for understanding these changes as part of a neoliberal turn (Lave, Mirowski, and Randalls 2010; Mirowski 2011; Moore et al. 2011).

Outside of STS, scholars have used the concept of neoliberalism in a variety of ways. Following Wacquant (2012), we might characterize these as a neoliberal governmentality approach, a neo-Marxist approach, and a "roll-out neoliberalism" (Peck and Tickell 2002) approach. The first, associated with Foucault ([1979] 2008) and Rose and Miller (1992), sees neoliberalism as a set of discourses and technologies which circulates outside, as well as through, the state, and produces subjects who are individualized, disciplined, and entrepreneurial. Neoliberalism is refracted through these subjects in local contexts, and thus is fragmented, playing out differently around the world (Ong 2006). Within STS, the governmentality school is central to discussions of biopolitics, but has been less visible in discussions of the organization of science (though see Drake 2011).

The neo-Marxist approach, represented by Harvey (2005), sees neoliberalism as a relatively coherent political–intellectual project characterized most prominently by the retreat of the state and its replacement with market institutions (Babb 2001; Campbell and Pedersen 2001). Among STS scholars, Moore et al. (2011, 508), who begin their definition of neoliberalism with a preference for "markets over governments as instruments of policy," align most closely with this approach.

Finally, "roll-out neoliberalism" combines elements of the other two, describing neoliberalism as a political–intellectual project focused on the state, but emphasizing the state's active role in producing market mechanisms rather than its withdrawal (Brenner and Theodore 2002). Thus, Peck and Tickell (2002) emphasize not only the retraction of worker protections but new punitive policies to govern the dispossessed, Krippner (2007) shows how the US Federal Reserve transfers functions to the market while nevertheless keeping them under state control, and Wacquant (2012, 71) argues that neoliberalism "entails not the dismantling but the reengineering of the state." Within STS, Lave, Mirowski, and Randalls' (2010, 661) emphasis on the state's "activist approach to the spread and promotion of 'free markets'" comes closest to roll-out neoliberalism (see also Mirowski 2011 in this paper). Given how STS discussions of neoliberal science have used the term, I will rely on Harvey's well-known definition of neoliberalism as "a theory of political economic practices that proposes that human well-being can best be advanced by liberating individual entrepreneurial freedoms and skills within an institutional framework characterized by strong private property rights, free markets and free trade" (Harvey 2005, 3-4), and simply but reinforce the point that such an institutional framework can be produced by a strong, active state rather than through state retreat.

Conversations within STS have typically implied a causal chain between a historical group of people who embraced neoliberal beliefs, their efforts to promote government policies consistent with that ideology, and the policies' reorganization of the relationship between science and the market.[1] Lave, Mirowski, and Randalls (2010, 661) usefully illustrate this narrative. They see neoliberals as combining a commitment to "the classical liberal economic faith in the ability of properly functioning markets to improve social welfare with a new political commitment to expand market relations into traditionally public arenas [and] an activist approach to the spread and promotion of 'free markets.'" From this ideology follows policies that will "encourage private investment in science and university–industry partnerships, through avenues such as strengthening intellectual property and decreasing public funding" (p. 662). Finally, the effects of neoliberalism are felt in

> the rollback of public funding for universities; the separation of research and teaching missions, leading to rising numbers of temporary faculty; the dissolution of the scientific author; the narrowing of research agendas to focus on the needs of commercial actors; an increasing reliance of market take-up to adjudicate intellectual disputes; and the intense fortification of intellectual property in an attempt to commercialize knowledge. (p. 659)

What is missing in the narrative, however, is an examination of the causal mechanisms between points one (the neoliberals), two (the policies), and three (the outcomes).

A short introductory essay cannot examine such questions in detail, but empirical work on neoliberalism and science is blurry in exactly the same place. Abraham and Ballinger (2012, 3), for example, claim to "trace the links between neoliberal ideology, the interests of the pharmaceutical industry and drug regulatory agencies, and the content of toxicological knowledge about pharmaceutical carcinogenicity." But while they do an excellent job of explaining how specific government policies gave industry a greater role in the regulatory process, ultimately changing what counted as knowledge about carcinogenicity—that is, making the connection between points two and three—they do not explain why those particular policies were "neoliberal"—that is, make the connection between points one and two. Fisher (2009), who explains the changing organization of pharmaceutical clinical trials in terms of "medical neoliberalism," similarly assumes but does not detail a connection between neoliberal ideology and the outcome characterized as neoliberal. Moore et al. (2011) come closest to acknowledging the difficulty with this causal connection. They emphasize that some of the policy changes they discuss in relation to neoliberal science, like the Bayh–Dole Act and the Supreme Court's *Diamond v. Chakrabarty* decision, "were not directly motivated by neoliberal ideology," and suggest that their neoliberal origins may lie further back, in the trade liberalization that created the conditions that led to those policies (p. 511). But here too it remains unclear what work actual neoliberals or neoliberal ideas did in creating present circumstances.

Neoliberalism or Economization?

The frequency with which this blurry spot appears should lead us to ask whether, in fact, it does make sense to talk about the changed science–market relationship as fundamentally neoliberal in character. I suggest that rather than reflecting neoliberalism, the underlying trend within US S&T

policy has been one of "economization": of seeing new areas (like S&T) as inputs into the economy and of governing those areas with the intent of affecting it.[2]

In the United States, S&T policy shifted significantly in the late 1970s and early 1980s as policy makers became vocally concerned with the state of technological innovation and made a variety of policy decisions that significantly altered the science–market relationship (Branscomb and Florida 1997; Turner 2006). A number of authors have discussed these decisions, including Slaughter and Rhoades, who examine the emergence of a "competitiveness research and development policy coalition"; Block (2008), who looks at policies tied to the "hidden developmental state"; and Berman (2012a), who analyzes government decisions affecting the relationship between academic science and the market (see Table 1).

A review of these works suggests that about fifteen policy decisions significantly affected the science–market relationship during the late 1970s and early 1980s.[3] Examining the politics behind these decisions should allow us to evaluate the extent to which they reflect a neoliberal move in S&T or one toward economization.

In general, if this dramatic policy shift were neoliberal in nature, we should expect to see one of two things. First, the policy decisions might themselves look neoliberal, reflecting the belief that the state should uphold property rights, maintain contracts, and allow markets to work, either with minimal further intervention or with intervention designed to strengthen market mechanisms. Second, the policies might be promoted by neoliberals, or by interest groups more loosely associated with neoliberalism, like big business. Alternatively, if neither of these were the case, we still might describe the whole policy shift as neoliberal if the new concern with technological innovation that helped to launch it was driven by neoliberal ideals, even if it resulted in policy decisions that were not consistently neoliberal.

If the policy shift reflected economization, we should instead expect to see decisions justified in terms of their effects on the economy, and S&T treated as an input into this process. We would have no expectation about whether this would be done through market means or through direct government action, nor about whether such policies would originate with neoliberals or not. However, we might find evidence that making economic arguments for a given S&T policy was politically advantageous.

A closer look at the fifteen policies shows that some key decisions strengthened markets and were promoted by business interests, while others

Table 1. Significant US Science and Technology (S&T) Policy Decisions, 1977–1985.

	Neoliberal	Interventionist
1977		NSF creates Small Business Innovation Research (SBIR) program
1978	Congress decides not to regulate recombinant DNA research Revenue Act of 1978 cuts capital gains tax rates	NSF creates Industry/University Cooperative Research Centers program
1979	Department of Labor permits pension funds to invest in venture capital	Major expansion of state funding for university–industry research centers begins (1979–1985)
1980	Bayh–Dole Act allows universities and small businesses to patent government-funded research *Diamond v. Chakrabarty* Supreme Court decision rules life forms are patentable	Stevenson–Wydler Act mandates federal agencies actively pursue technology transfer, creates (but does not fund) generic technology centers
1982	Federal Courts Improvement Act creates a national patent court	Small Business Innovation Development Act extends NSF's SBIR program to other agencies
1983	Bayh–Dole Act is extended to large businesses	Orphan Drug Act creates incentives for development of drugs to treat orphan diseases
1984	National Cooperative Research Act (NCRA) loosens antitrust rules limiting R&D collaboration among firms	NSF creates Engineering Research Centers program

Note: NSF = National Science Foundation; R&D = research and development.

tried to use government to solve perceived market failures and were initiated by supporters of such intervention. The Bayh–Dole Act and its 1983 extension, the *Chakrabarty* decision, and the creation of a national patent court all fall into the former group. They strengthened and expanded property rights, and their proponents were either part of the business community or vocal proponents of free enterprise. Similarly, the decision not to regulate recombinant DNA (rDNA) research was compatible with a larger deregulatory move, and was supported by business interests (though also by scientists). And the National Cooperative Research Act (NCRA), which loosened antitrust rules, was consistent with both neoliberal ideals and the preferences of the business community.

But the National Science Foundation's (NSF) programs to encourage university–industry research collaboration, as well as the Small Business Innovation Research (SBIR) program and its expansion, were clearly not neoliberal: both assigned government a direct role in encouraging industrial innovation. The Stevenson–Wydler Act gave federal agencies a mandate to actively promote technology transfer. And the Orphan Drug Act, passed in 1983 to encourage development of drugs for rare diseases, was championed by patient activist groups and opposed by the pharmaceutical industry. These policies were promoted by progressives, and while they had bipartisan support (as did the neoliberal policies), they were opposed by those most committed to a neoliberal vision of S&T policy.

So some, but far from all, of the policies that changed science–market relations fit the neoliberal narrative. Moreover, the concern with technological innovation that led to these policy changes itself was promoted by both neoliberal and interventionist groups (see Figure 1).

On one hand, a neoliberal group representing large R&D-intensive firms (e.g., General Electric, IBM, DuPont) did work to put innovation onto the policy agenda. These supporters argued that innovation would be strengthened by policies including stronger patent rights, looser antitrust enforcement, deregulation, and lower taxes (Berman 2012a).[4]

But another group that promoted attention to innovation cannot reasonably be called neoliberal: economists. The economists who dominated the study of innovation and were cited in science policy debates were not neoliberal representatives of the Chicago School, but Democratic-leaning technocrats like Robert Solow, Kenneth Arrow, and Richard Nelson. They worried about market failure—that since scientific research was a public good, with benefits that could not be captured completely by whomever was conducting it, firms would tend to underinvest in it—and thought government should ameliorate this problem (Berman 2012a). Thus, the broad label of "neoliberal" does not describe the rising concern with technological innovation during this period any better than it describes the changes in S&T policy themselves.

While these diverse policies and their promoters are not consistently neoliberal, they do consistently reflect a dynamic of economization. With one exception, both the neoliberal and the interventionist policies were tied to an increased concern with the economy, and a new view of technological innovation as a major driver of growth and productivity. Both neoliberals and interventionists saw S&T not just as ways to solve specific problems of defense or health, or even as useful to particular industries, but as *inputs* into an abstraction called the economy. Where the two sides differed was on what kind of S&T policy they thought would have the desired effects: a

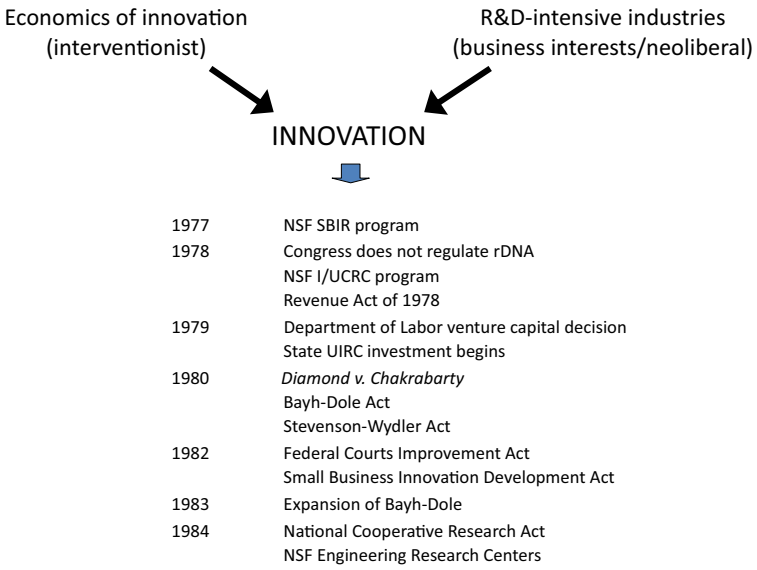

Figure 1. Both interventionist and neoliberal interests and ideas contributed to the increased concern with innovation that in turn shaped US S&T policy.

business-friendly strategy involving strong property rights, low taxes, limited antitrust enforcement, and deregulation; or an industrial policy approach that would actively facilitate cross-sector R&D collaboration and support research in economically significant areas.

The next section shows how, over several decades, policy makers came to think of S&T in terms of its impact on the economy, and how this resulted from a mixture of neoliberal and interventionist ideas and interests. The section that follows reviews the politics behind both the neoliberal and the interventionist policy decisions to demonstrate how both types of policy reflected a desire to use S&T to affect the economy.

The Rise of Economization in US S&T Policy

US S&T policy has long been driven by competing concerns, including military needs, medical advancement, and the advancement of pure science (Kleinman 1995). It is true that S&T policy always had one eye to *economic* concerns, in the sense of being aware of its importance to industry (Hart

1998b). But it was completely silent, prior to the 1960s, about the relationship between S&T and the *economy*, an absence reflected in landmark reports like Research—A National Resource (1938) and Science—The Endless Frontier (1945).

To a considerable extent, this is because "the economy," in its contemporary sense meaning the disembedded totality of economic activity, did not exist before the 1940s. The term economy referred instead to wise or thrifty use of resources, as in "economizing" (Emmison 1983; Suttles 2010). It was only with the emergence of national income and product accounts, not officially published on an annual basis until 1947 (Carson 1975), that it made sense to talk about the economy as "that which produces the net national product" (Suttles 2010, 30). This is not to suggest that politicians and the public did not have economic concerns before this period; of course issues of business, trade, and employment have long been central to politics. But the conception of "the economy" as a coherent object that government could act upon took hold surprisingly late (see Mitchell 1998 for a fuller account). Thus, while in the 1930s one might have used technology policy to help industry, it would be anachronistic to talk about it being used to help "the economy."

By 1950, though, "the economy" had become a widely accepted part of political and expert discourse (Suttles 2010, 34-35), and over the next few decades, several developments taught policy makers to see S&T as inputs into it. These included (1) the creation of economic statistics that made it possible to think more precisely about the economic effects of S&T, (2) the influence of economists, who theorized the connection between S&T and the economy, (3) the unfavorable economic environment of the 1970s, which encouraged more general attention to economic issues, and (4) the efforts of large R&D-intensive companies to promote concern with technological innovation. By about 1977, these developments were, collectively, cementing a new understanding of the purpose of S&T among US policy makers.

The change began in the 1950s and 1960s, as economists were able to draw on newly available data quantifying scientific as well as economic activity to theorize the connection between scientific inputs and economic outputs (Godin 2007, 2009). They developed knowledge regarding the major contributions technological innovation made to economic growth (Denison 1962; Solow 1957), the economic returns on investments in R&D (Griliches 1958; Mansfield 1965), and the relationship between technological knowledge and trade patterns (Posner 1961; Vernon 1966). During the 1960s, an intellectual community began to coalesce around the economics of innovation.

But while economists of innovation were politically visible—Robert Solow, Kenneth Arrow, and Richard Nelson all worked for President Kennedy's Council of Economic Advisers—their ideas did not have much immediate effect on policy making. Efforts to maximize the economic impact of technology were either limited (e.g., Kennedy's creation of a new Assistant Secretary of Commerce for Science & Technology) or ineffectual (e.g., the failed attempt to create a Civilian Industrial Technology Program to promote R&D in "technologically deficient" industries; see Nelkin 1971).

This started to change, however, after 1970. As the United States lost its postwar advantage over decimated Germany and Japan, the economy went into recession briefly in 1970 and then more painfully after the 1973 oil crisis (National Bureau of Economic Research 2010). Unemployment and inflation rose simultaneously, the trade balance became negative, and worker productivity flattened (US Department of Labor 2008, 2010a, 2010b). Economic issues became more politically visible (Smith 2007), while an increasingly quantitative, input–output conception of "the economy" led to heightened attention to how various policies would affect it.

Economization was not limited to S&T policy (see, e.g. Smith 2007, 123-30, 153), but it was particularly visible there as researchers drew possible links between S&T policy, technological innovation, and economic outputs. For example, government economist Michael Boretsky argued that the trade balance, which was nearing zero by 1970, had in fact been negative for years in most sectors, and had only been kept positive by high-tech exports, which flattened after the mid-1960s. This explanation suggested that inadequate levels of technological innovation might account for the emerging trade deficit, which in turn implied that policies designed to encourage innovation might have a favorable economic impact (Boffey 1971; National Academy of Engineering [NAE] 1971). During the 1970s, others drew causal links between S&T and economic outcomes like job creation and business growth (Flender and Morse 1975; National Venture Capital Association 1976).

One final effort helped this reconceptualization of S&T policy as affecting the economy via technological innovation to gain broad political acceptance: the vocal and increasingly well-organized community of R&D-intensive businesses. Mobilizing through associations like the National Academy of Engineering [NAE] (1971), National Research Council [NRC] (1978), and the Industrial Research Institute (Arthur D. Little and Industrial Research Institute 1973; Nason, Steger, and Manners 1978), these firms saw inadequate innovation as explaining many of the United States' economic problems, and connected numerical indicators suggesting a reduction in

innovation (Gellman Research Associates 1975) with the declining performance of US industry vis-à-vis foreign competitors. By 1976, the business press was paying attention, writing about how the "breakdown of U.S. innovation" was leading to "less economic growth, fewer jobs, a loss of foreign markets, greater import competition in domestic markets, and finally, of course, a potentially devastating rise in trade deficits" ("The Breakdown" 1976).[5] The issue reached a new level of political prominence in 1978, when President Carter created a Domestic Policy Review (DPR) of Industrial Innovation, which brought together 250 representatives of 28 different federal agencies with 500 private sector participants to study it ("Vanishing Innovation" 1978; Turner 2006, 124). From that point on, S&T policies were frequently discussed in economic terms, with Congress considering, in 1979, an astonishing "75 or 80 bills" that would affect innovation ("Innovation" 1979).

Thus by the late 1970s, economization was well underway in US S&T policy, with S&T seen as an economic input at a time when "the economy" was highly salient to policy makers. The result was not a series of neoliberal policy decisions, but bipartisan acceptance of a new purpose for S&T policy that led to both neoliberal and interventionist policies that could be argued to support technological innovation and thus the economy, many of which enjoyed unanimous or near-unanimous support in Congress (Slaughter 1998).[6] The next section discusses in more detail how the economization of S&T policy shaped both neoliberal and interventionist policy decisions.

Economization in US S&T Policy, 1977–1985

As Table 1 summarizes, between 1977 and 1985, the United States made a number of policy decisions that changed the relationship between S&T and the marketplace, some of which were neoliberal, and others of which were interventionist. In this section, I examine the politics behind these policy decisions to show how they collectively reflected a broader trend toward economization: trying to use S&T policy to affect the economy. In doing this, I am not suggesting that particular policies were not also neoliberal or interventionist. Nor am I suggesting that economization was necessarily the decisive factor in any given decision. My claim is more modest, but still significant: while these policy decisions reflected a mix of ideas about the appropriate relationship between government and the economy, with one exception their stated intent was to use S&T to affect the economy, and being able to claim that they could do so was politically beneficial.

To make this case concisely, I rely on prior research where possible. Of the fifteen policy decisions on this list, several can be treated as two parts of a larger episode, and I collapse them accordingly.[7] In seven of the eleven remaining episodes, existing scholarship has already emphasized the extent to which the policies were shaped by a desire to impact the economy. In four cases, however, past research has not explicitly made this claim. Thus, for the first seven episodes, I provide a table that summarizes existing accounts describing a process of economization, and give illustrations from two specific cases to provide a sense of how economization could affect a neoliberal decision and an interventionist decision. I then draw on primary research to discuss the final four cases in more detail, finding that in three of the four cases economization is highly visible.

Table 2 highlights existing research that addresses how arguments about the economy played into a variety of S&T policy decisions. It is striking how consistently authors from a variety of backgrounds and disciplines emphasize the political importance of justifying these policies in terms of their economic intent. As an example, consider the Federal Courts Improvement Act, which created a national patent court. This neoliberal decision has widely been recognized as strengthening patent rights, but its original motivation was to stop the practice of "forum shopping" for a sympathetic circuit court. The Justice Department lawyers who spearheaded this effort in the mid-1970s had trouble securing the champion they needed in the House Judiciary Committee to move legislation forward. The committee was relatively uninterested in the patent court proposal, but proved to be quite interested in the hot issue of "industrial innovation" (Abramson 2007; Jaffe and Lerner 2004; Meador 1992). Committee chair Robert Kastenmeier signed on to sponsor the patent court proposal because its proponents convinced him that "predictability as to the validity of patents was important in promoting investment in research and development" (Meador 1992, 615-16). Kastenmeier's own explanation of his support for the bill was that it would assist "the industrial and research organizations of this country upon whom we depend for advances in technology and economic competitiveness with the world" (US House 1981, 208).

Or consider the emergence of an interventionist policy: the creation of collaborative university–industry research programs at NSF. Senator Ted Kennedy, one of NSF's strongest supporters, was also concerned with industrial innovation and introduced into NSF's appropriations bill a measure that would have allowed businesses to compete on equal grounds with universities for NSF grants. NSF found this possibility distasteful, but its board recognized the political expedience of providing some kind of

Table 2. Secondary Accounts of Economization in US Science and Technology (S&T) Policy Decisions, 1979–1985.

Policy Decision	Description	Economic Argument	Key Moment	Major Sources
Congress decides not to regulate recombinant DNA (rDNA) research (1978)	Fears about the potential hazards of recombinant DNA research lead Congress to the brink of restricting it	Regulating will halt the development of a nascent industry with potential to drive economic growth	Reframing of the debate around the economic potential of rDNA marks a turning point	Wright (1986b, 1994)
NSF's Industry/University Cooperative Research Centers (1978) and Engineering Research Centers (1984)	NSF supports collaborative university–industry research centers	University–industry research centers will encourage the technological innovation that drives economic growth	NSF's governing body decides that it is politically expedient to create such centers due to key supporters' economic concern with industrial innovation	US House (1983), Belanger (1998)
Revenue Act of 1978; Department of Labor pension fund decision (1979)	Capital gains tax is cut dramatically; DOL allows pensions funds to invest in venture capital	Encouraging investment in venture capital will support small high-tech businesses responsible for job creation and driving growth	National Venture Capital Association representative visits legislators, makes job creation case, and gains their support	Johnson (1980), Crawford (1982), Longstreth (1986)
State UIRC funding (1979–1985)	Individual states target funding to university–industry collaborations and other efforts to develop small high-tech businesses	Support for small high-tech firms will drive bottom-up regional economic development	Council of State Planning Agencies promotes innovation-driven economic development through the National Governors Association	Eisinger (1988), Osborne (1988), Plosila (2004)

(continued)

Table 2. (continued)

Policy Decision	Description	Economic Argument	Key Moment	Major Sources
Bayh–Dole Act (1980) and its extension (1983)	Gives government grantees and contractors patent rights on federally funded inventions	Improving incentives for inventors will increase productivity and improve US economic competitiveness	Supporters of Bayh–Dole reframe bill as being about economic impact, not about improving the utilization of research	Eisenberg (1996), Mowery and Sampat (2001), Berman (2008)
Diamond v. Chakrabarty (1980)	Supreme Court allows life forms to be patented	Allowing patents on life forms will encourage the growth of genetic engineering and improve US competitiveness	Wide variety of industry and science groups file *amicus* briefs arguing for the economic importance of patents	Kevles (1994)
Federal Courts Improvement Act (1982)	Creates the Court of Appeals for the Federal Circuit, a specialized patent court	Making patent decisions more unified and predictable will help industry and improve US competitiveness	Proponents of the reform gain key Congressional supporter by reframing their project in terms of its impact on industrial innovation and competitiveness	Meador (1992), Newman (2001), Abramson (2007)

Note: NSF = National Science Foundation. UIRC = University-Industry Research Center. DOL = Department of Labor.

support to industry, and responded with a counterproposal for the Industry/University Cooperative Research Center (I/UCRC) program. This would nod to industry needs while not requiring direct university–industry competition for grant dollars ("House, Senate Split" 1977; US House 1983, 130-35). NSF director Richard Atkinson sold the small new program to an enthusiastic Congress by arguing that it reflected a "strong base of economic data indicating relationships between research and development activities and the gross national product" (US House 1978, 4). A few years later, continued Congressional interest in "restor[ing] American competitiveness in world markets" by solving "problems of national productivity" led NSF to launch the related, but larger, Engineering Research Centers program as well (Belanger 1998, 219).

The neoliberal Federal Courts Improvement Act was supported by big business and created a new court that strengthened intellectual property rights; NSF's interventionist university–industry research centers were prompted by liberal Ted Kennedy and led to a big new government program. Both, however, are at least partially attributable to policy makers' interest in using S&T to affect the economy. Similar stories can be told about all the other policies summarized in Table 2.

While past research highlights the importance of economic justifications in these seven episodes, in the remaining four—the Stevenson–Wydler Act, the Small Business Innovation Development Act, the Orphan Drug Act, and the NCRA—secondary sources do not fully indicate whether economization played a role. Below, I draw on primary and secondary sources to examine these four policies in more detail. In one case, economization is not in evidence. But in three of the four cases, economization is quite visible.

Orphan Drug Act

The Orphan Drug Act is the sole case among these fifteen decisions in which economization does not appear to have mattered at all. The Act created incentives for pharmaceutical manufacturers to develop drugs to treat diseases suffered by relatively small numbers of people. It was motivated by a letter sent by a distressed constituent to Representative Elizabeth Holtzman, who began promoting an early version of the bill, which was later picked up by Representative Henry Waxman. The pharmaceutical industry, which saw the bill as unwelcome government interference, initially opposed it, and its opposition helped to mobilize a coalition of patient groups in support of the bill. Those patient groups found a vocal ally in actor

Jack Klugman, who was invested in the issue for personal reasons. He made not one, but two episodes of the popular television show "Quincy, M.E." to draw attention to it. The TV shows led to an upswell of public support for orphan disease research, which encouraged some drug companies to negotiate for a bill they could live with. The bill narrowly avoided a pocket veto due to an unrelated attached provision, but ultimately became law in 1983 (Grossman 1984; Holtzman and Cooper 1996, 106-09; Meyers 2000; Richardson 1987; Waxman 1986). There is no evidence that efforts to impact the economy played any role in its passage.

Stevenson–Wydler Act

The Stevenson–Wydler Act, by contrast, was strongly motivated by concern with the economy, and by a belief that S&T could be used to improve it. The main impact of the 1980 Act was to give the US national laboratories a mandate to improve technology transfer, and to require them to set aside 0.5 percent of their R&D budgets for that purpose. Yet, the original aim of the bill was quite different: to dramatically expand NSF's aforementioned I/UCRC program throughout the federal government. Eighty percent of the funding authorized was for the creation of "generic technology centers" to advance precompetitive industrial technologies, and contemporary coverage of the bill focused almost entirely on these centers ("Carter Signs" 1980; "The Chemical Industry" 1980; "Congress Expected" 1980).

Both ideas came directly from President Carter's aforementioned Domestic Policy Review (DPR) of Industrial Innovation (Advisory Committee on Industrial Innovation 1979, 205-08), where they were sold as part of a larger effort to use S&T policy to improve the economy:

> [T]he importance of innovation is its role in increasing productivity and rates of economic growth .... [A]ll available evidence points to a significant, positive relationship between the amount of innovative activity in an economy (such as company sponsored R. & D.) and economic growth and productivity. Some of the research has indicated that the magnitude of the impact of this kind of innovative activity can be enormous. (Advisory Committee on Industrial Innovation 1979, 6)

Like the original proposals, Stevenson–Wydler was also justified in terms of its contributions to technological innovation, which, it was emphasized, was "a vital component of economic growth in both a domestic and an international context" (US House 1980, 3).

While the goal of promoting innovation was broadly supported, the interventionism of Stevenson–Wydler's approach was less universally favored. The chemical industry's reception of the bill "varied from skeptical to lukewarm," with one source suggesting the centers would be "absolute disasters" ("The Chemical Industry" 1980). And an architect of the Bayh–Dole Act, which was passing through Congress simultaneously, called Stevenson–Wydler a "piece of junk" that "solved no problems and created more bureaucracy" (Latker 2005).

Despite this, the bill passed both houses of Congress unanimously (Slaughter 1998). But its main purpose was never realized. The Reagan administration, though it shared the Carter administration's faith in the economic potential of technological innovation, was "scornful of the idea that direct federal action [could] improve the innovation process in industry," and simply chose not to fund the centers (Walsh 1981). With sponsors Adlai Stevenson and John Wydler out of office by this point, there was little push-back against this defunding, and the law's secondary provision regarding the national labs became its only lasting impact. The sorts of centers Stevenson–Wydler envisioned would nevertheless be created through other means in the 1980s, from NSF's Engineering Research Centers to the public–private SEMATECH consortium to the Department of Commerce's Manufacturing Extension Partnership and Advanced Technology Program.

Small Business Innovation Development Act

The Small Business Innovation Development Act, passed in 1982, and its antecedent, the SBIR program established by NSF in 1977, were similarly shaped by an interest in using S&T to drive the economy. The former, like NSF's I/UCRC program, resulted from a push by Senator Ted Kennedy, who was chair of the Senate subcommittee on NSF at the time, and was interested in "where [NSF] plug[ged] into national growth policy" (US Senate 1975, 51). This concern led him to add a provision to NSF's appropriations bill that would require the agency to give a certain fraction of its applied research grants to small businesses (Obermayer 2009).

The late-1970 s discussion of technological innovation and the economy singled small business out for particular attention, in part because widely circulated reports suggested that small high-tech companies grew much faster and created more jobs than mature companies (Birch 1979; Flender and Morse 1975). The 1979 DPR report emphasized that small business's disproportionate contribution in these areas meant it also contributed disproportionately to economic growth (Advisory Committee on Industrial

Innovation 1979, 260). The DPR highlighted NSF's program as a "successful model" and recommended that each large R&D agency "should allocate at least 1 percent of its R. & D. budget to the small business program using the same format as that of the National Science Foundation" (Advisory Committee on Industrial Innovation 1979, 267, 268).

But while the small business community made repeated attempts to get other agencies to adopt such set-asides, it had no quick success (NRC 1999, 18, 41-43). In response to agencies' reluctance, Kennedy drafted legislation requiring other agencies to create their own SBIR programs, which he turned over to Republican colleague Warren Rudman after Democrats lost control of the Senate in 1980 (Obermayer 2009). Rudman introduced the bill in 1981, citing evidence that "almost 50 percent of American economic growth stems from technological innovation and that traditionally, small firms have produced innovations and technological breakthroughs more efficiently and more effectively than some of the larger corporations" (US Senate 1981, 2). While the Reagan administration was "decidedly cool" to this interventionist approach, the bill still passed the Senate 90–0, with 82 cosponsors, in 1981 ("Aid for Small Businesses" 1981; Reinhold 1981).

After the unanimous Senate passage of what had been a low-profile bill, universities began to vocally oppose it, arguing that the set-aside would (ironically) interfere with the marketplace, go to lower-quality research, and come at the expense of basic research and education (Reinhold 1982; Russell 1982). Supporters, however, continued to make economic arguments, emphasizing that "[s]mall high-technology companies . . . are the wellspring of pioneering innovations in this country," and claiming that the bill would "boost the economy, shore up the sagging productivity rate, [and] create new jobs" (Reinhold 1981; Russell 1982). The bill ultimately passed the House by a 353–57 margin and was signed into law by President Reagan (Slaughter 1998). Since then the legislation has been renewed, and the size of the government set-aside increased, several times (Keller and Block 2012).

National Cooperative Research Act (NCRA)

Finally, the NCRA, which became law in October 1984, was also bolstered by the idea that technological innovation was key to international competitiveness. Intended to encourage precompetitive R&D collaboration among firms, its core provisions involved clarifying that such collaboration was not *per se* illegal under antitrust law, and eliminating the possibility of treble

damages for antitrust violations related to joint R&D ventures (Wright 1986a). Since the late 1960s, the business community had raised concerns about whether antitrust rules harmed technological innovation by limiting research collaboration (US Department of Commerce 1967, 47-55). But the immediate impetus for the NCRA came from the Microelectronics and Computer Consortium, whose firms wanted to conduct collaborative R&D in order to compete with the industry-wide research cooperation taking place in Japan (Gibson and Rogers 1994).

Although an industry group lobbied for the change and the loosening of antitrust restrictions are typically seen as neoliberal, support for such a reform was strongly bipartisan. Democratic representative Peter Rodino took the lead on the bill, the Reagan administration promoted its provisions, and it passed both houses of Congress unanimously (Crane 1984; Gibson and Rogers 1994, 472-73; Reagan 1983). Across the board, these diverse supporters emphasized the bill's potential economic impact, arguing that "it is difficult to overstate the importance of technological development to a strong and healthy economy" (Reagan 1983, 1) and that "the goal [of legislation] must be to increase the competitiveness of U.S. industries in world markets, to promote economic growth, and thereby to create jobs" (US Senate 1983, 170). Scholars noted at the time that "the ability to maintain international technological competitiveness is obviously of paramount importance to the well-being of the economy" (Crane 1984, 408), and later reports also emphasized that the legislation's success was tied to the widespread perception that it would "accelerate the pace of technological innovation" (Hart 2001, 930).

The legislative changes were themselves minor, serving more to reassure industry that such collaborations would not be challenged by the authorities than to break truly new ground in antitrust policy. Nevertheless, the NCRA launched an active period of industry R&D collaboration, and 575 joint ventures were registered with the Department of Justice over the next ten years (Hart 1998a). The newly prevalent understanding of technological innovation as a key economic input led proponents of both free markets and of industrial policy to support a provision that would encourage such activity.

The shift in US S&T policy that is generally agreed to have taken place in the late 1970s and early 1980s included at least eleven policy episodes, four of them consisting of two separate decisions. Of these fifteen total decisions, seven are basically interventionist and eight neoliberal: they share no consistent pattern in terms of their attitude toward government efforts to intervene in or encourage the creation of markets. But in fourteen of the

fifteen cases, decisions were justified as attempts to use S&T to affect the economy and impact related phenomena like productivity, growth, and competitiveness. While this article does not attempt to show that such arguments were decisive in any given policy decision, other scholarship has made that case for some of the specific decisions (see, e.g., Berman 2012a). Both types of policies typically had wide, often unanimous, bipartisan support (see note 6). All this is consistent with the argument that the changes in US S&T policy are better described as reflecting a process of economization, rather than a move toward neoliberalism.

Discussion and Conclusion

Explaining developments in US S&T as part of a larger shift toward neoliberalism, in which people holding neoliberal beliefs promoted neoliberal policies that changed how science is conducted, is not fully accurate. Some policies affecting science assumed that limited government, property rights, and free markets were the best ways to organize it, but others were based on the idea that markets would, on their own, fail to provide the economically optimal amount of R&D, and that government should intervene to fix that problem. Some policies were supported by proponents of market mechanisms and the private sector, but others were favored by those who thought new government programs could help. And while representatives of the R&D-intensive business community helped raise political concern with the issue of technological innovation, they could not have done so without the intellectual work done by center-left, technocratic economists.

Both interventionist and neoliberal S&T policy, however, reflected a larger trend toward economization. "The economy" and related concepts like productivity and competitiveness became more politically important, and policy makers became more focused on affecting them. S&T, as a primary source of innovation, became seen as inputs into this larger economic system, and government policies were increasingly aimed at using S&T to improve economic outcomes. This could be attempted through market mechanisms or through new government programs: either way, it involved economization.

Clarifying this distinction matters partly as a question of historical accuracy. But it also has implications for how we understand the present and think about the future. While neoliberalism is still an influential worldview, economization is in many ways a *more* powerful, and potentially more durable, trend. After all, many people disagree with the neoliberal argument that the way to increase human well-being is to use markets to organize

as much activity as possible. But economization simply says that government should be used to improve the economy. At this general level, it is almost impossible to disagree with: who wants a weak economy?

Since the period discussed in this article, economic ends have, if anything, become even more central to US S&T policy. For example, the America COMPETES Act of 2007 ("An Act to invest in innovation through research and development, and to improve the competitiveness of the United States") and its 2010 reauthorization have been the most important US S&T legislation of the past ten years. Among other provisions, the 2010 bill lays out, for the first time, specific "broader impacts" that NSF grants are supposed to have. The first two on the list are "[i]ncreased economic competitiveness of the United States" and "[d]evelopment of a globally competitive STEM workforce." Only then do more traditional aims of S&T policy appear.

But as policy areas are economized—that is, reoriented toward economic ends—those ends tend to crowd out other kinds of goals, whether the broad pursuit of knowledge or the solving of specific noneconomic problems (Stiglitz, Sen, and Fitoussi 2010). Economic ends have the capacity to displace other kinds of ends not only because of their near-universal appeal—after all, improvement in medicine is also a goal almost everyone would embrace—but because of our collective faith that we have, or can reasonably expect to develop, the knowledge required to make policy decisions that will achieve those goals.

Economization thus ultimately rests on the epistemic authority of economics. Despite policy makers' ambivalence about the practical value of economic advice, they still demonstrate a broad confidence in our ability to rationally identify policies that will improve our economic well-being. For example, in 2005, US presidential science adviser John Marburger argued that "a new interdisciplinary field of quantitative science policy studies," a field which would be "to a great extent a branch of economics," could identify policies that would "keep our technology-based economy strong" (Marburger 2005). This led to a major new initiative on the "Science of Science Policy," which held up "the Federal Reserve Board's econometric model" as the appropriate exemplar for making decisions about national investments in science (National Science and Technology Council 2008, 9).[8]

The problem, though, is that we do *not* have the capacity to rationally identify which policies will help S&T achieve economic ends, nor are we anywhere near being able to do so. Nearly forty years ago economist Edwin Mansfield stated, with admirable frankness, that "very little really is known

concerning the effects of many of these policy alternatives .... [I]n some areas, no one really knows how to study these questions effectively, let alone provide answers here and now" (Walsh 1976, 1103). Much more recently, economists Julia Lane and Dan Black wrote that "[g]overnments across the world are investing large amounts of money in scientific research, often with the belief that such investments will increase economic growth—yet the scientific evidence for this belief is, as Colin Macilwain (2010) notes, *patchy*" (Lane and Black 2012, 598; emphasis in original).

Indeed, the links between the conduct of scientific research and actual impact on people's material well-being are almost impossibly complex, as Sarewitz (2011, 342) illustrates with a Midwestern research university regent's regretful observation that "most of our agricultural research has ultimately led to rural decline." More broadly, the question of whether technological advances necessarily lead to a higher standard of living for the average person, or whether they might sometimes result in gains for those at the top and structural unemployment for less fortunate others, seems newly salient post-2008.

Thus, while the goal of using S&T to improve our economic well-being is admirable, and expanding our knowledge of how the two are related is worthwhile, explicitly orienting science policy toward economic outcomes is unlikely to have the desired results. At the same time, a move toward economization has costs. It leads to support for efforts that *sound* like they're connected to economic development, which can come at the expense of equally valuable—and more achievable—goals: good, cost-effective science that expands our knowledge base and helps us solve critical technological problems. For example, in a recent *Atlantic* article on how to make government more cost-effective, former White House officials point to National Institutes of Health (NIH) as a place where "big cuts" would be stupid, because NIH is an "engine . . . of economic growth" (Bridgeland and Orszag 2013, 66). But the link between NIH and economic growth is fairly tenuous, while the link between NIH and better medicine is quite strong. Trying to maximize the former impact, rather than the latter, is misguided. Indeed, further expanding the portion of the economy devoted to health care might, on balance, be a negative outcome.

It is true that some aspects of US S&T policy over the last few decades have reflected a neoliberal preference for private solutions over public ones and for market mechanisms over direct government action. But defining these changes as most fundamental to what has happened in S&T overlooks a change that is at least as important, one that encompasses both the neoliberal strand of S&T policy and an equally prominent interventionist effort to

use government to maximize the economic impact of S&T. Both of these coexisting developments reflect a broader trend toward economization: coming to see the purpose and value of S&T in their contribution to the economy, not their contribution to the quality of human life. Economic goals are important ones. But when coupled with too great a faith in our ability to rationally pursue them, efforts to achieve these goals will have unintended consequences—crowding out other ends—without necessarily having the desired effect. Science, and humanity, may be better served if we are more honest about how little we still know about how science has its effects in the world.

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Notes

1. The assumption of a direct link between neoliberals, policies, and outcomes is particularly visible within science, technology, and society (STS); outside it, a number of scholars have told a more complex story. Bockman (2011), for example, emphasizes the complexity of the relationship between neoliberalism as ideology and policy, and Mudge (2008) highlights the fact that in the European Union neoliberal policies were often advanced by those on the political left.

2. This builds upon, though it is not identical with, the concept of economization suggested by Callon (1998) and Çalişkan and Callon (2009), and is also linked to Fourcade's (2009) discussion of the "economicization" of social policy.
3. I reviewed additional works but did not identify other significant science and technology (S&T) policies during these years.
4. See, for example, Arthur D. Little and Industrial Research Institute (1973), Manners and Nason (1978), National Research Council (1978), and National Science Foundation (1976), as well as many articles in the business and trade press (e.g., *Business Week*, *Time*, *The Economist*, *Chemical Week*), particularly between 1976 and 1980.
5. For a few of the many possible examples of such coverage, see "R&D on the Skids" (1976); "The Silent Crisis in R&D" (1976); "The Innovation Recession" (1978); and "Vanishing Innovation" (1978).
6. The Bayh–Dole Act, the Stevenson–Wydler Act, the Orphan Drug Act, and the National Cooperative Research Act all passed unanimously in both houses; the Small Business Innovation Development Act passed unanimously in the Senate and 353-57 in the House; and the Federal Courts Improvement Act passed 83-6 in the Senate and 321-76 in the House.
7. These are the creation of the Small Business Innovation Research program at National Science Foundation (NSF) and its expansion through the Small Business Innovation Development Act, the Revenue Act of 1978 and the Department of Labor decision to allow pension funds to invest in venture capital, the Bayh–Dole Act and its 1983 extension to large businesses, and NSF's creation of the Industry/University Cooperative Research Center (I/UCRC) program and the related Engineering Research Center program.
8. My thanks to the editor for pointing to Marburger's speech, and its consequences, as a recent example of economization.

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