Toward an assessment of impacts from US technology and innovation policies

By: Barry Bozeman and Albert N. Link

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Abstract:

Five important policy initiatives were promulgated in response to the slowdown in US productivity in the early 1970s, and then again in the late 1970s and early 1980s. These initiatives included the Bayh–Dole Act of 1980, the Stevenson–Wydler Act of 1980, the Research and Experimentation Tax Credit Act of 1981, the Small Business Innovation and Development Act of 1982, and the National Cooperative Research Act of 1984. Scholars and policy-makers have long debated the direction and magnitude of impacts from these policies but empirical evidence remains modest, especially evidence of their aggregate effects. Our assessment of these policies is based on quantifying their collective impact on industrial investments in R&D in the post-productivity slowdown period. Our findings support the conclusion that the relative levels of industrial investments in R&D from 1980 onwards were significantly higher than before, *ceteris paribus*.

Keywords: technology | innovation | R and D | policy assessment

Article:

1. Introduction

There is a significant academic literature assessing the meaning and impact of particular components of US technology and innovation legislation implemented during the late 1970s and early 1980s in response to the productivity slowdown.[1] Assessments of the Bayh–Dole Act (Mowery et al. 2001; Rafferty 2008; Kenney and Patton 2009) and the Research and Experimentation (R&E) Tax Credit Act policies (Eisner et al. 1984; Bozeman and Link 1985; Berger 1993; Bloom et al. 2002) are especially common, but one also finds studies (DelaBarre 1986; Lee and Gaertner 1994; Bozeman 1994; Link et al. 2011) focusing on related

[1] Regarding our use of the term technology and innovation policy, we define technology as the application of new knowledge and define innovation as technology put into use or commercialized.

technology policy legislative initiatives of that era. Despite the many useful and informative studies focusing on particular aspects of post-1980 US technology and policies, there is a conspicuous dearth of studies providing a systematic and aggregate economic assessment of these foundational technology and innovation policies on industrial R&D spending. The purpose of this paper is to begin to fill this void by offering a first step toward that end.

The remainder of this paper is organized as follows: the US productivity slowdown is documented and the attendant policy responses are summarized in Section 2. An initial assessment of these policies is proffered in Section 3. Section 4 concludes the paper with brief summary remarks and a call for additional study of this important topic.

2. US productivity slowdown

Policy-makers in the USA have largely eschewed comprehensive or long-range planning for science and technology (Mason 1979; Brooks 1996). As a result, technology- and innovation-focused policies, even relatively sweeping policies, have typically been more responsive than strategic (Kleinman 1995; Brooks 1996; Crow and Bozeman 1998; Guston 2000). This implies that an understanding of technology and innovation policy change requires a considerable knowledge of context, usually changes in the economy or in national security. Inasmuch as the technology and innovation policies examined herein are responsive to the US productivity slowdown preceding them, an understanding of those policies requires some attention to that economic decline.

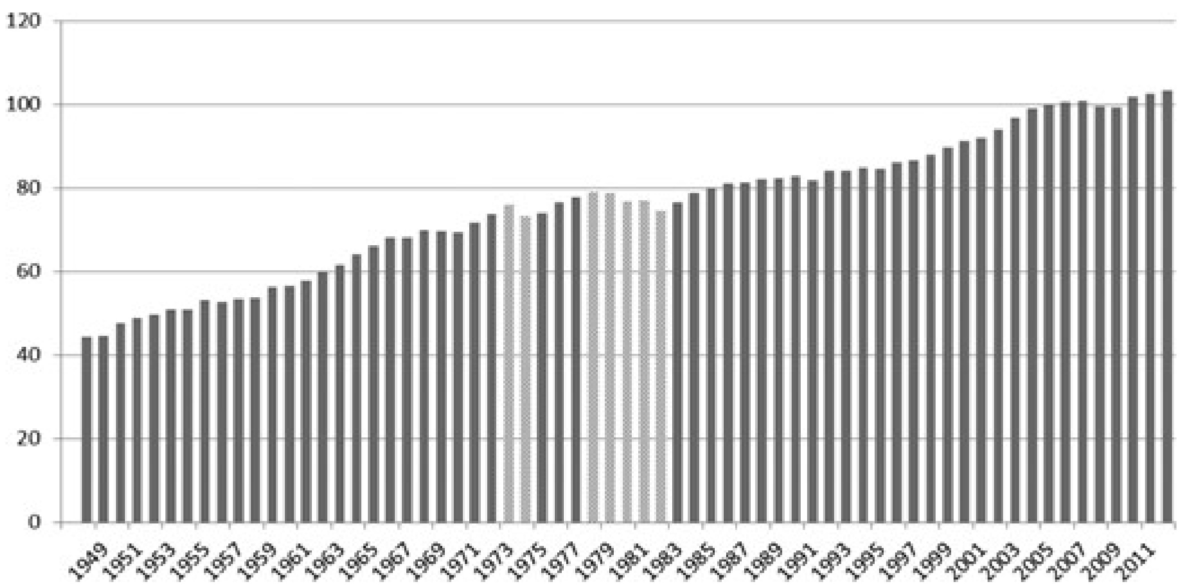

Figure 1. US TFP index for private business sector, 1948–2012 (2005 = 100).
Source: U.S. Bureau of Labor Statistics: < http://www.bls.gov/mfp/mprdload.htm >.

Fig. 1 shows the US Bureau of Labor Statistics (BLS) total factor productivity (TFP) index for the private business sector for the period 1948–2012, normalized to 2005 (2005 = 100).[2] The

[2] The BLS refers to this index as a multifactor productivity index, although the academic literature seems to prefer the term total factor productivity (TFP). Put simply, the BLS calculations assume that output (Q), at various levels of aggregations, is functionally related to that level's investments in capital (K), labor (L), materials (M), energy (E),

academic literature, as reviewed by Link (1987), has defined two episodic periods of productivity slowdown that motivated modern US technology and innovation policy. These two periods are highlighted within Fig. 1. The first time period was 1973–4, and the second time period was 1978–82.

The 1973–4 productivity slowdown was presumed by many economists, and likely many policy-makers as well, to be a result of non-recurring and periodic events.[33] The key event was associated with the energy crisis of 1973:

> Energy prices stand as the single most important contributor to the 1973 [productivity] break. (Siegel 1979: 60)

Many thought at the time, and some may still be of the opinion, that such events were normal, one-time cyclical shocks to the economy, and movement in the TFP index was accordingly a normal cyclical response around more stable, long-term growth in productivity.

From both an economic and a policy perspective, especially as related to the US technology and innovation policies considered herein, the more important slowdown began in 1978 and ended in 1982. In fact, in 1978 the BLSTFP index was 78.842, the highest it had been in the post-World War II period. By the end of 1982, the TFP index was 74.323, only slightly higher that it had been a decade earlier.[4]

Congress was quick to respond at the beginning of what would become the second productivity slowdown, perhaps in an effort to avert another episode in the economy like the one in 1973–4. In response to President Carter's 1979 Domestic Policy Review on Industrial Innovation initiatives, Congress passed the Bayh–Dole Act of 1980 and the Stevenson–Wydler Act of 1980 to facilitate the transfer of federally-funded technology from universities and national laboratories, respectively, to the private sector (see Table 1).[5]

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and purchased business services (S). Thus, TFP = Q/(F(K, L, M, E, S)) (see < http://www.bls.gov/mfp/mprtech.htm > accessed on 18 Feb 2014).

[3] Of course, there was a productivity slowdown in the period 2008–9, but the emphasis of this paper is on the productivity slowdowns that were the antecedents of the US technology and innovation policies in Table 2 .

[4] Link and Siegel (2003: 58) wrote, reflecting the concern that the 1978–82 slowdown was not a response to cyclical, one-time, and temporary shocks but rather a response to a more fundamental and enduring change in long-term growth prospects:

> In the early 1980s there was great concern among economists and policy-makers in the United States regarding the pervasive slowdown in productivity growth and the concomitant decline in the global competitiveness of American firms in key high-technology industries. One of the alleged culprits of this productivity slowdown was a decline in the rate of technological innovation, which is a reflection of declining entrepreneurship [and declining investments in R&D].

[5] Shapley (1979) and especially Turner (2006) discuss the Domestic Policy Review in greater detail.

Table 1. US technology- and innovation-related policies initiated in post-productivity slowdown period

Legislation	Description	Those targeted	Phase of R&D cycle
University and Small Business Patent Procedure Act of 1980 (known as the Bayh–Dole Act of 1980) [1]	The Act redefined property rights that facilitated the transfer of existing knowledge resulting from public-sector support from universities to the private sector	Universities Private-sector firms	Basic and applied research [3]
Stevenson–Wydler Technology Innovation Act of 1980 (known as the Stevenson–Wydler Act of 1980)	The Act called for federal laboratories to actively promote technology transfer to the private sector for commercial exploitation. Each national laboratory was mandated to establish an Office of Research and Technology Applications to facilitate this technology transfer	National laboratories and other research organizations Private-sector firms	Basic and applied research [3]
Economic Recovery Tax Act of 1981 (relevant portion known as the R&E Tax Credit of 1981)	The Act provided a 25% marginal tax credit, that is a 25% tax credit for qualified R&E expenditures in excess of the average amount spent during the previous three taxable years, in an effort to increase private-sector R&D spending. The marginal rate was later lowered to 20%	Firms conducting R&D	Basic and applied research, and development
Small Business Innovation Development Act of 1982	The Act created the Small Business Innovation Research (SBIR) program to provide research grants to small firms for the purposes of stimulating technology development and it subsequent commercialization	Small firms (<500 employees)	Development [4]
National Cooperative Research Act of 1984 [2]	The Act created a registration process under which joint R&D ventures, or more simply research joint ventures (RJVs), can voluntarily disclose their research intentions to the US Department of Justice and thereby gain partial indemnification from antitrust laws and penalties	Firms or all sizes and their research partners	Basic and applied research, and development [5]

[1] See Stevens (2004) for history of Bayh–Dole Act.
[2] See Link (1989) for history of National Cooperative Research Act.
[3] The transferred technology represents applied research but its origin at a university or a federal laboratory was basic research.
[4] The enabling legislation emphasizes that commercialization is an objective of the SBIR program.
[5]Bozeman et al. (1986) argued that firms are more likely to cooperative in research if the research is toward the basic end of the R&D spectrum, but the Act does not mandate this.
Source: Based on Link and Link (2010) and Leyden and Link (forthcoming).

The R&E Tax Credit Act of 1981 and the Small Business Innovation Development Act of 1982 soon followed.[6] The tax credit was designed to increase R&D investments regardless of the size of the performing firm, but the Small Business Innovation Research (SBIR) program created by the Small Business Innovation Development Act focused on assisting small firms to commercialize their funded technology. Then, in 1984, the National Cooperative Research Act (NCRA) encouraged collaborative research. The act indemnified research joint venture (RJV) members from certain antitrust concerns.

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[6] R&E expenditures are more narrowly defined than R&D expenditures, which include all costs incident to development. R&E does not include ordinary testing or inspection of materials or products for quality control of those for efficiency studies etc. R&E, in a sense, is the experimental portion of R&D. For a discussion of definitions associated with the components of R&E and R&D, see Gallaher et al. (2006). Atkinson (2007) and Tassey (2007) debate the economic and policy merits of a marginal versus flat R&E tax credit.

Collectively, these five legislative initiatives are the US technology and innovation policies focused on in this paper.[7] These Acts have not been collectively studied in terms of their impact on aspects of aggregate industrial R&D investment, or for that matter on any private-sector R&D investment strategy. Rather, what has been investigated is the relationship between each individual act and selected performance measures.

Regarding the Bayh–Dole Act, Mowery et al. (2001), Mowery and Ziedonis (2002), and Mowery and Sampat (2005: 120) have demonstrated that the aggregate university propensity to patent trend after 1981 is a:

> … continuation of a trend that dates at least as far back as the early 1970s; there is no [empirical] evidence of a 'structural break' in trends in patent propensity after Bayh–Dole.

Link et al. (2011: 1098) also concluded from their case studies of Sandia National Laboratories (SNL) and the National Institute of Standards and Technology (NIST) that:

> … the enactment of the Stevenson-Wydler Act … was not sufficient to induce an increase in patent applications by scientists at SNL or NIST. However, it appears that the establishment of financial incentive systems, meaning the passage of the Federal Technology Transfer Act [of 1986, discussed below] and the allocation of internal resources to support technology transfer, is correlated with an increase in such activity.

Evidence to date suggests that the R&E tax credit and the SBIR program have had a direct impact on affected firms. For example, with respect to the R&E tax credit, Guenther (2013: 22) noted:

> … one can argue the [R&E tax] credit may have boosted [R&D] spending [from 1999 to 2009] somewhere between 2.1% and 4.2%, compared with investment that might have taken place in the absence of the credit.

With respect to the SBIR program, less than 20% of a representative sample of firms that received SBIR awards responded to a National Research Council survey that in the absence of the SBIR award they would have still pursued their funded technology project (Link and Scott 2012). Not only did funded firms allocate their own resources to enhance the SBIR-funded

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[7] Many point to President George H. W. Bush's 1990 document (Executive Office of the President 1990) as the first formal domestic technology policy statement. Albeit an important initial policy effort, it paled in significance in comparison to President Carter's Domestic Policy Review in terms of specifics and it failed to articulate a foundation for government's role in technology and innovation. Rather, this document implicitly assumed that government had a role, as was articulated more than half a century earlier by Bush (1945). As stated in *U.S. Technology Policy* (Executive Office of the President 1990 : 2):

> … The goal of U.S. technology policy is to make the best use of technology in achieving the national goals of improved quality of life for all Americans, continued economic growth, and national security.

technologies (i.e. the legislation did lead to new R&D spending), but also other private equity was obtained to support the development of the new technology (Link et al. 2014).[8]

Finally, the NCRA was expected to speed up the R&D process and lower R&D costs by reducing redundant research.[9] These economic benefits associated with RJV activity might then provide an incentive for a collaborating firm to increase its R&D commitment to the project as well as to pursue subsequent R&D projects.

Legislative initiatives have helped to make the impact of these Acts long-lived. For example, the Stevenson–Wydler Act was amended by the Federal Technology Transfer Act of 1986 which provide financial incentives to laboratory scientists responsible for inventing the transferred technology. It also enabled the laboratories to enter into cooperative R&D agreements with outside organizations or parties.

The R&E tax credit was never made permanent but was reauthorized numerous times (sometimes retrospectively). Similarly, the SBIR program has been reauthorized several times, and the set-aside percentage has been periodically increased.

Finally, the NCRA was amended by the National Cooperative Research and Production Act of 1993 and again by the Standards Development Organization Advancement Act of 2004. In both instances, the activities initially indemnified by the NCRA were broadened.

Viewing these Acts as a whole, an assessment question remains. Have these five post-productivity slowdown technology and innovation policies, and their amendments, had a measurable impact on aspects of industrial investments in R&D?[10] While various individual legislative assessments have generally concluded that the effects have been positive, the aggregate effects have not been systematically examined. Moreover, we cannot conclude that the aggregate effects are straightforward and cumulative. It is often the case that policies examined individually seem beneficial but, when taken together, they are sometimes revealed as working at cross-purposes, perhaps proving less beneficial than assumed or sometimes even harmful (Rose 1993). Thus, a collective empirical assessment seems in order.

3. An initial assessment of impacts from post-productivity slowdown policies

An inspection of the trend in inflation-adjusted industrial R&D investments in Fig. 2 shows a decline in the period 1969–71, an increase in the period 1972–4, and then a decline in 1975. Afterwards, the trend was generally increasing but with periodic slowdowns. Thus, based on Fig.

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[8] These leveraged R&D investments have been shown to increase the probability that the SBIR-funded project would be successful, where success is measured in terms of the probability of the developed technology being commercialized (Link and Ruhm 2009; Link and Scott 2009, 2010).

[9] Subsequent economic theory supports this assertion (Vonortas 1997; Hagedoorn et al. 2000; Link 2006; Link et al. 2002; Combs and Link 2003).

[10] We thank an anonymous referee for emphasizing that technology and innovation policies are not discrete actions: one policy often leads to another policy or legislative directive. We contend that the five policies discussed in Table 1 are foundational in the sense that subsequent initiatives have built on their focus. Of course, additional research is warranted to substantiate our conjecture. Such research might follow a mapping process such as that in Hall et al. (2014).

2, it appears that industrial R&D investments began to pick up in 1976 prior to the introduction of the five Acts discussed above. However, that increase may have been precipitated by economic factors other than the technology and innovation polices summarized in Table 1.

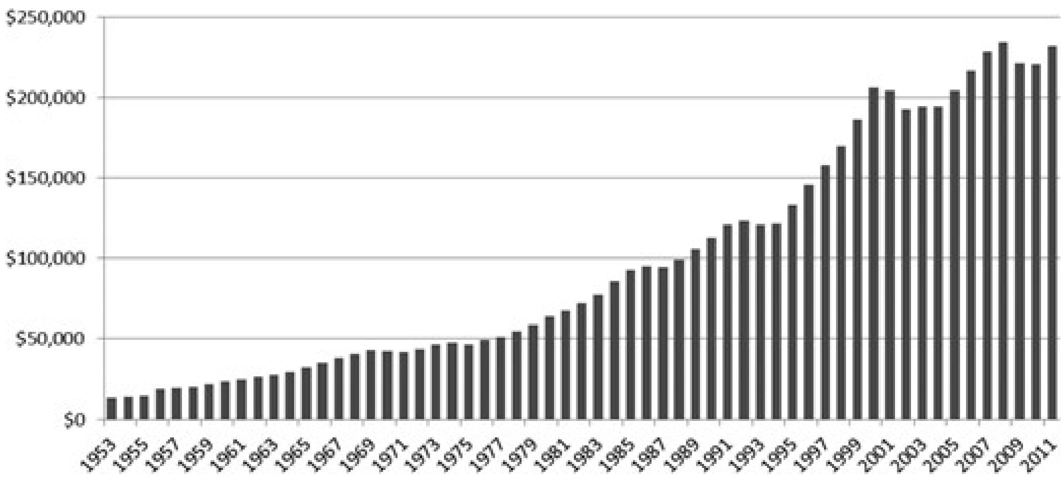

Figure 2. Industrial R&D expenditures, 1953–2011 (millions $2005).
Source: Figure 2 and Bureau of Labor Statistics: < http://www.bls.gov/mfp/mprdload.htm >.

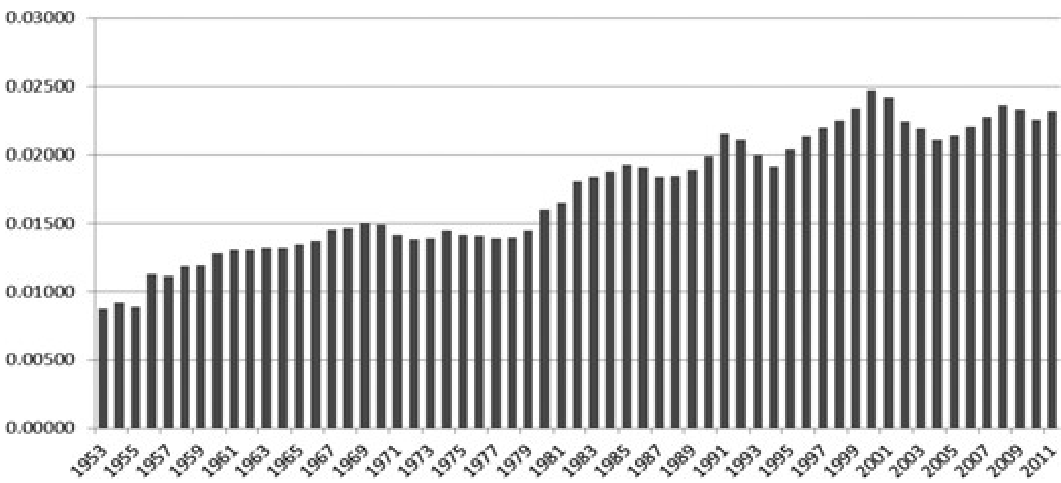

Figure 3. Ratio of industrial R&D investments (millions $2005) to value added in private business sector (millions $2005).
Source: National Science Board (2012) and < http://www.nsf.gov/statistics/infbrief/nsf13313/ >.

In an effort to explore the trend in industrial R&D investments that is relative to other economic factors, Fig. 3 shows the ratio of industrial R&D investments to value added in the private business sector. Fig. 3 shows that the ratio of R&D to value added begins to increase around 1980 followed by several cyclical declines. With reference to the pattern over time in Fig. 3, we initially considered a descriptive model of the form:

$$R\&D/VA = \alpha + \beta Year + \varepsilon \quad (1)$$

where *R&D/VA* is the ratio of industrial R&D investments to value added in the private business sector, *Year* is an annual counter for the period 1953–2011, and ε is a random error term. Descriptive statistics for these variables are given in Table 2.

Table 2. Descriptive statistics on variables in Equations (1) and (2), $n = 59$

Variable	Mean	Standard deviation	Range
R&D	\$96.98 billion [1]	71.87	13.6234.2
VA	\$4,974 billion [1]	2,755	1,540–10,030
R&D/VA	0.0174	0.0044	0.0087–0.0247
Year	1982	17.18	1953–2011
Dmy_1	0.525	0.504	0/1
Dmy_2	0.186	0.393	0/1

Delimiting the analysis are data on R&D. First year of published R&D data by the National Science Foundation (NSF) is 1953.
See Link (1996) for a brief history of NSF's R&D definition's and collection processes.

The results from the estimation of Equation (1) are in column (1) of Table 3. The estimated coefficient on *Year* is positive, as expected from Fig. 2, and it is statistically significant. However, the structure of Equation (1) is not stable over time. Based on recursive regressions on Equation (1), we identified two significant break points in the data. One statistical break point occurs in 1981 and the other statistical break point occurs in 2001. A visual inspection of Fig. 3 also suggests these break points.[11] Thus, a more accurate characterization of Fig. 3 is that the data reveal three splines, the first covering the period 1953–80,[12] the second covering 1981–2000, and the third spanning 2001–11.

Table 3. Least-squares regression results from Equation (2), $n = 59$ (standard errors)

Variable	(1)	(2)
Intercept	−0.476	−0.401
	(0.0334) **	(0.055) **
Dmy_1		−0.259
		(0.109)*
Dmy_2		0.660
		(0.253) **
Year	0.000025	0.00021
	(0.000017) **	(0.000028) **
$Year*Dmy_1$		0.00013
		(0.000055)*
$Year*Dmy_2$		−0.00033
		(0.00013) **
R^2	0.9777	0.9806
Durbin-Watson	2.025	1.8548

Yule–Walker procedure was used to correct for serial correlation.
**significant at 0.01 level, *significant at 0.05 level.

Based on the statistical identification of these two structural breaks, Equation (1) was re-specified as:

[11] These break points were identified by both a cumulative sum (cusum) and a cumulative sum of squares (cusumsq) statistic at the 0.05 level. Chow tests also show that the breaks in these two years are more significant that in any neighboring years.
[12] The Bayh–Dole Act and Stevenson–Wydler Act were passed in December 1980.

$$R\&D/VA = \alpha + \beta_1 Dmy_1 + \beta_2 Dmy_2 + \beta_3 Year + \beta_4 Year * Dmy_1 + \beta_5 Year * Dmy_2 + \varepsilon \quad (2)$$

where Dmy_1 = 1 for the years 1981–2000 and 0 otherwise, and where Dmy_2 = 1 for the years 2001–11 and 0 otherwise.

The results from the estimation of Equation (2) are shown in Table 3 in column (2). The principle finding from these regression results are that the estimated coefficient on $YearDmy_1$ is positive and statistically significant. We interpret this finding to mean that the technology and innovation policies summarized in Table 1, and their amendments (and possibly related initiatives during the 1990s), had a positive and measurable impact on the relative level of industrial R&D spending. But, this impact does not appear to be permanent. The fact that the estimated coefficient on $YearDmy_2$ is negative, statistically significant, and numerically larger than the estimated coefficient on *Year* could be interpreted as suggestive evidence that the relative industrial R&D impact of the technology and innovation policies under study has waned.

4. Conclusions

The findings presented in Table 3 suggest that the technology and innovation policies under study in this paper—and these are the policies that shaped the post-productivity slowdown legislative response—did indeed have a measurable impact on the relative level of industrial investments in R&D, but that impact has waned.

Thus, this paper provides two contributions to the extant literature, albeit that these contributions follow from what is an exploratory empirical analysis. First, analyzing the technology and innovation policies collectively allows inference about the overall strategic importance of disparate policies aimed at addressing the historic productivity slowdown in the USA. This is not to say that the policies were systematically integrated in design and intent, only that they had the same broad goals and, thus, were *de facto* strategic policies. A second contribution is equally important, suggesting the directional impact of these technology and innovation policies. Having such an initial estimate as we have presented here could be useful to policy-makers who seek to use technology and innovation policies instrumentally to remedy future economic declines but who have no basis whatsoever for estimating the likely extent of their impacts.

That said, any generalizations from the findings presented in this paper should be interpreted cautiously. First, the ability to model the interaction of policies with contemporaneous economic events and with related non-technology/innovation policies remains quite limited. Second, as with many policy assessments, attribution is critical yet difficult. Thus, we do not know precisely from our empirical findings the extent to which the policies in question, even denominating industrial R&D investments by value added to control for other economic factors, increased or even leveraged the spending on industrial R&D in the USA. Thus, a next and more challenging research step is to model the interactive effects of technology and innovation policies and both industrial and federal R&D investments to determine the net social benefits of policies.

References

Atkinson, R. D. (2007) 'Expanding the R&E tax credit to drive innovation, competitiveness and prosperity', Journal of Technology Transfer, 32: 617–28.

Berger, P. G. (1993) 'Explicit and implicit tax effects of the R&D tax credit', Journal of Accounting Research, 31: 131–71.

Bloom, N., Griffith, R. and Van Reenen, J. (2002) 'Do R&D tax credits work? Evidence from a panel of countries 1979–1997', Journal of Public Economics, 85: 1–31.

Bozeman, B. (1994) 'Evaluating government technology transfer', Policy Studies Journal, 22: 322–37.

—— and Link, A. N. (1985) 'Public support for private R&D: The case of the research tax credit', Journal of Policy Analysis and Management, 4: 370–82.

——, —— and Zardkoohi, A. (1986) 'An economic analysis of R&D joint ventures', Managerial and Decision Economics, 7: 263–6.

Brooks, H. (1996) 'The evolution of U.S. science policy'. In: Smith, B. and Barfield, C. (eds) Technology, R&D, and the Economy, pp. 15–48. Washington DC: Brookings Institution.

Bush, V. (1945) Science—the Endless Frontier. Washington, DC: US Government Printing Office.

Combs, K. L. and Link, A. N. (2003) 'Innovation policy in search of an economic foundation: The case of research partnerships in the United States', Technology Analysis and Strategic Management, 15: 177–87.

Crow, M. M. and Bozeman, B. (1998) Limited by Design: R&D Laboratories in the U.S. National Innovation System. New York: Columbia University Press.

DelaBarre, D. M. (1986) 'Federal Technology Transfer Act of 1986: PL99-502 at a glance', Journal of Technology Transfer, 11: 19–20.

Eisner, R., Albert, S. H. and Sullivan, M. A. (1984) 'The new incremental tax credit for R&D: Incentive or disincentive?', National Tax Journal, 37: 171–83.

Executive Office of the President. (1990) U.S. Technology Policy. Washington, DC: Office of Science and Technology Policy.

Gallaher, M. P., Link, A. N. and Petrusa, J. (2006) Innovation in the U.S. Service Sector. London: Routledge.

Guenther, G. (2013) 'Research tax credit: Current law, legislation in the 113th Congress, and policy issues'. Washington, DC: Congressional Research Service.

Guston, D. H. (2000) 'Retiring the social contract for science', Issues in Science and Technology, 16: 32–6.

Hagedoorn, J., Link, A. N. and Vonortas, N. S. (2000) 'Research partnerships', Research Policy, 29: 567–86.

Hall, M. J., Layson, S. K. and Link, A. N. (2014) ‘The returns to R&D: Division of policy research and analysis at the National Science Foundation’, Science and Public Policy, 41: 458–63.

Kenney, M. and Patton, D. (2009) ‘Reconsidering the Bayh–Dole Act and the current university invention ownership model’, Research Policy, 38: 1407–22.

Kleinman, D. L. (1995) Politics on the Endless Frontier: Postwar Research Policy in the United States. Durham, NC: Duke University Press.

Lee, Y. and Gaertner, R. (1994) ‘Technology transfer from university to industry’, Policy Studies Journal, 22: 384–99.

Leyden, D. P. and Link, A. N. (forthcoming) Public Sector Entrepreneurship. New York: OUP.

Link, A. N. (1987) Technological Change and Productivity Growth. Chur, Switzerland: Harwood Academic.

—— (1989) Cooperative Research in U.S. Manufacturing: Assessing Policy Initiatives and Corporate Strategies. Lexington, MA: D. C. Heath.

—— (1996) ‘On the classification of industrial R&D’, Research Policy, 25: 397–401.

—— (2006) Public/Private Partnerships: Innovation Strategies and Policy Alternatives. New York: Springer.

—— and Link, J. R. (2010) Government as Entrepreneur. New York: OUP.

——, Paton, D. and Siegel, D. S. (2002) ‘An analysis of policy initiatives to promote strategic research partnerships’, Research Policy, 31: 1459–66.

—— and Ruhm, C. J. (2009) ‘Bringing science to market: Commercializing from NIH SBIR Awards’, Economics of Innovation and New Technology, 18: 381–402.

——, —— and Siegel, D. S. (2014) ‘Private equity and the innovation strategies of entrepreneurial firms: Empirical evidence from the Small Business Innovation Research Program’, Managerial and Decision Economics, 35: 103–13.

—— and Scott, J. T. (2009) ‘Private investor participation and commercialization rates for government-sponsored research and development: Would a prediction market improve the performance of the SBIR Programme?’, Economica, 76: 264–81.

—— and —— (2010) ‘Government as entrepreneur: Evaluating the commercialization success of SBIR projects’, Research Policy, 39: 589–601.

—— and —— (2012) Employment Growth from Public Support of Innovation in Small Firms. Kalamazoo, MI: W. E. Upjohn Institute for Employment Research.

—— and Siegel, D. S. (2003) Technological Change and Economic Performance. London: Routledge.

——, —— and Van Fleet, D. D. (2011) ‘Public science and public innovation: Assessing the relationship between patenting at U.S. National Laboratories and the Bayh–Dole Act’, Research Policy, 40: 1094–9.

Mason, R. O. (1979) ‘The role of management in science’, Public Administration Review, 39: 112–6.

Mowery, D. C., Nelson, R. R., Sampat, B. N. and Ziedonis, A.A. (2001) ‘The growth of patenting and licensing by U.S. universities: An assessment of the effects of the Bayh–Dole Act of 1980’, Research Policy, 30: 99–119.

—— and Sampat, B. N. (2005) ‘The Bayh–Dole Act of 1980 and university–industry technology transfer: A model for other OECD governments?’, Journal of Technology Transfer, 30: 115–27.

—— and Ziedonis, A. A. (2002) ‘Academic patent quality and quantity before and after the Bayh–Dole Act in the United States’, Research Policy, 31: 399–418.

National Science Board. (2012) Science and Engineering Indicators, 2012. Arlington, VA: National Science Foundation.

Rafferty, M. (2008) ‘The Bayh–Dole Act and university research and development’, Research Policy, 37: 2–40.

Rose, R. (1993) Lesson-Drawing in Public Policy: A Guide to Learning across Time and Space. Chatham, NJ: Chatham House.

Shapely, W. H. (1979) ‘Federal R&D support’. In: Perkins, C.D. (ed.) Industrial Innovation and Public Policy Options, pp. 51–64. Washington, DC: National Academy Press.

Siegel, R. (1979) ‘Why has productivity slowed down?’, Data Resources U.S. Review, 1: 59–65.

Stevens, A. J. (2004) ‘The enactment of Bayh–Dole’, Journal of Technology Transfer, 29: 93–9.

Tassey, G. (2007) ‘Tax incentives for innovation: Time to restructure the R&E tax credit’, Journal of Technology Transfer, 32: 605–15.

Turner, J. (2006) ‘The next innovation revolution: Laying the groundwork for the United States’, Innovations, spring issue: 123–44.

Vonortas, N. S. (1997) Cooperation in Research and Development. Boston, MA: Kluwer.