

## Vannevar Bush: A Public Sector Entrepreneur

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### Abstract:

In this monograph, I define public sector entrepreneurship in terms of innovative public policy initiatives that generate greater economic prosperity by transforming a *status quo* economic environment into one that is more conducive to economic units engaging in creative activities in the face of uncertainty. Using that definition, I propose that Vannevar Bush is a quintessential example of a public sector entrepreneur. I then propose that the Bayh-Dole Act of 1980 is an innovative public policy initiative that has ingredients of Bush’s philosophy about the role of government in technological advancement. Using Bush and the Bayh-Dole Act as examples of public sector entrepreneurship, I conclude the monograph with framework that might serve as a unifying taxonomy for interpreting future research on public sector entrepreneurship.

**Keywords:** public sector entrepreneurship | Vannevar Bush | public policy

### Article:

#### 1 An Overview of the Monograph

*It ain't what they call you, it's what you answer to.*  
—W.C. Fields

*Who in the world am I? Ah, that's the great puzzle!*  
—Lewis Carroll (Alice)

I would not be surprised if many readers who are interested in the topic of entrepreneurship, or if the many students who study entrepreneurship as either an intellectual concept or a vocational pursuit, do not recognize the name *Vannevar Bush*. And, I would also not be surprised if many who are about to embark on a journey through the pages that follow are not familiar with the use of the term *public sector* as an adjective to modify the term *entrepreneurship*. In this opening section, I will bound the scope of the monograph by clarifying who Dr. Vannevar Bush was and what is meant by the term *public sector entrepreneur*.

Before I go into selected details about Vannevar Bush and public sector entrepreneurship, I offer the following overview of what is to follow. First, herein the term *public sector entrepreneurship* is defined as (Leyden and Link, 2015, p. 14):

[P]ublic sector entrepreneurship refers to innovative public policy initiatives that generate greater economic prosperity by transforming a *status quo* economic environment into one that is more conducive to economic units engaging in creative activities in the face of uncertainty.

Or, as rephrased by Hayter *et al.* (2018, p. 682):

Public-sector entrepreneurship refers to the formation of innovative public-sector initiatives that transform a *status quo* social and economic environment into one that is more conducive to creative change in the face of uncertainty.

And, the “public policy initiatives” or “public-sector initiatives” mentioned in these two definitions, and that will be discussed as examples of public sector entrepreneurship in the following sections, began, at least in part, to be initiated or put in place in the late-1970s and early 1980s because of the entrepreneurial insight exhibited by Vannevar Bush in the 1940s.

One can tell from the Leyden and Link (2015) definition and from the Hayter *et al.* (2018) restatement, that my focus in this monograph is on the public policy performance of an entrepreneur who is active in the public sector (Demircioglu and Chowdhury, 2020). Hereafter, I use the Leyden and Link definition as the benchmark for who a public sector entrepreneur is and what a public sector entrepreneur does. More specifically, I use the Leyden and Link definition to make the case that Bush is a quintessential example of a public sector entrepreneur.<sup>1</sup>

## 1.1 Background on Vannevar Bush

Vannevar Bush was born in 1890 in Everett, Massachusetts. This was, for Bush, a fortuitous time to be alive (Zachary, 1997, p. 22):<sup>2</sup>

In the 1890s, an outpouring of technical advances was undermining old patterns in American life—and was a fast path to riches. Bush could not have missed this ‘technological torrent.’

Educationally, Bush graduated from Tufts College in 1913, and he received the Ph.D. from the Massachusetts Institute of Technology (MIT) in 1916. Skipping ahead in time, although one can read in Zachary’s (1997) excellent biography about Bush and his experiences prior to being active in Washington, DC, I want to emphasize in this section Bush’s Washington, DC

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<sup>1</sup> I thank Irwin Feller for pointing out to me that perhaps the earliest example of a public sector entrepreneur is Alexander Hamilton (1757–1804). To this point, see <https://www.freenterprise.com/americas-founding-small-business-owners/>.

<sup>2</sup> As a personal acknowledgement, Zachary (1997) has been an invaluable reference source for detailed information about Vannevar Bush. His book is an example of brilliant scholarship.

experiences as a means to set the stage for later asserting that Bush was a public sector entrepreneur in the Leyden and Link (2015) sense.

In 1938, while holding the offices of Vice President of MIT and Dean of its School of Engineering, Bush was appointed to the National Advisory Committee for Aeronautics (NACA) where he acquired “his first taste of the bewildering politics surrounding military technology” (Zachary, 1997, p. 86).<sup>3</sup> In 1939, Bush arrived in Washington, DC, where, on January 1, he became president of the Carnegie Institution of Washington. As chronicled, Bush arrived in Washington, DC with confidence about his ability to initiate change (Zachary, 1997, p. 96):

Bush had strong opinions about the institution’s general direction. He believed he could gain a working grasp of any scientific subject with a few days study . . . He thought the institution should support only the core, hard sciences, dispensing with “marginal” subjects such as the history of science and archaeology.

While World War II was underway in Europe, Bush exhibited his natural personality of being a perceptive as well as a forward looking individual, a characteristic of an entrepreneur as discussed in the following section. As Zachary (1997, p. 103) wrote:

Bush had neither been in combat nor studied military history. Yet, he wisely asserted that every innovation in war could be stymied by a counter-innovation . . . He glimpsed around the curve of knowledge, exuding a poise and confidence that tomorrow’s invention would erase the advantage of today’s dominant weapons . . . He foresaw a large role for research in the second world war even as he worried how to convince the Army and the Navy to push for common solutions to technical problems. Civilians were essential to mobilization, Bush knew, yet no existing organization, inside or outside the military, could produce the required technical advances.

As Zachary (1997) explained, the National Academy of Science (the Academy) was the premier assemblage of scientists at the time, and its members had to be won over to the idea that government support of research, basic research in particular, was for the good of the nation and that the military was not the only organizational structure to advance defense innovations (Zachary, 1997, pp. 106, 109):

Bush’s [had] confidence that military men would accommodate scientists. But would scientists accept military rules?

Only a new organization, free of the legacy of mistrust that had plagued past collaborations between researchers and the military, could satisfy the needs of the moment. Only Bush had a neck stiff enough to run it.

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<sup>3</sup> “The National Advisory Committee for Aeronautics (NACA) was a U.S. federal agency founded on March 3, 1915 to undertake, promote, and institutionalize aeronautical research. On October 1, 1958 the agency was dissolved, and its assets and personnel [were] transferred to the newly created National Aeronautics and Space Administration (NASA).” See, <https://digital.library.unt.edu/explore/collections/NACA/>.

The next step was for Bush to meet with President Roosevelt and to champion himself and his ideas. With the help of others, a meeting was scheduled for Bush to meet with the president in early June 1939. This meeting would allow Bush to act, through this opportunity, on his perception that having government support research was for the common good. By the end of Bush's June 12 15-minute meeting with President Roosevelt, the president had agreed to the formation of the National Defense Research Committee, and for the Committee to (Zachary, 1997, p. 115):

. . . correlate and support scientific research on mechanisms and devices of warfare [and to support] with funds for office staff, and for financing research in laboratories of educational and scientific institutions or industry.

The rapidity with which the President agreed to the formation of the National Defense Research Committee was possibly due to the logical and pervasive way that Bush proposed it, as well as to the President's own concerns about the role, if any, that the United States would have in the war in Europe. The conclusion that I draw from Bush's meeting with President Roosevelt and the President's almost immediate positive response to Bush's ideas (keeping in mind the theme of this monograph) is that Bush perceived an opportunity for a new approach for government support of defense research that included the expertise of civilian researchers, and he had the ability to act on that opportunity through the creation of the National Defense Research Committee.

Bush's so-called *federalism by contract* system—so called by Bush's critics—allowed for a national network of the very best scientists to be assembled to work on the nation's defense efforts within their own laboratories.<sup>4</sup> The *federalism by contract* approach to defense-related research represented a “shift in American governance” from a military structured approach to defense research to one in which scientists could not only identify and pursue relevant basic research but also could pursue that basic research themselves in an atmosphere of uninterrupted funding (Zachary, 1997, pp. 118–119).<sup>5</sup>

While Bush had agreed to a close collaboration with the military in the aftermath of his June 12 meeting with President Roosevelt, Bush was, according to Zachary (1997, p. 131):

. . . simply not interested in listening to the views of the military. [However, it] became more difficult over time for the military to dismiss his views about the “centrality of expertise in a complex world.”

The military eventually ceded to Bush some of their authority over the need for and the design of new weapons.

The National Defense Research Committee was funded through the President's emergency funds. In May 1941, President Roosevelt approved Bush's request for the formation of the Office

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<sup>4</sup> The National Defense Research Committee encouraged, and was also successful in attracting, civilian scientists to military research (Link, 2021).

<sup>5</sup> As Zachary (1997) pointed out, industry could not be counted on for an uninterrupted supply of basic research funding. Their primary investment focus was on product development.

of Scientific Research and Development (OSRD). The Office of Scientific Research and Development (Wiesner, 1979, p. 97):

. . . was a remarkable invention, but the most significant innovation was the plan by which, instead of building large government laboratories, contracts were made with universities and industrial laboratories for research appropriate to their capabilities . . . Bush believed that World War II could be won only through advances in technology, and he proved to be correct.<sup>6</sup>

The purposes of the Office of Scientific Research and Development were, among other things, to:<sup>7</sup>

e. Initiate and support scientific research on the mechanisms and devices of warfare with the objective of creating, developing, and improving instrumentalities, methods, and materials required for national defense.

f. Initiate and support scientific research on medical problems affecting the national defense.

g. Initiate and support such scientific and medical research as may be requested by the Government of any country whose defense the President deems vital to the defense of the United States under the terms of the Act of March 11, 1941, entitled ‘An Act to Promote the Defense of the United States’; and serve as the central liaison office for the conduct of such scientific and medical research for such countries.

This Office of Scientific Research and Development became a funding vehicle for Bush’s research agenda implemented through contracted scientists because the Office of Scientific Research and Development would receive funds directly from Congress rather than from the President’s emergency funds. As explained by Zachary (1997, p. 133):<sup>8</sup>

Bush [as director of the Office of Scientific Research and Development] now had the authority to build small batches of weapons and equipment created by his researchers . . . Bush could go ahead with production himself, demonstrate the weapon and then dare the service [i.e., the Army and the Navy] to ignore it.

Bush utilized institutional laboratories and the resources of government agencies through the Office of Scientific Research and Development’s support of federal research centers. The first such federal research center was the Radiation Laboratory at MIT, which was operational before the Office of Scientific Research and Development was officially formed (Dale and Moy, 2000). These federal research centers were soon referred to as Federal Contract Research Centers

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<sup>6</sup> Recall the quote above from Zachary (1997, p. 103) about what Bush believed: “every innovation in war could be stymied by a counter-innovation.”

<sup>7</sup> See, <https://www.presidency.ucsb.edu/documents/executive-order-8807-establishing-the-office-scientific-research-and-development>.

<sup>8</sup> Zachary (1997) provides an in-depth discussion of the disconnect between the military and the academic community through their relationships at the Office of Scientific Research and Development.

(FCRCs) because their research programs were funded through federal contracts and because their employees—both their scientists and staff—were not federal employees (Link, 2021). The next research center was the Naval Operations Research Group, which later became the Center for Naval Analysis (Carnegie Mellon University, 2017; Link, 2021). These research centers represented the organizational harbinger of what eventually was to become Federally Funded Research and Development Centers (FFRDCs).<sup>9,10</sup>

A hallmark of Bush's tenure in the Roosevelt administration was the organizational structure he assembled to harness the brainpower of civilian researchers. To that point (Zachary, 1997, p. 142):

Bush's singular contribution to [a] "real and tough world" would not be to build more powerful bombs, but to organize the experts who would. He would not immerse himself in the making of any special weapon, but [he would] become the father, so to speak, to all weapons that would spring from the labs [such as the Radiation Lab, or Rad Lab as it was called, at MIT].<sup>11</sup>

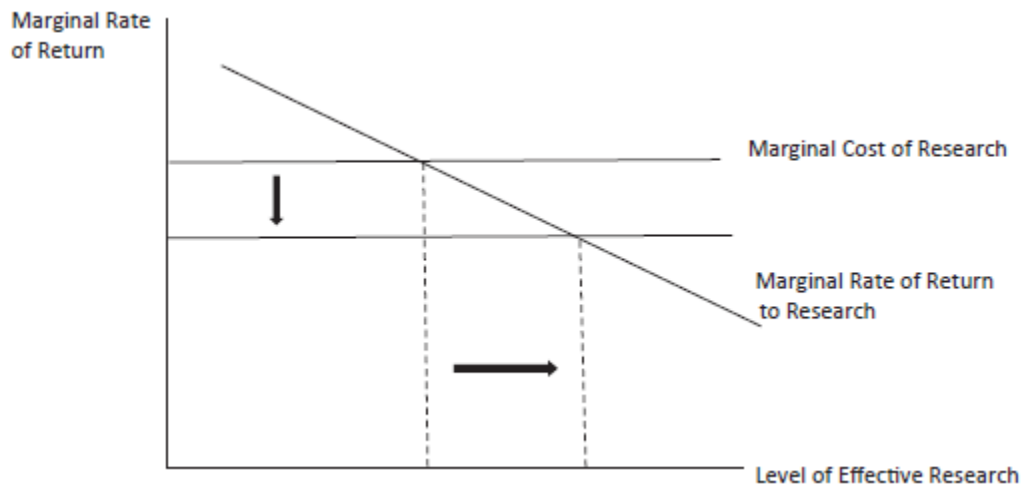
One might consider Figure 1.1 to be an analytical framework to describe Bush's actions through the formation and activation of the Office of Scientific Research and Development. Allowing scientists to work in their own university laboratory as opposed to working in a military or government laboratory was the most cost-effective way to accomplish research results. The implication of this cost effectiveness is shown in the figure. Measured on the horizontal axis is the level of effective research conducted. The marginal cost of research resources schedule is shown to be constant for simplicity. Measured on the vertical axis is the marginal cost of research resources measured as percentage equal to the opportunity cost of research resources. A downward sloping marginal rate of return to research resources schedule is shown. It is drawn to be downward sloping due to diminishing returns to the use of research resources. A decrease in the marginal cost of research resources, which is asserted to be an implication of the new organizational structure of the Office of Scientific Research and Development, is associated with an increase in the level of effective research conducted. More specifically, the increase in the level of effective research shown is (1) an increase in the level of cost-effective research, and (2) it is not necessarily the case that the Office of Scientific Research and Development or anyone else was endeavoring to increase research up to the point that the marginal benefits equaled the marginal costs. The downward arrow shows the decrease in the marginal cost of research resources and the rightward pointing arrow shows the increase in the level of effective research conducted.

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<sup>9</sup> See also, <https://www.everysreport.com/reports/R44629.html>.

<sup>10</sup> According to Link (2021, p. 2), "FFRDCs became a research infrastructure to assist the government make cost effective choices in technology development, policy formation, systems acquisition and integration, and other vital elements of government operations (OTA, 1995). Many scientists after the war did not want to move to military laboratories or did not want to be government employees. They saw benefits being in a university setting or an industrial setting. Thus, FFRDCs were in practice a vehicle through which the federal government could capture this base of scientific knowledge. Fundamentally, FFRDCs facilitate cost effectiveness by emphasizing (Carnegie Mellon University, 2017: 27): 'a commitment to the public interest, a long-term horizon, and an organizational structure outside of and apart from government, ensuring an absence of conflicts of interest.' "

<sup>11</sup> A brief history of the Rad Lab at MIT, which would become the Lincoln Laboratory is at: <https://www.ll.mit.edu/about/history/mit-radiation-laboratory>.



**Figure 1.1.** The economic impact of the organizational structure of the office of scientific research and development.

The United States declared war on Japan after it bombed Pearl Harbor on December 7, 1941. Days thereafter, Hitler (Germany) and Mussolini (Italy) declared war on the United States and President Roosevelt responded with an in-kind declaration of war.

Zachary (1997, pp. 151–152), described what happened to Bush after President Roosevelt declared war:

With the U.S. officially at war, the media turned to trumpeting the nation’s prospects and shipping up enthusiasm for its leaders. Bush’s relative anonymity vanished. Overnight, he became a minor celebrity . . . [*Collier’s* magazine painted]<sup>12</sup> the image of Bush as king of the scientists and engineers in an age when technological advantage determined national security . . . The key to gaining this technical advantage . . . wasn’t necessarily assigning the smartest individuals to a problem, but assigning the smartest *team* [emphasis added] of people . . . By the early 1940s, a compelling group of leaders had emerged with an attempted solution . . . [T]hese leaders sought to blend the best features of the public and private sectors by fusing ‘the entrepreneurial role with a penchant for action in the public sphere’ . . . At once a technical expert and bureaucratic wizard, the *public entrepreneur* [emphasis added] had ‘the expertise, the charisma, and the will to move burgeoning governmental agencies to undertake actions that might otherwise be stalled by democratic politics.’ Significantly, this new kind of leader ‘creates or profoundly elaborates a public organization so as to alter greatly the existing pattern of allocation of scarce resources. Such persons arise and succeed in organization and political milieus which contain contradictory mixes of values received from the past. *Public entrepreneurs* [emphasis added] characteristically exploit such contradictions.’<sup>13</sup>

<sup>12</sup> For the history of *Collier’s* magazine see, <https://colliersmagazine.com/about-us/>.

<sup>13</sup> The quoted sentences in the passage quoted from Zachary came from Graebner (1991), p. 66.

Bush's role in the development of the atomic bomb is clearly described in Zachary (1997). For the theme of this monograph, the background about Bush offered above is sufficient for me to, at a minimum, make the case that Bush was an entrepreneur whose actions took place in the public sector. Exhibiting the entrepreneurial talent of perceiving an opportunity and having the ability to act on that perception while employed in the public sector (i.e., employed in the U.S. government during the Roosevelt Administration) does not in itself define Bush as a public sector entrepreneur as defined by Leyden and Link (2015, p. 14) above.

However, I will attempt to make the case in what follows in this monograph that Bush's actions which led to the creations of the Office of Scientific Research and Development, and which were described by the phrase *federalism by contract*, do define him in the Leyden and Link (2015) sense of being a public sector entrepreneur.

In the following subsection of this section I summarize historical thought about who the entrepreneur is and what he/she does. A number of the characteristics or themes of an entrepreneur set forth by the classical and semi-modern scholars are revealed through Bush's actions and activities that have been briefly summarized above. Historical thought on the topic of entrepreneurship provides the context for the topic of public sector entrepreneurship which I discuss in the final subsection of this section and again in Section 2.

## 1.2 Entrepreneurship

Hébert and Link (1988, 1989, 2006a,b, 2009), as the purveyors of the contextual importance of the intellectual history of the entrepreneur and his/her entrepreneurship-related activities, identified 12 themes in the scholarly literature that describe who the entrepreneur is. These are the themes present in the classical and semi-modern writings that characterize the purposive actions of an entrepreneur.<sup>14</sup> These themes are described in terms of actions, and it is these actions that define who the entrepreneur is:

- the person who assumes the risk associated with uncertainty (Cantillon, 1931; Knight, 1921),
- the person who supplies financial capital (Smith, 1976),
- an innovator (Baudeau, 1910; Cantillon, 1931; Schumpeter, 1934, 1950),
- a decision maker (Menger, 1950),
- an industrial leader (Say, 1840, 1845),
- a manager or superintendent (Mill, 1965),
- an organizer and coordinator of economic resources (Walras, 1954, 1965),
- the owner of an enterprise (Quesnay, 1888),
- an employer of factors of production (Walker, 1866),
- a contractor (Bentham, 1952, 1962),
- an arbitrageur (Kirzner, 1973, 1979a,b, 1985), and actions as
- an allocator of resources among alternative uses (Schultz, 1975, 1980).

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<sup>14</sup> Audretsch *et al.* (2015) suggest that identifying these various actions of an entrepreneur has resulted in an eclectic paradigm for the study of entrepreneurship.



See Table 1.1.

The themes in the list above are from the classical and semi-modern writings that are important in the sense that they characterize the entrepreneur’s roles through which he/she exhibits purposive action. However, it is also important that a number of these writers go further than simply characterizing a role; they also emphasize that a characteristic of an entrepreneur is one who perceives an opportunity *and* [emphasis added]<sup>15</sup> through his/her role has the ability to act on those perceptions of opportunities. With reference to Bush, his actions as an entrepreneur in the public sector are purposive and specifically focused on public policy initiatives.<sup>16</sup> More specifically, Bush demonstrated an ability to perceive opportunities *and* the ability to act on that perception of an opportunity.<sup>17</sup> Bush thus exemplifies the dynamic nature of a public sector entrepreneur through his perception and action, or in the Leyden and Link (2015) sense through perceiving the need for a new public policy initiative that is transformative.<sup>18</sup>

**Table 1.1.** Comparison of the classical and semi-modern views of an entrepreneur to Bush

<b>Themes Associated with the Purposive Actions of an Entrepreneur . . .</b>	<b>Classical and Semi-Modern Writers</b>	<b>Vannevar Bush</b>
The person who assumes the risk associated with uncertainty	Cantillon	The risk associated with the uncertainty that the Office of Scientific Research and Development would be successful
The person who supplies financial capital	Smith	
An innovator	Cantillon, Baudeau, Schumpeter	Using contracted university scientists on defense related research projects
A decision maker	Menger	The decision to act on his perception of an opportunity
An industrial leader	Say	
A manger or superintendent	Mill	
An organizer and coordinator of economic resources	Walras	Realigning research scientists to university laboratories
The owner of an enterprise	Quesnay	
An employer of factors of production	Walker	
A contactor	Bentham	
An arbitrageur	Kirzner	Dealing with the military norms
An allocator of resources among alternative uses	Schultz	Realigning research scientists to university laboratories

<sup>15</sup> My emphasis on the word *and* is intended to emphasize that an entrepreneur exhibits both perception as well as action; both characteristics are necessary conditions of entrepreneurship.

<sup>16</sup> From my perspective, the extant literature reviewed in Section 2 shows that not all public sector entrepreneurs are defined in terms of a focus on public policy initiatives. The literature reports a variety of performance outcomes resulting from public sector entrepreneurship. However, herein I emphasize the focus on public policy initiatives in the Leyden and Link (2015) sense.

<sup>17</sup> With reference again to classical writers, von Wieser (1927, p. 327) thought about a multifarious entrepreneur as being required to be, at a minimum, multitalented: “he must possess the quick perception that seizes new terms in current transactions as his affairs develop; [and] he must possess the independent forcefulness to regulate his business according to his views.”

<sup>18</sup> As Kirzner (1985, pp. 63–64) wrote: “In the [dynamic] case entrepreneurial alertness must include the entrepreneur’s perception of the way in which creative and imaginative action may vitally shape the kind of transactions that will be entered into in future . . . periods.”

### 1.3 Bush: A Public Sector Entrepreneur

To substantiate my claim that Bush was not only an entrepreneur in the public sector but also a public sector entrepreneur, I repeat here for the purpose of emphasis the Leyden and Link (2015, p. 14) definition:

[P]ublic sector entrepreneurship refers to innovative public policy initiatives that generate greater economic prosperity by transforming a *status quo* economic environment into one that is more conducive to economic units engaging in creative activities in the face of uncertainty.

And, by reflecting on quoted portions of this definition, my view of Bush's efforts to champion the National Defense Research Committee and especially the Office of Scientific Research and Development has yielded the proposition that these are the quintessential examples of a transformation of the "*status quo* economic environment" which established a foundation for "economic units engaging in creative activities in the face of uncertainty." The "creative activities" were the basic research projects undertaken in large part in universities and through the harnessing of the brainpower of contracted civilian researchers in, generally, university laboratories as part of a team approach to science. The "uncertainty" was about what knowledge would result from the basic research and whether that knowledge would leverage industrial applied research and development for an improvement in U.S. defense.

As with many innovative ideas and practices, there are spillover effects, and some of the spillover effects have positive benefits (i.e., positive externalities) to the economy.<sup>19</sup> And, in my view, the conceptual foundation that Bush's insight engendered—insight about government supported research that gives autonomy to scientists and to their research staffs—is itself the *per se* positive spillover benefit of Bush being a public sector entrepreneur. These positive spillover benefits, which transformed "a *status quo* economic environment," are reflected in *Science—the Endless Frontier*, in the eventual establishment of the National Science Foundation (NSF), and in a number of subsequent public policies initiated by Congress such as the Bayh-Dole Act of 1980, the 1990 *U.S. Technology Policy* statement, and The Endless Frontier Act.<sup>20</sup>

In Section 2, I review the extant literature, authored by scholars from a number of academic disciplines, on the topic of public sector entrepreneurship (and like-named topics), and I draw several unifying themes from that literature.

In Section 3, I discuss Bush's report to President Truman entitled *Science—the Endless Frontier* and the eventual establishment of the National Science Foundation, and I also note in Section 3 the public sector entrepreneurship themes reflected in *Science—the Endless Frontier*. Finally, I emphasize in this section that Bush's view was in favor of a government having an indirect role in its support of research.

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<sup>19</sup> Bush's innovativeness came in the form of disembodied knowledge. See Kennedy (2013) for a discussion of different forms of innovation and innovativeness.

<sup>20</sup> The Bayh-Dole Act of 1980 is discussed in some detail in Section 4. The *U.S. Technology Policy* statement and The Endless Frontier Act are discussed in some detail in Section 5.

In Section 4, I offer the view that the Bayh-Dole Act of 1980<sup>21</sup> might, more than any other modern legislation, epitomize Bush's views about government funded university-based research and the ownership of that research. And, I conclude in Section 4 that Bush's points of view have transcended time, and they are reflected in the current day through legislation similar to the Bayh-Dole Act in numerous other countries.

The monograph concludes in Section 5 with a discussion of *U.S. Technology Policy* and a discussion of The Endless Frontier Act followed by brief summary remarks and a suggested framework for future research on public sector entrepreneurship.

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<sup>21</sup> The full title of this Act is the Patent and Trademark Act Amendments of 1980: Public Law 96-517. It is also referred to as University and Small Business Patent Procedure Act of 1980.

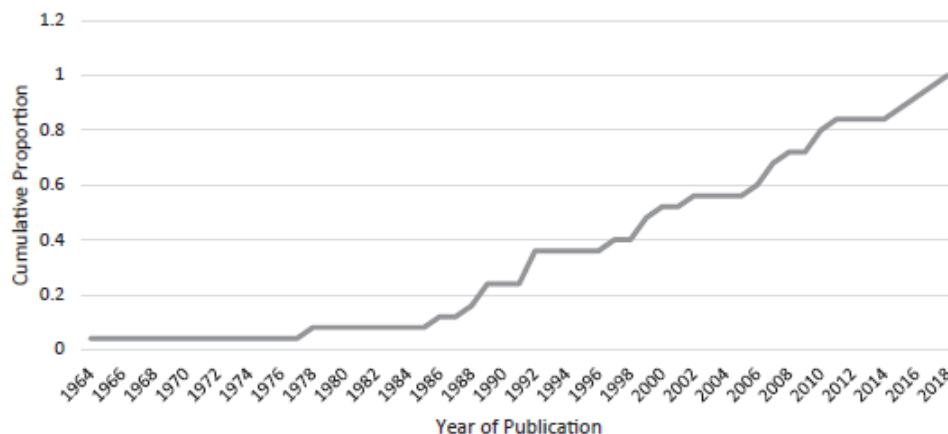
## 2 More Formally Defining Public Sector Entrepreneurship

### 2.1 What Scholars Have Said

In this section, I summarize the extant literature on the relationship between the concept of entrepreneurship and the public sector as the location for an entrepreneur's entrepreneurial activity. I am not claiming that the literature review that follows relates to public sector entrepreneurship *per se* because scholars in different disciplines are certainly entitled to advance a concept within their disciplines' paradigm of behavior. However, I am offering this review as a starting point for characterizing and understanding the context of this concept, and not unexpectedly, I am using the Leyden and Link (2015) definition of public sector entrepreneurship as the initial benchmark for the reader to use as a comparison.

Table 2.1 presents alternative conceptualizations and definitions of the relationship between entrepreneurial activity and the public sector.<sup>1</sup> Each entry contains a quoted passage that illustrates the author's (authors') explicit or implied definition of public sector, or sometimes just public, entrepreneurship.

A number of generalizations can be seen from the information in Table 2.1, as I discuss in the subsections below. But first, consider the chronology associated with the cited literature, that is the years over which definitions have been put forth. Figure 2.1 illustrates through what might be called an arrival model. Figure 2.1 illustrates, with the curve over time of the cumulative proportion of the literature published, the trend in the arrival of the cited literature into the printed public domain. The curve itself shows the cumulative proportion of the literature that has appeared any given time, and the slope of the curve would then reflect so-called arrival rates. A structural change appears to have occurred in the mid-1980s, but the smoothness of the trend in arrival rates as reflected in the slope of the curve since then suggests to me that the topic of public sector entrepreneurship, from an academic perspective, is growing in importance.



**Figure 2.1.** Cumulative proportion of the cited literature on public sector entrepreneurship arriving into the printed public domain.

Source: Based on Table 2.1.

<sup>1</sup> Any omissions from this list of contributions to the literature are unintentional, and clearly that—an unintended act of omission.

**Table 2.1.** Views about public sector entrepreneurship.

Author(s)	Entrepreneurial Activity
Ostrom <sup>a</sup> (1964, pp. 1–2)	“[Public] entrepreneurship is a particular form of leadership focused primarily on problem solving and putting heterogeneous processes together in complementary and effective ways . . . [P]ublic entrepreneurs working closely with citizens frequently do find new ways of putting services together, using a mixture of local talent and resources. The costs of effective self-organization are lower when formal authority exists to craft institutions that match the problems faced.”
Jones (1978, p. 499)	“A political entrepreneur is someone who recognizes that a group of individuals share a desire for the provision of a collective good or common goal, and who believes there to be a profit to himself in undertaking the costs of providing an organization which will furnish such a goal. One may assume that his intention is to maximize this profit, and in the pursuit of this he may mobilize an otherwise latent group of individuals.”
Ramamurti (1986, pp. 144–155)	“The public entrepreneur, like his private counterpart, is a highly creative, self-confident person with many innovative ideas, who works doggedly to translate his ideas into reality . . . The public entrepreneur . . . is a salaried manager and usually does not share in his enterprise’s profits . . . Public entrepreneurs seem to him in grandiose terms . . . Public entrepreneurs seek independence . . . [and they obtain it] by overcoming dependencies . . . The public entrepreneur is prone to take the personal risk of acting with approval on [his] assumption that rule-breaking will be condoned if the results that it produces are considered good . . . Public entrepreneurs have a high tolerance for ambiguity and have no difficulty living with unresolved conflicts among goals . . . the public entrepreneur is also prone to exploit the principle that success will permit more rule-breaking; starting with relatively minor violations and relatively minor successes, he is likely to move towards relatively major violations in the hope of relatively major successes . . . and the public entrepreneur is also likely to search very carefully inside the organization for good people who can be motivated by the same non-economic incentives that drew him to the public sector in the first place.”
Oakerson and Parks (1988, p. 106)	“Public entrepreneurship can be understood as a response to citizen voice. Public entrepreneurs, like private entrepreneurs, seek to build enterprises that can survive and grow. To do so, a private entrepreneur must relate both to a product market where consumers make the critical decisions and to a factor market where a combination of individual factor owners and firms make the critical decisions. In a complex metropolitan area, a public entrepreneur is in a similar position. To succeed, he or she must relate both to a set of primary local jurisdictions in which citizens make the critical decisions and to a multijurisdictional environment in which other public agents make the critical decisions. Private entrepreneurship without the constraint of the marketplace is dysfunctional; it leads to monopoly power and the sacrifice of consumer interests. Public entrepreneurship without the effective constraint of citizen voice may be similarly dysfunctional.”
Kirchheimer (1989, pp. 119–133)	A theory of public entrepreneurship should define the associated institutional functions: “The first entrepreneurial function is starting and managing new organizations which introduce new service . . . The second entrepreneurial function is applying innovative strategies to mobilize new resources . . . The third entrepreneurial function [is] risk bearing.”
Roberts and King (1989, pp. 10–11)	“[P]ublic sector entrepreneurship is the process of introducing innovation to the public sector. Innovation in turn is defined as the generation and implementation of new ideas.”
Bellone and Goerl (1992, p. 132)	“Public administrators who seek to be entrepreneurial have added to their responsibilities by trying to generate new sources of revenue for financing public services and providing more services that pay for themselves.”
Roberts (1992, p. 55)	“Public entrepreneurship is defined as the generation of a novel or innovative idea and the design and implementation of the innovative idea into public sector practice.”

Author(s)	Entrepreneurial Activity
Schneider and Teske (1992, p. 741)	“[P]olitical entrepreneurs develop new and innovative policies and galvanize otherwise difficult-to-organize, dispersed citizens to support their policies.”
Boyett (1997, p. 88)	“Entrepreneurship occurs in the public sector where there is an uncertain environment, a devolution of power, and at the same time re-allocation of resource ownership, to unit management level. It is driven by those individuals, particularly susceptible to the ‘manipulation’ of their stakeholders and with a desire for a high level of social ‘self-satisfaction’, who have the ability to spot market opportunities and who are able through follower ‘manipulation’ to act on them.”
Moon (1999, pp. 32–33)	There are “three different dimensions for managerial entrepreneurship: product-based entrepreneurship, process-based entrepreneurship, and behavior-based entrepreneurship. Product-based managerial entrepreneurship emphasizes the quality of the final outcome (product or service) that an organization produces . . . process-based managerial entrepreneurship . . . refers to the improvements in administrative procedures, intraorganizational communications, and intraorganizational interactions [and] behavior-based managerial entrepreneurship refers to the propensity for risk-taking.”
Morris and Jones (1999, p. 71)	“Entrepreneurship [in public sector organizations] is conceptualized as a manageable process with underlying dimensions of innovativeness, risk-taking, and proactiveness.”
Sadler (2000, pp. 34–35)	<p>“[F]actors as stimulating corporate entrepreneurship in the public sector:</p> <ul style="list-style-type: none"> <li>• clearly understood objectives;</li> <li>• cohesive work groups;</li> <li>• decision-making which relies upon few integrating devices;</li> <li>• effective reward/punishment systems;</li> <li>• lack of resources fosters innovative thinking, but resources are required to implement the innovation;</li> <li>• larger organisations have more resources to innovate;</li> <li>• little or no political intrusion;</li> <li>• moderate personnel turnover;</li> <li>• multiplicity of goals particularly where government policy is inconsistent;</li> <li>• organisational autonomy;</li> <li>• outputs rather than inputs focused;</li> <li>• participative decision-making;</li> <li>• perceived competition;</li> <li>• performance objectives developed from a shared participation; and</li> <li>• turbulent operating environment.”</li> </ul>
Holcombe (2002, p. 43)	“Political entrepreneurship occurs when an individual observes and acts on a political profit opportunity. As with market entrepreneurship, entrepreneurial actions require, first, that a profit opportunity exists, second, that someone is alert enough to spot the opportunity and recognize the opportunity for profit, and third, that the individual is willing to act on the opportunity once it is spotted. Each of these three requirements are common elements.”
Shockley <i>et al.</i> (2006, p. 205)	“[P]ublic sector entrepreneurship occurs whenever a political or governmental actor is alert to, and acts on, potential political profit opportunities, thus equilibrating the policy subsystem in which the actor is embedded and moving it toward a new equilibrium.”

Author(s)	Entrepreneurial Activity
Bernier and Hafsi (2007, p. 489)	“[A] public entrepreneur . . . is an entrepreneur who contributes to building a public organization or increasing its ability to deliver services and create value.”
Schnellenbach (2007, p. 185)	“ <i>Public entrepreneurs</i> will . . . be understood [to be] individuals who promote political innovations as sketched above, i.e., non-incremental changes of political paradigms . . . <i>Political entrepreneurs</i> and <i>policy entrepreneurs</i> can be understood as special cases of the more encompassing category of public entrepreneurs. Political entrepreneurs are those who introduce political innovations in the process of competing for office, and policy entrepreneurs are those whose effort is directed directly at implementing novel policies.”
Currie <i>et al.</i> (2008, pp. 1005–1006)	<p>There are three roles for the public sector entrepreneur:</p> <p><i>Political agent</i>: Ability to understand, assess and predict the political landscape that shapes the market environment where ‘profitable’ opportunities may arise. This is particularly evident when there is significant change and turbulence within a market.</p> <p><i>Stakeholder agent</i>: Ability to navigate the way through the range of internal and external stakeholders with the variety of organizational processes that must be adhered to in order to gain wide consent for entrepreneurial development.</p> <p><i>Entrepreneurial agent</i>: Ability to identify and exploit opportunities individually or by supporting, motivating, manipulating and empowering colleagues to turn innovative ideas into organizational profit’ through entrepreneurial endeavours. This is evident where there is the mechanism to implicitly ‘pull’ innovation and entrepreneurial activity out from the organization and align it with the wider business strategy.</p> <p>The public sector entrepreneur identifies market opportunities within the political landscape, optimizes the performance-enhancing potential of innovation for the public sector organization, and carries stakeholders in a way that both permits risk and recognizes the stewardship of public sector resources.”</p>
Klein <i>et al.</i> (2010, p. 2)	“The starting point for our analysis is the idea of public agents as nominal stewards of resources that are commonly or jointly owned by members of a community. Public entrepreneurship is manifest in a variety of activities, such as changing the institutional environment or rules of the game, establishing new public organizations, creating and managing new public resources, and taking advantage of spillovers by private action for the wider good.”
Zampetakis and Moustakis (2010, p. 873)	“[E]ntrepreneurship in the public sector context may well be approached as a process, which unfolds when individuals act to pursue opportunities towards value creation . . . however, that value in the public sector is multifaceted and tightly linked with citizen welfare.”
Padt and Luloff (2011, pp. 445–446)	“Entrepreneurial governments [are] described as: competitive; community owned; result oriented; mission driven; customer driven; anticipatory; enterprising; decentralised; market oriented; and catalytic.”
Leyden and Link (2015, p. 14)	“[P]ublic sector entrepreneurship refers to innovative public policy initiatives that generate greater economic prosperity by transforming a <i>status quo</i> economic environment into one that is more conducive to economic units engaging in creative activities in the face of uncertainty.”

Author(s)	Entrepreneurial Activity
Leyden (2016, pp. 557–562)	<p>“Leyden and Link (2015) define public-sector entrepreneurship as the process by those in the public sector of identifying and exploiting heretofore unexploited opportunities, that is, by engaging in the uncertain process of public-sector innovation. Unlike private-sector entrepreneurship, this innovation process focuses on government policies. Those policies can take either a direct form that is manifest in the institutional reform of government to make it more economically productive, or an indirect form that attempts to make the private-sector environment more conducive to entrepreneurial action through changes in private-sector rules of the game. Thus, public-sector entrepreneurship refers to innovative public-policy initiatives that generate greater economic prosperity by transforming a <i>status quo</i> economic environment into one that is more conducive to individuals in either the public sector or the private sector engaging in greater innovative activities in the face of uncertainty . . . Indirect public-sector entrepreneurship is manifest through changes in laws, regulations, etc. in order to foster private-sector entrepreneurial action and hence innovation and economic growth . . . [A]cts of direct public-sector entrepreneurship can foster a more effective public sector environment that reduces the uncertainty that the public-sector entrepreneur and the public are otherwise subject to, thereby encouraging and supporting public-sector entrepreneurial action.”</p>
Dhliwayo (2017, p. 157)	<p>There are three public sector entrepreneurship (PSE) typologies:  <i>For a civil–political service agent:</i>  “Public service transformation: PSE aligns new, diverse open and collaborative service models with new opportunities for growth. The innovative, proactive process of creating value for citizens and steering towards improved quality of life.  <i>Economic facilitation and administration:</i>  Enabling and empowering firms and individuals to exploit opportunities: The development and regulation of existing and emerging markets. The state ensures that entrepreneurs and leading researchers are appropriately rewarded. Ensure that the investment climate is attractive and regulatory regimes manage rather than stifle entrepreneurship across public markets and beyond.  <i>Commercial market participation:</i>  Active market participation: The state owns and operates business in competition with mainly private sector entities.</p>
Hayter <i>et al.</i> (2018, p. 682)	<p>“In our view, public-sector entrepreneurship is a variant of the classical notion of entrepreneurship. What distinguishes public-sector entrepreneurship is the institutional environment in which entrepreneurial action occurs. Public-sector and private-sector entrepreneurs identify (i.e., are perceptive of) heretofore unexploited opportunities and then exploit them (i.e., take innovative action); the outcome of an entrepreneur’s perception and innovative action is of course uncertain. Following the literature, public-sector and private-sector entrepreneurs have differing motivations for their actions, some more altruistic than others; and, the attendant processes focus on alternative outcomes, some narrow in scope (organizational outcomes) and some broad in scope (social outcomes).  Public-sector entrepreneurship refers to the formation of innovative public-sector initiatives that transform a <i>status quo</i> social and economic environment into one that is more conducive to creative change in the face of uncertainty.”</p>

Note: “See also Ostrom (2005).



## 2.2 Reoccurring Themes

Above, I offered the point of view that the actions of an entrepreneur include both the perception of an opportunity *and* the ability to act on that perception of the opportunity. Perception and action, as a theme, is noticeably present in some of the literature cited in Table 1.1. For example (and paraphrasing):

- Jones (1978) uses the phrase *recognizes and undertakes*,
- Boyett (1997) uses the phrase *spot opportunities and act on them*,
- Holcombe (2002) uses the phrase *observes and acts* as well as the phrase *spots and recognizes and acts on the opportunity once spotted*,
- Currie *et al.* (2008) use the phrase *identify and exploit*, and finally
- Hayter *et al.* (2018) use the phrase *identify and exploit*.

I also referred above to public sector entrepreneurship involving one's engagement in creative activities in the face of uncertainty. A number of the authors who are referenced in Table 2.1 also associate public sector entrepreneurship with uncertainty and/or risk, and I quote the relevant words or phrases below. These authors are:

- Ramamurti (1986): "to take the personal risk,"
- Kirchheimer (1989): "risk bearing,"
- Boyett (1997): "uncertain environment,"
- Moon (1999): "risk-taking,"
- Morris and Jones (1999): "risk-taking,"
- Currie *et al.* (2008): "permits risk,"
- Leyden (2016): "uncertain process," and
- Hayter *et al.* (2018): "face of uncertainty."

As an aside, uncertainty and risk are not synonyms. As Leyden and Link (2015, p. 39) explain, using Knight (1921) as their point of reference:

Knight charged that previous risk theories were ambiguous because they did not distinguish sufficiently between two very different kinds of risk. On the one hand, risk signifies a quantity capable of being measured, that is, the objective probability that an event will happen. Because this kind of risk can be shifted from the entrepreneur to another party by an insurance contract, it is not an uncertainty in any meaningful sense. On the other hand, risk is often taken to mean a non-measurable eventuality, because all possible outcomes cannot be specified and/or the probabilities of all possible outcomes are not known, such as the inability to predict the consumer demand. Knight dubbed the latter true uncertainty and geared his theories of profit and entrepreneurship to its magnitude.

Perhaps the best summary statement of the difference between risk and uncertainty also comes from Knight himself (Knight, 1921, pp. 119–120):

[N]ot all risks necessarily give rise to profit, or loss. Many kinds can be insured against, which eliminates them as factors of uncertainty. . . . The essential point for profit theory is that insofar as it is possible to insure by any method against risk, the cost of carrying it is converted into a constant element of expense, and it ceases to be a cause of profit and loss. The uncertainties which persist as causes of profit are those which are uninsurable because there is no objective measure of the probability of gain or loss. This is true especially of the prediction of demand. It not only cannot be foreseen accurately, but there is no basis for saying that the probability of its being of one sort rather than another is of a certain value – as we can compute the chance that a man will live to a certain age. Situations in regard to which business judgment must be exercised do not repeat themselves with sufficient conformity to type to make possible a computation of probability.

Finally, again building on the Leyden and Link (2015) definition of public sector entrepreneurship, which is the foundational basis of the assertion in this monograph that Bush was a public sector entrepreneur (as rather boldly stated in the title of this monograph), Leyden and Link wrote that public sector entrepreneurship refers to innovative public policy initiatives that “generate greater economic prosperity.” A number of the references in Table 2.1 are also explicit in their definition that the actions of a public or public sector entrepreneur are undertaken for the commonweal. The phrases about the economic consequences of a public sector entrepreneur that were used are:

- “seek to build enterprises that can survive and grow” (Oakerson and Parks, 1988, p. 106),
- “for the wider good” (Klein *et al.*, 2010, p. 2),
- “tightly linked with citizen welfare” (Zampetakis and Moustakis, 2010, p. 837),
- “creating value for citizens and steering towards improved quality of life” (Dhliwayo, 2017, p. 157), and
- “social outcomes” (Hayter *et al.*, 2018, p. 682).

These themes about public sector entrepreneurship are summarized in Table 2.2.

The paucity of authors who have written about public sector entrepreneurship over the past one-half of a century is noticeable from Table 2.1, and the growth rate in that literature as shown in Figure 2.1 suggests that the topic remains nascent. But, it should also be pointed out for purposes of comparison that the flow of research on the topic of entrepreneurship remains healthy even though the early literature on that topic dates to Cantillon in the 18th century.

**Table 2.2.** Themes about public sector entrepreneurs

Themes	Authors
Perception and action	Jones (1978), Boyett (1997), Holcombe (2002), Currie <i>et al.</i> (2008), and Hayter <i>et al.</i> (2018)
Undertake activities in the face of uncertainty	Ramamurti (1986), Kirchheimer (1989), Boyett (1997), Moon (1999), Morris and Jones (1999), Currie <i>et al.</i> (2008), Leyden (2016), and Hayter <i>et al.</i> (2018).
Actions taken for the commonweal	Oakerson and Parks (1988), Klein <i>et al.</i> (2010), Zampetakis and Moustakis (2010), Dhilwayo (2017), and Hayter <i>et al.</i> (2018)

Source: Based on Table 2.1.

### 3 Science—the Endless Frontier

None of the authors listed in Table 2.1 offered insight into the source of funds needed for the public sector entrepreneur to do what the public sector entrepreneur does. The arguments in the papers referenced in the previous section, which are for the most part conceptual, describe consequential behavior. In some instances, the authors in the table do allude to the motivation for such behavior.

There are at least three noteworthy examples in the literature that describe the motivation of the public sector entrepreneur. Bellone and Goerl (1992, p. 132) suggest that public sector entrepreneurs, who are in their writings referred to simply as public administrators, seek:

. . . to be entrepreneurial [by adding] to their responsibilities [the generation of] new sources of revenue for financing public services.

Boyett (1997, p. 88) mentioned that an entrepreneur in the public sector is motivated by “a desire for a high level of social ‘self-satisfaction.’ ”

Finally, Leyden and Link (2015, p. 50) developed a theoretical mathematical model that describes the public sector entrepreneur’s motivation in terms of him/her maximizing the likelihood of “successfully identifying an input combination that achieves the desired innovation.”<sup>1</sup> More specifically, these authors wrote, the public sector entrepreneur focuses on (Leyden and Link, 2015, p. 50):

. . . the development of innovative public policies that affect the private sector innovation process, that is, the transformation of knowledge into economic knowledge.

One important implication of the theoretical modeling of Leyden and Link (2015, p. 52) is:

. . . that it is not the accumulated knowledge of the entrepreneur that affects the entrepreneur’s likelihood of success in identifying the input mix that succeeds in producing the [desired] innovation; rather,<sup>2</sup> it is the effectiveness of the entrepreneur’s networks . . .<sup>3</sup>

And, this implication applies to the *modus operandi* of Bush and the successfulness of his *federalism by contract* system of identifying relevant inventions, developed by contracted scientists likely working from their university laboratory, and bringing those innovations into use as new innovations.

The remainder of this section focuses on the financial resources available for a public sector entrepreneur to pursue his/her objectives. More specifically, the policy related question that I ask

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<sup>1</sup> The Leyden and Link (2015) model follows from the analytics in Leyden *et al.* (2014). See also, Leyden and Menter (2018).

<sup>2</sup> See Audretsch and Link’s (2019) discussion about experience as a source of knowledge that influences entrepreneurial behavior.

<sup>3</sup> Recall from Section 1 the quoted passage from Zachary (1997, p. 152): “The key to gaining this technical advantage . . . wasn’t necessarily assigning the smartest individuals to a problem, but assigning the smartest *team* [emphasis added] of people . . .”

is: Should the public sector, and the public sector entrepreneur who motivates that sector's policy, have a direct or indirect role in its support of attendant policy? Or, stated differently and in a more general vein: Should there be a direct role or an indirect role for the government in its funding of research that leads to (Leyden and Link, 2015, p. 14):

. . . innovative public policy initiatives that generate greater economic prosperity by transforming a *status quo* economic environment into one that is more conducive to economic units engaging in creative activities in the face of uncertainty [?].

### 3.1 Direct versus an Indirect Role for Government Support of Research

A centerpiece of the activity of the National Defense Research Committee and the Office of Scientific Research and Development was university-based research. And, in Bush's *Science—the Endless Frontier* (discussed below), the university and its research capabilities were, to no surprise, prominently highlighted (Bush, 1945, p. 14):<sup>4</sup>

It is chiefly in these institutions [i.e., universities] that scientists may work in an atmosphere which is relatively free from the adverse pressure of convention, prejudice, or commercial necessity. At their best they provide the scientific worker with a strong sense of solidarity and security, as well as a substantial degree of personal intellectual freedom. All of these factors are of great importance in the development of new knowledge, since much of new knowledge is certain to arouse opposition because of its tendency to challenge current beliefs or practice.

Senator Harley Kilgore (D-WV) opposed research autonomy for scientists, especially those scientists working in universities and research institutes who were involved in setting research agendas, defense research agendas in particular. Kilgore provided context for his position using historical references (Kilgore, 1945, p. 630):

There may be some scientists . . . who want to know why the Government is concerned with affairs of science. I want to quote . . . from the writing of George Washington, who died in 1799. Washington believed, and said, that the “arts and sciences are essential to the prosperity of the state and to the ornament and happiness of human life.” The Founding Fathers<sup>5</sup> believed that the Government should sponsor scientific research, and they incorporated into the Constitution a clause to the effect that the Congress should provide for the common defense and promote the general welfare. It is under the general-welfare clause that most of our peacetime research has been inaugurated.

Thus, one might conclude that Bush's view was for an indirect role for the government in its support of scientific research; and that Kilgore's view was for a direct role for the government—

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<sup>4</sup> Page number references to quoted passages from *Science—the Endless Frontier* are from the online version of Bush's book available at: <https://slac.uconn.edu/wp-content/uploads/sites/2215/2019/10/Science-the-Endless-Frontier.pdf>.

<sup>5</sup> The term *Founding Fathers* refers to “that generation of men who were active in the American Revolution and the formation of the early American Republic and the Constitution.” See, <https://oll.libertyfund.org/group/the-founding-fathers-of-the-u-s-constitution>.

where the word *role* refers to setting an agenda or direction for government-funded research—that entailed having strings attached to bound any research agenda that was pursued.<sup>6</sup> There was not disagreement between the two about government having a funding role, but the nature and focus (i.e., university autonomy versus political involvement) of the role was an area of contention. As Brooks (1996, p. 16) pointed out:

Bush selected the university as the centerpiece of postwar science policy specifically because of its independence and autonomy.

However, Kilgore called for:

. . . a much closer linkage to political institutions and less autonomy for the scientific community in setting the [national] research agenda.

### 3.2 President Roosevelt’s Charge to Bush

On November 17, 1944, President Roosevelt wrote to Bush (Bush, 1945, pp. 3–4):

DEAR DR. BUSH: The Office of Scientific Research and Development, of which you are the Director, represents a unique experiment of team-work and cooperation in coordinating scientific research and in applying existing scientific knowledge to the solution of the technical problems paramount in war. Its work has been conducted in the utmost secrecy and carried on without public recognition of any kind; but its tangible results can be found in the communiques coming in from the battlefronts all over the world. Some day the full story of its achievements can be told.

There is, however, no reason why the lessons to be found in this experiment cannot be profitably employed in times of peace. The information, the techniques, and the research experience developed by the Office of Scientific Research and Development and by the thousands of scientists in the universities and in private industry, should be used in the days of peace ahead for the improvement of the national health, the creation of new enterprises bringing new jobs, and the betterment of the national standard of living.

It is with that objective in mind that I would like to have your recommendations on the following four major points:

First: What can be done, consistent with military security, and with the prior approval of the military authorities, to make known to the world as soon as possible the contributions which have been made during our war effort to scientific knowledge?

The diffusion of such knowledge should help us stimulate new enterprises, provide jobs for our returning servicemen and other workers, and make possible great strides for the improvement of the national well-being.

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<sup>6</sup> There are other important issues of disagreement between Bush and Kilgore, namely the ownership of patents traceable to government funded research, which I discuss below in Section 4. The patent issue is debated even today. See Link *et al.* (2018) and Marr and Phan (2020). See also Blair (2021) on the Bush-Kilgore debate.

Second: With particular reference to the war of science against disease, what can be done now to organize a program for continuing in the future the work which has been done in medicine and related sciences? The fact that the annual deaths in this country from one or two diseases alone are far in excess of the total number of lives lost by us in battle during this war should make us conscious of the duty we owe future generations.

Third: What can the Government do now and in the future to aid research activities by public and private organizations? The proper roles of public and of private research, and their interrelation, should be carefully considered.

Fourth: Can an effective program be proposed for discovering and developing scientific talent in American youth so that the continuing future of scientific research in this country may be assured on a level comparable to what has been done during the war?

New frontiers of the mind are before us, and if they are pioneered with the same vision, boldness, and drive with which we have waged this war we can create a fuller and more fruitful employment and a fuller and more fruitful life.

I hope that, after such consultation as you may deem advisable with your associates and others, you can let me have your considered judgment on these matters as soon as convenient – reporting on each when you are ready, rather than waiting for completion of your studies in all.

### 3.3 Bush's Response to President Roosevelt's Charge

On July 5, 1945, Bush submitted his report to President Harry S. Truman.<sup>7</sup> In his letter of transmittal he wrote (Bush, 1945, p. 3):

A single mechanism for implementing the recommendations of the several committees is essential. In proposing such a mechanism, I have departed somewhat from the specific recommendations of the committees, but I have since been assured that the plan I am proposing is fully acceptable to the committee members.

The pioneer spirit is still vigorous within this nation. Science offers a largely unexplored hinterland for the pioneer who has the tools for his task. The rewards of such exploration both for the Nation and the individual are great. Scientific progress is one essential key to our security as a nation, to our better health, to more jobs, to a higher standard of living, and to our cultural progress.

The “mechanism” to which Bush referred in his letter of transmittal was a National Research Foundation (Bush, 1945, p. 25):

It is my judgment that the national interest in scientific research and scientific education can best be promoted by the creation of a National Research Foundation.

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<sup>7</sup> President Roosevelt died on April 12, 1945.

The National Research Foundation should develop and promote a national policy for scientific research and scientific education, should support basic research in *nonprofit organizations* [i.e., universities, emphasis added], should develop scientific talent in American youth by means of scholarships and fellowships, and should by contract and otherwise support long-range research on military matters.

Responsibility to the people, through the President and Congress, should be placed in the hands of, say nine Members, who *should be persons not otherwise connected with the Government and not representative of any special interest* [emphasis added], who should be known as National Research Foundation Members, selected by the President on the basis of their interest in and capacity to promote the purposes of the Foundation.

Bush's proposed National Research Foundation echoed the premise behind President Roosevelt's third question that was quoted above:

What can the Government do now and in the future to aid research activities by public and private organizations? The proper roles of public and of private research, and their interrelation, should be carefully considered.

As suggested by Zachary (1997), this question might have presupposed an answer that Bush had previously given. Bush had previously (McDougall, 1985, pp. 79–80):

. . . impressed on the President the need to maintain autonomy for scientists lest their work be squelched or misguided by military supervisors . . . The ORSD would contract out most of its programs to universities, deemphasizing federal laboratories in favor of tapping the talents of society as a whole . . . The obvious solution to ongoing federal R&D, and the one favored by Bush, was to extend something like the OSRD [Office of Scientific Research and Development] into peacetime . . . [b]ut the difficulties of such a plan came to light in the proposed legislation of Senator Harley M. Kilgore . . .<sup>8</sup>

A Congressional science policy study (Task Force on Science Policy, 1986, p. 26) wrote about this point in history, and thus the Task Force indirectly wrote about *Science—the Endless Frontier*:

A clear consensus was reached [by 1945] regarding the need for Government support for science and the desirability of establishing a science foundation. The areas of disagreement corresponded to the differences expressed earlier between Kilgore and Bush, namely the organization of the foundation, the distribution of funding [i.e., to basic and applied research (Kilgore) or only to basic research (Bush)], the role of social sciences [which Bush did not want to fund], and patent policy [about ownership of government funded research].

Bush later wrote, although not as a direct response to the Task Force on Science Policy, about his views on basic research versus applied research (1949, pp. 5–6):

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<sup>8</sup> For Kilgore's legislative opposition to Bush's view, see Bush (1943). See also, Kevles (1977).

What science produces, in the way of applications within its own changing limitations, depends upon what is desired by authority, by those who rule or represent the people. Pure science [i.e., basic research] may go its own way if it is allowed to do so, exploring the unknown with no thought other than to expand the boundaries of fundamental knowledge. But applied science [i.e., applied research], the intricate process by which new knowledge becomes utilized by the forces of engineering and industry, pursues the path pointed out to it by authority. In a free country, in a democracy, this is the path that public opinion wishes to have pursued, whether it led to new cures for man's ills, or new sources of a raised standard of living, or new ways of waging war. In a dictatorship the path is the one that is dictated, whether the dictator be an individual or a self-perpetuating group.

And Bush revisited this same theme about basic research being the foundation of science more than a decade later, but this time his view was expressed in a more philosophical manner (Bush, 1967, p. 191):

Science has a simple faith, which transcends utility. Nearly all men of science, all men of learning for that matter, and men of simple ways too, have it in some form and in some degree. It is the faith that it is the privilege of man to learn to understand, and that this is his mission.

With the passing of President Roosevelt in 1945, the end of World War II, and the influence of the Office of Scientific Research and Development ending at the end of 1947, a number of Bush's ideas for a National Research Foundation changed in favor of some of Kilgore's ideas,<sup>9</sup> although *Science—the Endless Frontier* is heralded even today as being the “blueprint for government supported science through a central agency.”<sup>10</sup>

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<sup>9</sup> Many, but not all, of Bush's conceptual ideas were modified by Steelman, the White House aid to President Truman, in *Science and Public Policy: A Program for the Nation* (See, [https://www.nsf.gov/about/history/nsf50/science\\_policy.jsp](https://www.nsf.gov/about/history/nsf50/science_policy.jsp)).

<sup>10</sup> See, <https://www.nsf.gov/about/history/nsf50/nsf8816.jsp>.



## 4 The Bayh-Dole Act of 1980

In this section, I offer support for the premise that the Bayh-Dole Act of 1980 might, more than any other contemporary legislation, epitomize Bush's views about government-funded university-based research and the ownership of such research.

### 4.1 A Legislative Overview<sup>1</sup>

On December 12, 1980, President Jimmy Carter signed Public Law 96-517, Amendments to the Patent and Trademark Laws Act.<sup>2</sup> This act is formally known as the University and Small Business Patent Procedure Act of 1980, and it is informally or commonly known as the Bayh-Dole Act of 1980.

The legislative process which led to the passage of the Bayh-Dole Act began on March 26, 1980 as H.R. 6933.<sup>3</sup> The act was introduced in the aftermath of productivity slowdowns in various sectors of the U.S. economy. The Economist (2002) referred to this period of time before the passage of the act as the period of "technological malaise that befell America in the late 1970s."

Figure 4.1 illustrates a Multifactor Productivity (MFP) index for the years 1965 through 1985 for the Private Business Sector in the United States.<sup>4</sup> MFP, or as many economists refer to it as total factor productivity (TFP), is widely regarded as an index that measures technological advancement.<sup>5</sup> This figure clearly shows the decline in MFP in the early 1970s and then again in the late 1970s and early 1980s.<sup>6</sup>

Figure 4.2 shows, over the same time period of 1965 through 1985, the annual percentage change in MFP for the Private Business Sector. Figures 4.1 and 4.2 tell the same story; technological advancement slowed in the United States in the early 1970s and then again in the late 1970s and early 1980s. It was these two periods of productivity slowdown or "technological malaise" that initiated several new and responsive technology policies in the United States. That policy story could be argued to have begun during the Administration of President Jimmy Carter.<sup>7</sup>

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<sup>1</sup> This section draws directly on Gores and Link (2021). Many other scholars have written about the Bayh-Dole Act, and that literature is also reviewed in Leyden and Link (2015) and in Link and van Hasselt (2019).

<sup>2</sup> This Public Law amends the Patent Act of 1790, the Patent Act of 1836, the Patent Act of 1922, and the Patent Act of 1952.

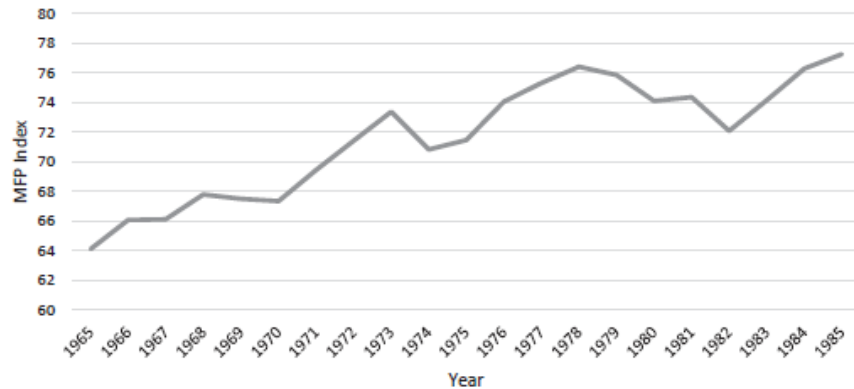
<sup>3</sup> A legislative history of H.R. 6933 is available at 20 House Report No. 96-1307, 96th Cong., 2d Sess. (1980).

<sup>4</sup> Publications related to the documentation of the measurement of multifactor productivity by the U.S. Bureau of Labor Statistics are listed at: <https://www.bls.gov/mfp/home.htm#technotes>.

<sup>5</sup> This interpretation of TFP arguably dates to Solow (1957).

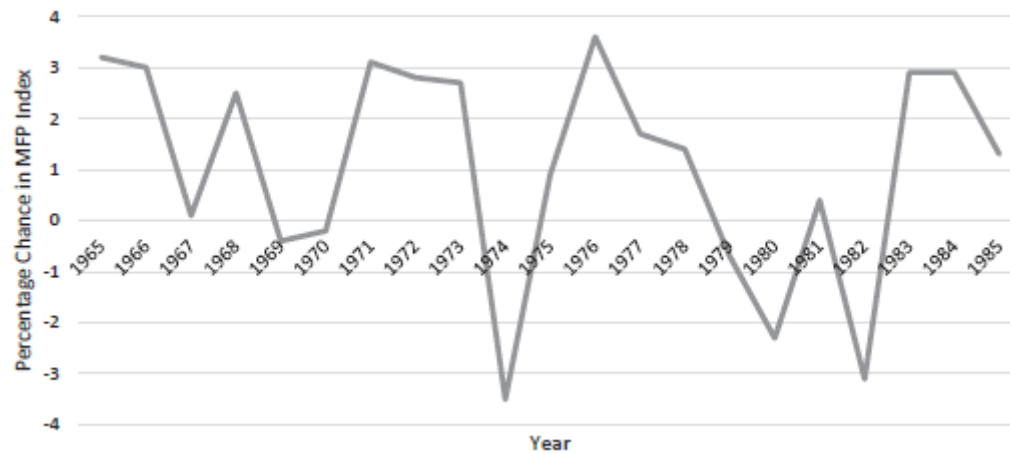
<sup>6</sup> These are the periods of decline referred to in The Economist (2002) article as "technological malaise." An excellent academic history of the Bayh-Dole Act is in Stevens (2004).

<sup>7</sup> See Leyden and Link (2015), and the references therein, for the historical background on the Bayh-Dole Act.



**Figure 4.1.** Annual multifactor productivity (MFP) index for the private business sector in the United States, 1965–1985 (2012 = 100).

Source: Bureau of labor statistics, historical multifactor productivity measures.



**Figure 4.2.** Annual multifactor productivity percentage change for the private business sector in the United States, 1965–1985.

Source: Bureau of labor statistics, historical multifactor productivity measures.

President Jimmy Carter’s policy prescriptions for reversing this productivity decline were set forth, at least in part, in what has become known as his Domestic Policy Review (1979).<sup>8</sup> Therein, the President’s remarks are:

I will also support the retention of patent ownership by *small business* and *universities* [emphasis added], the prime thrust of legislation now in Congress, in recognition of their special place in our society.

The Bayh-Dole Act [with emphasis added] states:

It is the policy and objective of the Congress to use the patent system to promote the utilization of inventions arising from federally supported research or development; to encourage maximum participation of *small business firms* in federally supported research

<sup>8</sup> James (Jimmy) Earl Carter Jr. served as the 39th president of the United States from 1977 to 1981.

and development efforts; to promote collaboration between commercial concerns and *nonprofit organizations*, including *universities*; to ensure that inventions made by nonprofit organizations and small business firms are used in a manner to promote free competition and enterprise; to promote the commercialization and public availability of inventions made in the United States by United States industry and labor; to ensure that the Government obtains sufficient rights in federally supported inventions to meet the needs of the Government and protect the public against nonuse or unreasonable use of inventions; and to minimize the costs of administering policies in this area.

And, the act goes on to state:

Each nonprofit organization [i.e., university] or small business firm may, within a reasonable time after disclosure . . . elect to retain title to any subject invention . . .<sup>9</sup>

The Bayh-Dole Act was one of several reasoned policy responses to the productivity slowdown that plagued the private sector of the United States. Again, this productivity slowdown was what *The Economist* article had referred to as the period of “technological malaise” in the United States.

The transfer of ownership of government funded research results to universities, that is allowing universities to “elect to retain title to any subject invention,” would have been in principle an area of contention between Kilgore and Bush. As Sampat (2020, p. 42) explained:

The Bush-Kilgore debates are typically remembered for the protagonists’ differences on such matters as the appropriate roles for scientists and politicians in determining research priorities, the types of research that should be funded, and whether funds should go to the best scientists or be broadly geographically distributed. Equally contentious, but perhaps less well known, was the question of taxpayer rights in patents arising from government-funded research. Kilgore complained about government-funded ideas being given away . . . Bush worried that government control of such patents would reduce commercialism incentives and public-private interactions.

Although the transfer of ownership of government-funded research results to universities is not a topic that is clearly addressed in *Science—the Endless Frontier*, it is a topic that helps to reinforce the argument that the Bayh-Dole Act does mirror the views and philosophy of Bush. And, to echo the Leyden and Link (2015) definition of public sector entrepreneurship, the transfer of ownership of government-funded research results to universities is indeed an “innovative public policy initiative.”<sup>10</sup>

As late as 1977, through a published draft study from the Department of Commerce, the following was recommended to become a part of U.S. technology policy (Anker-Johnson and Chang, 1977, pp. 72–74):

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<sup>9</sup> The act mandates: “A requirement [to disclose] each subject invention to the Federal agency [that funded the research] within a reasonable time after it is made and that the Federal Government may receive title to any subject invention not reported to it within such time.”

<sup>10</sup> This phrase is quoted from the Leyden and Link (2015) definition of public sector entrepreneurship.

There are relatively few commercial uses made of Government-owned inventions. In order for a U.S. Government-owned patent to be used by a company, a license must be issued. A tiny fraction of U.S. Government-owned patents available for licensing are actually licensed . . . A partial reason for the lack of commercialization is simple lack of awareness on the part of potential users of the invention . . . Perhaps the major reason for so few patents [issued] from Government-funded R&D is that government inventions are usually not developed sufficiently to allow a reasonable assessment of commercial potential . . . [This raises the following concern]: Most Government-owned inventions are not commercialized, indeed much Government-funded R&D is not exploited for patentable inventions, so that U.S. taxpayers do not obtain an adequate return on their investment in R&D. . . [The Department of Commerce] has been directed by [President Carter] to develop plans for more aggressive exploitation of government-owned inventions . . . A Government-sponsored invention development and licensing function is performed in every other industrialized nation . . . The organization performing this function usually obtains proprietary rights to inventions arising out of Government-funded laboratories and frequently assists in the development of privately sponsored inventions, with a sharing of rights . . . These nations have set up independent corporations for this purpose because R&D performers usually give this function little or no attention . . .

As pointed out above, President Carter, through his 1979 Domestic Policy Review, rejected such a recommended centralization of property rights when it comes to government-funded R&D at universities and in small firms, and thus, the Bayh-Dole Act of 1980 is a manifestation not only of the President's entrepreneurial insight but also of the influence of Bush's indirect role of government for all research-based actions to be independent of a centralized (i.e., governmental) direction.

To address the claim implied by the title of this monograph, the following section further suggests that the Bayh-Dole Act reflects the philosophy of Bush. Having done this, the subsequent section then suggests that the Bayh-Dole Act does in fact represent a policy effort that falls under the Leyden and Link (2015) definition of public sector entrepreneurship. In other words, the remainder of this section is my written effort to make my case that Vannevar Bush was, in the academic sense, a public sector entrepreneur.

#### 4.2 Themes from *Science—the Endless Frontier* in the Bayh-Dole Act

The quoted statement above about Congress's intent in the Bayh-Dole Act highlights the impact areas emphasized in the act as including universities, and it is well known that the scientific research conducted in universities is primarily focused on basic research.

Keeping the Congressional intent of the act in mind from the quoted statement above, there are a number of aspects emphasized in *Science—the Endless Frontier* that are somewhat foretelling of the ingredients within the Bayh-Dole Act. Bush wrote in his report [with emphasis added]:

Progress . . . depends upon a flow of new scientific knowledge. New products, new industries, and more jobs require continuous additions to knowledge of the laws of nature, and the application of that knowledge to practical purposes. (pp. 4–5)

How do we increase . . . scientific capital? [W]e must strengthen the centers of basic research which are principally the colleges, *universities*, and research institutes. These institutions provide the environment which is most conducive to the creation of *new scientific knowledge* and least under pressure for immediate, tangible results. With some notable exceptions, most research in industry and Government involves application of existing scientific knowledge to practical problems. It is only the colleges, universities, and a few research institutes that devote most of their research efforts to expanding the *frontiers of knowledge*. (p. 6)

It has been basic United States policy that Government should foster the *opening of new frontiers* . . . [S]cientific progress is, and must be, of vital interest to Government. Without scientific progress the national health would deteriorate; without scientific progress we could not hope for improvement in our standard of living or for an increased number of jobs for our citizens; and without scientific progress we could not have maintained our liberties against tyranny. (p. 9)

The publicly and privately supported colleges, universities, and research institutes are the centers of *basic research*. They are the wellsprings of knowledge and understanding. As long as they are vigorous and healthy and their scientists are free to *pursue the truth wherever it may lead*, there will be a flow of new scientific knowledge to those who can apply it to practical problems in Government, in industry, or elsewhere. (p. 9)

Basic research leads to new knowledge. It provides scientific capital. It creates the fund from which the practical applications of knowledge must be drawn. New products and new processes do not appear full-grown. They are founded on new principles and new conceptions, which in turn are painstakingly developed by research in the purest realms of science. Today, it is truer than ever that basic research is the pacemaker of technological progress . . . Industry is generally inhibited by preconceived goals, by its own clearly defined standards, and by the constant pressure of commercial necessity. *Satisfactory progress in basic science seldom occurs under conditions prevailing in the normal industrial laboratory*. There are some notable exceptions, it is true, but even in such cases it is rarely possible to match the universities in respect to the freedom which is so important to scientific discovery. (p. 14)

Replete in this quoted passage are references to the intersection between scientific research and university activity defined by scientists. To wit, and this is a point that cannot be over emphasized:

[R]esearch institutes are the centers of basic research. They are the wellsprings of knowledge and understanding. As long as they are vigorous and healthy and their scientists are free to pursue the truth wherever it may lead, there will be a flow of new

scientific knowledge to those who can apply it to practical problems in Government, in industry, or elsewhere.

An emphasis of the Bayh-Dole Act is not only to transfer ownership of government-funded research to universities, but also an emphasis is the social importance of university-based research, basic research in particular, that is embodied in patented knowledge. Universities and their basic research are the “pacemaker of technological progress” as was stated in *Science—the Endless Frontier* 35-years earlier.

#### 4.3 Bushian Public Sector Entrepreneurship Elements in the Bayh-Dole Act

I again make reference to the Leyden and Link (2015) definition of public sector entrepreneurship in Table 4.1. As shown in the table, the Bayh-Dole Act reflects two specific elements from Bush and from his *Science—the Endless Frontier*. Those elements are the indirect nature of public support of research and the innovative nature of the act itself.

Regarding the indirect nature of public support of universities, university scientists are not mandated to pursue pre-defined research topics, and they are not mandated how any research results should enter society. Regarding the innovative nature of the act itself (i.e., of the public policy initiative), universities can on their own develop, or not, technology transfer mechanisms.

The segue from the Bayh-Dole Act being an embodiment of Bush’s ideas and philosophy to the act also representing a public sector entrepreneurial endeavor, Table 4.1 summarizes how the act transforms the *status quo* economic environment through university technology transfer which thus enhances economic growth through the advancement of knowledge within firms. And, this transformation occurs in an environment of uncertainty, uncertainty about the application of any adopted research results and the uses of those results.

To also exemplify the innovative nature of the Bayh-Dole Act is the fact that it has been adopted, in various modified forms, throughout the world. Table 4.2 shows the various countries that have implemented Bayh-Dole like legislation.<sup>11</sup>

Figure 4.3 illustrates over time the cumulative proportion of Bayh-Dole like legislation attained across the countries listed in Table 4.2. From the figure, it appears that the adoption of such legislation increased noticeably beginning in the late 1990s.

Thus, to make the case that Bush was a public sector entrepreneur, I have in this section attempted to correlate the views and philosophy of Bush as reflected through *Science—the Endless Frontier* with the innovative public policy initiative of the Bayh-Dole Act of 1980.

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<sup>11</sup> See Gores and Link (2021) for a detailed description of the legislative initiatives in each country in Table 4.2.

**Table 4.1. Public sector entrepreneurship elements in the Bayh-Dole Act**

“[P]ublic sector entrepreneurship refers to innovative public policy initiatives that generate greater economic prosperity by transforming a <i>status quo</i> economic environment into one that is more conducive to economic units engaging in creative activities in the face of uncertainty”				
Targeted party	Direct versus indirect nature of public support	Innovative nature of the act	<i>Status quo</i> economic environment transformed	Dimensions of uncertainty
Universities and private sector firms	Indirect option to universities, effects are indirect based on research success	Transferring technology from universities creates new production possibilities for firms	Advancement of knowledge within firms, which enhances economic growth	Adoption of university-based technology is outside of the routine and thus has uncertain outcomes

Source: Based on Hayter *et al.* (2018).

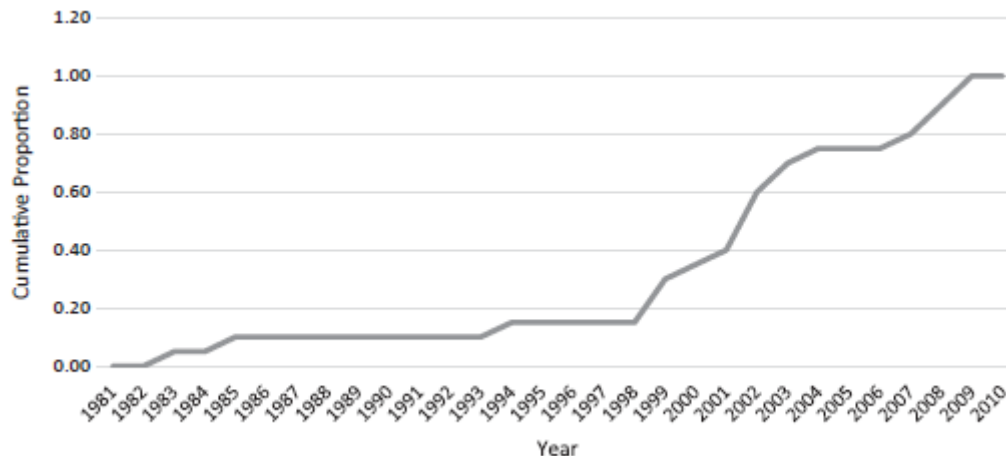
Note: The quoted definition is from Leyden and Link (2015, p. 14).

**Table 4.2. *Status quo* economic environments transformed by the Bayh-Dole act**

Country	Year of Initial Legislation	Country	Year of Initial Legislation
Spain	1983	Indonesia	2002
United Kingdom	1985	Mexico	2002
China	1994	Norway	2003
Denmark	1999	Russia	2003
France	1999	Brazil	2004
Japan	1999	Finland	2007
South Korea	2000	<i>India</i>	<i>2008</i>
Italy	2001	South Africa	2008
Austria	2002	Malaysia	2009
Germany	2002	Philippines	2009

Source: Based on Gores and Link (2021).

Notes: Countries are listed alphabetically within the same year of the initial legislation. India is listed in italics because legislation was proposed in 2008 that would affect university-based technology transfer, but it was tabled in 2014.



**Figure 4.3. Cumulative proportion for the adoption of Bayh-Dole like legislation across countries.**

Source: Based on Table 4.2.

## 5 Concluding Remarks

Before offering a summary of the ideas and themes developed in this monograph, I suggest that the ideas and philosophy of Bush, which I believe define him as a public sector entrepreneur, were exhibited directly through his public sector activities and initiatives under President Roosevelt and indirectly through *Science—the Endless Frontier* and in his other writings. In addition, his public sector entrepreneurial nature and influence remains evident in that it has had an imprint on the Bayh-Dole Act of 1980 and on other “innovative public policy initiatives” in our nation.<sup>1</sup>

Here, I want to discuss Bush’s threads in two contemporary “innovative public policy initiatives.” The first initiative is the 1990 report, *U.S. Technology Policy*, issued through the Executive Office of the President, Office of Science and Technology Policy under President George H.W. Bush (OSTP, 1990).<sup>2</sup> The second initiative is The Endless Frontier Act, introduced in May 2020 by Senator Charles Schumer (D-NY) as Senate bill S.3832.

There are other “public policy initiatives” that merit a similar discussion, but that is for another time. Leyden and Menter (2018, p. 228), building on Leyden and Link (2015), perceptively note—with respect to the Bayh-Dole Act of 1980, the Stevenson-Wydler Act of 1980, the 1981 R&E Tax Credit, the 1982 Small Business Innovation Development Act, the 1984 National Cooperative Research Act, and the 1988 Omnibus Trade and Competitiveness Act—the following:<sup>3</sup>

Remarkably, the common foci of these policies are on the importance of new knowledge as the foundation for innovation and the need to continually (re)create and maintain a system of knowledge creation and innovation, the development and enhancement of experiential ties among researchers to foster the flow of knowledge from basic research to applied research, and the fundamental value of innovation to economic, social, and political prosperity. These common foci conform closely to the policy recommendations in Bush’s report [*Science—the Endless Frontier*].

### 5.1 *U.S. Technology Policy*

Link and Cunningham (2021, p. 82) make the claim that:

*U.S. Technology Policy* is a very important document because it represents what we believe is the reigning public statement about U.S. technology policy.

The stated goal of U.S. technology policy (Office of Science and Technology Policy, 1990, p. 2) is:

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<sup>1</sup> This phrase is quoted from the Leyden and Link (2015) definition of public sector entrepreneurship.

<sup>2</sup> To the best of my knowledge, Vannevar Bush is not related to President George H.W. Bush or President George W. Bush.

<sup>3</sup> See Link and Cunningham (2021) for a comparison of each of these initiatives and the portion of the text of *Science—the Endless Frontier* to which each relates.



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.

This goal statement parallels the thoughts of Bush as expressed in his July 5, 1945, letter of transmittal of *Science—the Endless Frontier* to President Truman:

The pioneer spirit is still vigorous within this Nation. Science offers a largely unexplored hinterland for the pioneer who has the tools for his task. The rewards of such exploration both for the Nation and the individual are great. Scientific progress is one essential key to our security as a nation, to our better health, to more jobs, to a higher standard of living, and to our cultural progress.

For a more direct comparison between themes in *Science—the Endless Frontier* and in *U.S. Technology Policy*, see Table 5.1 in which I have offered parallel quoted passages.

**Table 5.1.** Comparison of themes in *Science—the Endless Frontier* and *U.S. Technology Policy*

<i>Science—the Endless Frontier</i>	<i>U.S. Technology Policy</i>
“Scientific progress is one essential key to our security as a nation, to our better health, to more jobs, to a higher standard of living, and to our cultural progress.” (p. 3)	“The goal of U.S. technology policy is to be achieved by . . . a healthy economic environment conducive to . . . diffusion of new technologies . . .” (p. 2)
“New products, new industries, and more jobs require continuous additions to knowledge of the laws of nature, and the application of that knowledge to practical purposes.” (pp. 4–5)	“Identify and aggressively pursue potential commercial applications for technology developed by . . . universities . . .” (p. 3)
“. . . we must strengthen the centers of basic research which are principally the colleges, universities, and research institutes.” (p. 6)	“[A federal R&D responsibility is to increase] Federal investment in support of basic research.” (p. 5)
“If the colleges, universities, and research institutes are to meet the rapidly increasing demands of industry and Government for new scientific knowledge, their basic research should be strengthened by use of public funds.” (p. 6)	
“The most important ways in which the Government can promote industrial research are to increase the flow of new scientific knowledge through support of basic research . . .” (p. 6)	

*Note:* Page number references to quoted passages from *Science—the Endless Frontier* are from the online version of Bush’s book available at: <https://slac.uconn.edu/wp-content/uploads/sites/2215/2019/10/Science-the-Endless-Frontier.pdf>.

An element of the character of an entrepreneur that was overlooked by the classical and semi-modern scholars discussed in Section 1 and summarized in Table 1.1 is the source of the entrepreneur’s perception, that is the genesis of creative ideas. Audretsch and Link (2018, 2019) previously address this point in two ways: through a discussion of the origin of innovation capital and through an epistemological discussion about sources of knowledge.<sup>4</sup>

<sup>4</sup> In a different context but along the same lines, Feldman and Francis (2002) have used the term *entrepreneurial spark* with reference to the formation of (i.e., the creative idea behind) innovative clusters.

Bush gave mention to what I am calling entrepreneurial perception. He made reference to “new scientific knowledge” as a so-called economic spark (Bush, 1945, pp. 6–7):

The responsibility for the creation of new scientific knowledge—and for most of its application—rests on that small body of men and women who understand the fundamental laws of nature and are skilled in the techniques of scientific research. We shall have rapid or slow advance on any scientific frontier depending on the number of highly qualified and trained scientists exploring it . . . The Government should provide a reasonable number of undergraduate scholarships and graduate fellowships in order to develop scientific talent in American youth. The plans should be designed to attract into science only that proportion of youthful talent appropriate to the needs of science in relation to the other needs of the Nation for high abilities . . . The Government should accept new responsibilities for promoting the flow of new scientific knowledge and the development of scientific talent in our youth. These responsibilities are the proper concern of the Government for they vitally affect our health, our jobs, and our national security.

The source for new scientific knowledge was also mentioned in *U.S. Technology Policy*, but different terms were emphasized to underscore the government’s responsibility in this area (Office of Science and Technology Policy, 1990, pp. 3–4):

[T]he private sector has the responsibility to improve the skills and abilities of its workforce to meet its specific needs; and participate cooperatively in improving the quality of U.S. education . . . [But, the government can revitalize] education at all levels including not only the training of scientists, engineers, and the technical workforce, but also educating our population to be sufficiently literate in science and technology to deal with the social issues arising from rapid scientific and technical change.

## 5.2 The Endless Frontier Act

The purpose of The Endless Frontier Act is:<sup>5</sup>

To establish a new Directorate for Technology in the redesignated National Science and Technology Foundation, to establish a regional technology hub program, to require a strategy and report on economic security, science, research, and innovation, and for other purposes.

There are many points of emphasis in The Endless Frontier Act that mirror Bush’s points of view and philosophy as expressed in *Science—the Endless Frontier*. As shown in Table 5.2 for comparison purposes, what is emphasized is government support of basic research at universities through Bush’s proposed National Research Foundation, and through The Endless Frontier Act such government support is proposed through a National Science and Technology Foundation.

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<sup>5</sup> At the time of writing this monograph, there are indications that The Endless Frontier Act may be renamed the U.S. Innovation and Competition Act.

**Table 5.2.** Comparison of themes in *Science—the Endless Frontier* and The Endless Frontier Act

<i>Science—the Endless Frontier</i>	<i>U.S. Technology Policy</i>
<p>“The most important ways in which the Government can promote industrial research are to increase the flow of new scientific knowledge through support of basic research . . .” (p. 6)</p> <p>“ . . . we must strengthen the centers of basic research which are principally the colleges, universities, and research institutes.” (p. 6)</p> <p>“Satisfactory progress in basic science seldom occurs under conditions prevailing in the normal industrial laboratory. There are some notable exceptions, it is true, but even in such cases it is rarely possible to match the universities in respect to the freedom which is so important to scientific discovery.” (p. 14)</p> <p>“ . . . the measure of a successful research contract lies not in the dollar cost but in the qualitative and quantitative contribution which is made to our knowledge. The extent of this contribution in turn depends on the creative spirit and talent which can be brought to bear within a research laboratory. The National Research Foundation must, therefore, be free to place its research contracts or grants not only with those institutions which have a demonstrated research capacity but also with other institutions whose latent talent or creative atmosphere affords promise of research success.” (p. 29)</p>	<p>“The Federal Government must catalyze United States innovation by boosting fundamental [i.e., basic] research investments focused on discovering, creating, commercializing, and producing new technologies to ensure the leadership of the United States in the industries of the future.”</p> <p>“From amounts made available to the Directorate, the Director shall, through a competitive application and selection process, award grants to or enter into cooperative agreements with institutions of higher education or consortia . . . to establish university technology centers . . . to carry out fundamental [i.e., basic] research to advance innovation . . . and to further the development of innovations in the key technology focus areas . . .”</p>

Note: Page number references to quoted passages from *Science—the Endless Frontier* are from the online version of Bush’s book available at: <https://slac.uconn.edu/wp-content/uploads/sites/2215/2019/10/Science-the-Endless-Frontier.pdf>.

There is, however, a noticeable difference in points of emphasis between Bush’s report and the act itself. The act acknowledges the competitive importance of the commercialization of new technologies and it proposes the following:

The Director shall establish a program in the Directorate to award grants, on a competitive basis, to institutions of higher education or consortia . . . [to] enable new technologies to mature to the point where the technologies are more likely to succeed in the commercial market . . . [and to] . . . reduce the risks to commercial success for new technologies earlier in their development.

Whereas in *Science—the Endless Frontier*, such efforts are left entirely to the marketplace (Bush, 1945, pp. 14, 17):

Industry is generally inhibited by preconceived goals, by its own clearly defined standards, and by the constant pressure of commercial necessity . . . Industry will fully rise to the challenge of applying new knowledge to new products. The commercial incentive can be relied upon for that.

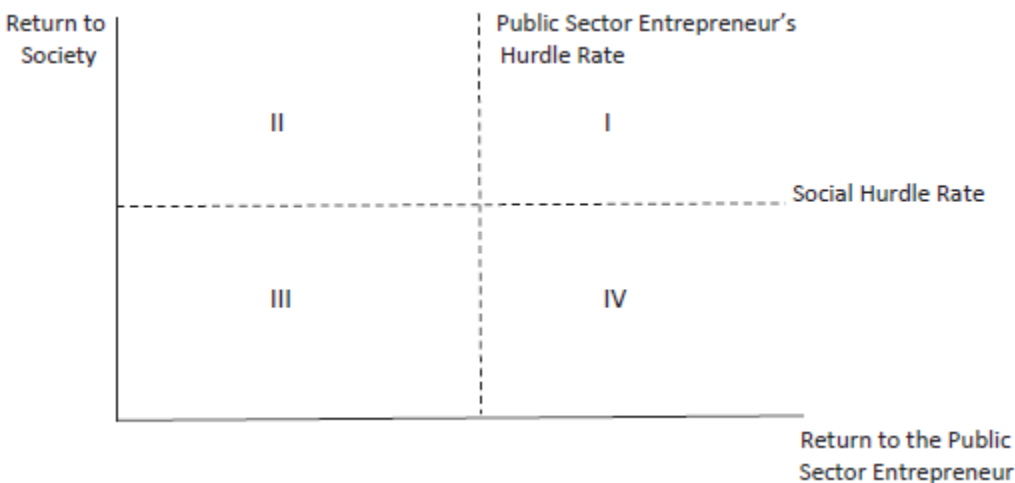
It would only be speculation on my part to suggest that this difference between *Science—the Endless Frontier* and The Endless Frontier Act would give Bush pause about the proposed act . . . but I do wonder.

Nevertheless, I am not speculating to emphasize that I believe that the forgoing discussion and arguments provide support for my claim that Vannevar Bush was, in the academic sense, a public sector entrepreneur.

### 5.3 A Framework for Future Research on Public Sector Entrepreneurship

One dimension of public sector entrepreneurship that I did not discuss with reference to Bush, or to Kilgore for that matter, was their motivation for taking positions related to the role of government funded R&D.<sup>6</sup>

I assert that a public sector entrepreneur has a preconceived rate of return from taking action, as Leyden and Link (2015, p. 14) would contend, toward “innovative public policy initiatives that generate greater economic prosperity by transforming a *status quo* economic environment into one that is more conducive to economic units engaging in creative activities in the face of uncertainty.” And, there is in the mind of a public sector entrepreneur some minimum rate of return to enhancing his/her professional status that he/she expects before taking such action. In Figure 5.1, this minimum rate of return is labeled as the public sector entrepreneur’s hurdle rate, which is the minimum rate of return the public sector entrepreneur expects. If the expected rate of return to action is less than this hurdle rate, the public sector entrepreneur would not pursue the action.



**Figure 5.1.** The entrepreneur’s and society’s rate of return from innovative public policy initiatives.

Society also has a hurdle rate. Society would like to see its resources used for innovative public policy initiatives that yield a rate of return that is above the social hurdle rate, which is the minimum rate of return society is willing to accept from the use of its resources. If the expected

<sup>6</sup> Some of the authors cited in Table 2.1 did refer to motivations, but only in passing, as I discussed above.

rate of return to the use of society's resources is less than this hurdle rate, society would prefer that the resources not be used. Thus, in an ideal situation, both the public sector entrepreneur and society would like to see any innovative public policy initiative resulting in a position in Quadrant I in Figure 5.1, where the public sector entrepreneur is realizing a rate of return from his/her actions that is greater than his/her hurdle rate and where society is realizing a rate of return from his/her actions that is greater than its hurdle rate.

I propose that Bush (and Kilgore) are in Quadrant I or Quadrant IV based on their individual actions to ensure that government funds private-sector R&D. I believe that the consensus opinion is that the social rate of return from purposive public-sector support of R&D in a Bushian manner is also above society's hurdle rate, although there are dissenters.<sup>7</sup> Relatedly, I offer the proposition that the sponsors of the Bayh-Dole Act and the act itself are both in Quadrant I rather than in Quadrant II.

However, future studies of public sector initiatives might initially position the public sector entrepreneur and his/her innovative public sector initiative in Quadrant I but, over time, aspects of the innovative public policy initiative that he/she championed might yield a social rate of return below the social hurdle rate. That is, the innovative public policy initiative might result in unintended consequences.<sup>8</sup> As a result, both the public sector entrepreneur and his/her innovative initiative might be in Quadrant IV.

Frédéric Bastiat wrote about unintended consequences in 1848 in *Selected Essays on Political Economy* (1995, p. 1, emphases in the original):

In the economic sphere an act, a habit, an institution, a law produces not only one effect, but a series of effects. Of these effects, the first alone is immediate; it appears simultaneously with its cause; it is seen. The other effects emerge only subsequently; they are not seen; we are fortunate if we foresee them.

There is only one difference between a bad economist and a good one: the bad economist confines himself to the visible effect; the good economist takes into account both the effect that can be seen and those effects that must be foreseen.

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<sup>7</sup> Some might not accept this latter statement. For example, Sarewitz (2016), if asked, might respond that *Science—the Endless Frontier*, and other Bush writings, might be placed in Quadrant III or Quadrant IV. Sarewitz (2016, pp. 6–7) wrote about Bush and *Science—the Endless Frontier*: “[Bush wrote in the *Endless Frontier*] by pursuing ‘research in the purest realms of science’ scientists would build the foundation for ‘new products and new processes’ to deliver health, full employment, and military security to the nation. From this perspective, the lie as Bush told it was perhaps less a conscious effort to deceive than a seductive manipulation, for political aims, of widely held beliefs about the purity of science . . . [Bush’s lie goes like this], Scientific progress on a broad front results from the free play of free intellects, working on subjects of their own choice, in the manner dictated by their curiosity for exploration of the unknown . . . [T]he beautiful lie provided a politically brilliant rationale for public spending with little public accountability. Politicians delivered taxpayer funding to scientists, but only scientists could evaluate the research they were doing. Outside efforts to guide the course of science would only interfere with its free and unpredictable advance.” See also, Kealey (2021).

<sup>8</sup> Unanticipated consequences associated with a legislated initiative are not at odds with the concept of government failure (Dolfsma, 2011; Le Grand, 1991; Wolf Jr., 1988).

Yet this difference is tremendous; for it almost always happens that when the immediate consequence is favorable, the later consequences are disastrous, and vice versa. Whence it follows that the bad economist pursues a small present good that will be followed by a great evil to come, while the good economist pursues a great good to come, at the risk of a small present evil.

And of course, due to political pressure, a public sector entrepreneur might find himself/herself, promoting an innovative public sector initiative that results in a rate of return for the public sector entrepreneur that is less than his/her hurdle rate. And, the innovative public sector initiative might begin with a social rate of return greater than society's hurdle rate—Quadrant II—and end with elements that are below society's hurdle rate—Quadrant III, given the shortfall of the public sector entrepreneur's rate of return.

Perhaps the framework in Figure 5.1 will motivate scholars to think about public sector entrepreneurs and entrepreneurship in a more dynamic manner, meaning in a manner that considers the consequences of a public sector entrepreneur's innovative public sector initiatives in the present as well as in the future.

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