Dan Ports

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The Multifaceted Influence of Government on Technology

Though promoting technological progress was not originally considered to be one of the primary functions of a government, the United States government nonetheless has historically played a major role in the development of technology in the nation, and its influence has only increased over time. The impact of technological developments on the nation has been profound, so the government has recognized that it can use its influence on technology to advance the nation's interests: military security, economic strength, and quality of life, among others. The multiple facets of the government's ability to affect technological development arise from the different forms of power it wields: both legislative authority and economic strength. Legislative power allows it to encourage certain industries through ~~of~~ patents and tariffs, as well as devising and enforcing regulations on the use of technologies. The government's economic strength, resulting from the fact that it represents such a major sector of the national economy, allows it to fund major projects that lead to important technological advancements; often this refers to technologies considered important for national defense and funded by the military. Over the years, a balance has evolved between publicly and privately funded technological development. An analysis of the development of a few representative technologies and the industries that grew up around them reveals the depths of the government's connection to scientific and technological research.

The question of what policies the government should enact towards technological development has been an issue since the earliest days of the history of the United States. Of course,

at the time the issue took on somewhat of a different form; the word "technology" itself did not come into common use until many years later in 1859 [1]. Nonetheless, relevant clauses can be found in the US Constitution. The most notable example is the clause that made possible the establishment of patent and copyright systems, by granting Congress the ability "to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries" [2]. The intended effect of this patent system was to provide an incentive for the development of new technologies by allowing the inventor a legally-recognized monopoly on his or her product. The extent to which this approach was effective is a complex issue that remains controversial today, but the fact that it was explicitly included in the Constitution is a clear indication that government and technological development have been interconnected since the founding of the government. Also noteworthy is the previous clause, which calls for the establishment of a system of "post offices and post roads." Though this is not typically considered an example of technology, it can be viewed as a predecessor of sorts to the large technological systems that were prevalent later; accordingly, it is significant that this early network was established using government resources.

The major technological issue of the era was industrialization. To be sure, this is far from merely a technological concern; it also involved major social and economic questions. It is these social and economic issues that are most controversial: the transition from an economy of individualist agriculture to increasingly large manufacturers, and the migration from rural areas to cities, for example. Here, the technological and social issues are inseparable, so the debate that ensued over whether the government should promote the development of a manufacturing industry was inherently connected to the question of whether the government should support technological development. Alexander Hamilton argued in 1791 that industrialization would be to the benefit of the nation: "The expediency of encouraging manufactures in the United States, which was not long

since deemed very questionable, appears at this time to be pretty generally admitted … not only the wealth, but the independence and security of a Country, appear to be materially connected with the prosperity of manufactures." In order to achieve these goals, he called for the government to institute economic measures, such as protective tariffs and premiums, as well as "the encouragement of new inventions and discoveries, at home, and of the introduction into the United states of such as may have been made in other countries, particularly those which related to machinery" and "the facilitating of the transportation of commodities" [3]. By contrast, Thomas Jefferson famously argued in favor of an agricultural society rather than an industrialized one, asserting that "those who labour in the earth are the chosen people of God, if ever he had a chosen people, whose breasts he has made his peculiar deposit for substantial and genuine virtue" [4], but even he later conceded that "manufactures are now as necessary to our independence as our comfort" [5]. The results of these debates were various government policies intended to promote manufacturing through tariffs and other policies and thus indirectly encourage technological change, or directly encourage new technologies by providing support for inventors, as with patents.

Historically, one way in which the government has encouraged the development of new technologies has typically been through the use of its large buying power to help establish certain industries. In particular, the military plays a large role in this, as it has an interest in using technology to gain an advantage in event of war. The technological innovations resulting from this government support are frequently eventually released into the private sector where they can make a great impact on industry. The mechanization of the arms industry serves as a representative example case. Eli Whitney perceived the potential of a new process to "greatly diminish the labor and facilitate the Manufacture of this Article" through "Machines for forging, rolling, floating, boreing, Grinding, Polishing etc" [6]. In light of growing conflict with France that many feared

would lead to war, he was awarded a contract from the government to manufacture ten thousand muskets. It was critically important that this effort was supported by the government rather than private enterprise, as the government was willing to pay for the muskets in advance; this made it possible for the high setup costs inherent in establishing a mechanized manufacturing operation to be met, as well as saving Whitney from his financial troubles incurred as a result of his patent troubles with the cotton gin. The use of machinery made possible a truly significant change in the resulting products: the advent of interchangeable parts. Whitney described the tools he was creating as being able to "give expedition, uniformity, and exactness to the whole [product] … the tools which I contemplate are similar to an engraving on a copper plate from which may be taken a great number of impressions, perceptibly alike" [7]. Though it is not clear if Whitney ever did succeed in producing muskets with interchangeable parts, others such as Simeon North and John H. Hall, who were respectively producing pistols and rifles for the government, were also working towards the same goals, and did indeed create armaments that interchangeable parts. These practices were quickly adopted by other industries. Cowan describes how the use of these techniques, which came to be known as "armory practice" or "the American system of manufacture," allowed clockmakers could raise their production from four or five clocks a year to two hundred a year, and eventually even higher; other industries showed similar results [8]. The practice became commonplace as a result of its introduction into the armaments industry, which could not have happened government monetary support.

This notion of government-funded technology research for military goals reached a much greater height during the World War II and Cold War era, in which superiority of technology was considered to be an essential means for ensuring military victory. It became typical for this research to be carried out not only at private defense contractors but also at universities. Vannevar Bush was one of the earliest leading proponents of this philosophy, calling for the establishment of a national

policy on science and a governmental organization for funding scientific research — the National Science Foundation — in his report entitled "Science — The Endless Frontier." He wrote that during World War II, "it has become clear beyond all doubt that scientific research is absolutely essential to national security" [9]. This view is supported by a number of examples of technologies developed for use in World War II. The atomic bomb, developed by academic scientists under military management through the Manhattan Project, played an obvious role in bringing about the end of the war. The development of radar, while somewhat less dramatic, was nonetheless a critical achievement; the research required to bring this about was largely done in academia as well, much of it at MIT's Radiation Laboratory. Bush noted that the "ever-continuing battle of [scientific] techniques" had become a critical facet of modern warfare, and thus scientific research in the interest of the national defense must be a priority of the government: "the obligation of Government to support research on military proposals is inescapable" [10]. Again, the advances from this technology research did not merely benefit the military, but parts of them made their way to the world ~~of~~ industry. Jeff Bingaman and Bobby R. Inman describe the benefits of what they call "dual-use technologies — those with both military and civilian applications," claiming that "we are entering an era in which it is imperative that we link our economic policy and our military policy" [11]. The advantages to the nation from the strengthened economy resulting from the civilian applications of these new technologies, combined with the security obtained from the immediate military applications, made the government spending on research justifiable to many.

Moreover, Bush also asserted the government had an interest in funding basic scientific research, not just those areas with immediate practical applications. This type of research often led to great advances in many fields — to take one well-known example, theoretical physics research in nuclear fission eventually led to the atomic bomb and nuclear power. However, since ~~this~~ the fruits of this research frequently do not appear for many years, if at all, it is usually not compatible with

the short focus of industry, where the next quarterly earnings report may be all that matters. Bush envisioned the government funding work that "has ultimate practical objectives but … involves long-term investigations of a fundamental nature," a task it is uniquely suited for because the government can afford to not be "so concerned with immediate practical objectives as are the laboratories of industry" and be more "free to explore any natural phenomena without regard to possible economic applications" [12]. This knowledge, often obtained at universities, could then later be applied by industry to create a product and benefit the country. Indeed, this research was not restricted to fields related to the military; research in other fields was also seen as beneficial if it could improve the nation's economy or quality of life. Bush envisioned a utopian future through scientific research: it could mean "more jobs, higher wages, shorter hours, more abundant crops, more leisure for recreation ... higher standards of living, the prevention or cure of diseases ... a high level of employment" [13]. While this is certainly a glorified depiction of the potential benefits, it is not without validity; progress in economic strength and quality of life has often resulted directly from technological innovation. Though the idea of government-funded research with no immediate application was a radically new one at the time of Bush's proposal, and it is still sometimes controversial today, it has generally come to be accepted as one of the functions of the government because of the many advantages that it can provide society.

Of course, many new technological systems were introduced in the private sector without government support. Even in some of these cases, however, the government has exerted an influence after the technology has been established. It is insightful to consider the example of the electrical system. It is difficult to characterize the ways in which electricity was first introduced, as they were so heterogeneous: electricity was not a universal service but a collection of individual systems operated by the various entities that used them. David E. Nye describes the situation in one typical town as "not one but three electrical systems. The first was private and served downtown

business and a few wealthy homes. The second was a municipal plant for street lighting. The third was private and drove the streetcars … the merger of the three systems was not a rapid process" [14]. Though government ownership was not uncommon for public services such as municipal lighting, the majority of early electrical installations were business-related — in factories, for example — so private ownership became commonplace. As the years passed, electricity rapidly became more widespread as people became aware of the assortment of potential benefits it could provide in the home, in the workplace, and elsewhere. By this time, the electrical system had been dominated by private power companies. However, the private power industry had failed in one key respect: over 90% of farmers did not have access to electricity, because the electric companies believed there was not sufficient demand to justify the costs of running long power lines to rural areas [15]. In order to provide power to them, government intervention was required. This took the form of the Rural Electrification Administration and Tennessee Valley Authority, a pair of programs introduced as part of Roosevelt's New Deal plans; the REA provided loans to groups of farmers to financially support the construction of power lines, and the TVA established a large power agency in one particular area. The significance of these programs cannot be understated; they radically changed the landscape of rural America, and had no small impact on the country as a whole. Electric power allowed farmers to make use of many new technologies; some of these were domestic, such as electric lighting and refrigeration, and increased the quality of life, while other machinery was applied on the farm. The advent of agricultural mechanization made possible such a great increase in technology that the nation's agricultural needs could be met by a small number of larger farms rather than many small family farms: more than 50% of Americans were farmers in 1910, compared to less than 3% in 1980 [16]. In this case, the development of the technology for electricity was largely handled in the private sector, but government support was required to ensure universal access when the private power companies did not feel it was economically justifiable for them.

As a final example of a technological sector greatly influenced by government, consider the development and history of the air transportation industry. As with so many other technology-related industries, this one had an early history intimately connected with the government and military; however, this was not the sole extent of the government influence. The federal government also passed legislation establishing agencies for regulating air transportation in order to ensure safety. Though the industry existed for some years before, it was not very successful until World War I, when the government began to purchase aircraft for military use. In 1917, the government set aside $640 million for the purchase of nearly 25,000 aircraft during the war; this sudden infusion of money was responsible for an immediate surge of growth in the aircraft industry, which had previously sold a mere 416 aircraft in the preceding year [17]. World War II had similar but more greatly intensified effects; by that time, "military strategists assumed that supremacy in the air was going to be a key — some said *the* key — component of victory," and the substantial increase in the military's demand for aircraft reflected this belief [18]. By the end of the war, well over a hundred thousand aircraft were being produced annually by an industry that employed over two million workers [19]. During times of peace, the government supported the aerospace industry through the postal service: initially the postal service ran its own air transport operation, but after the passage of the Kelly Airmail Act of 1925, it also supported the young commercial airline industry by outsourcing some of the mail-carrying business to them. Furthermore, another form of government support of this industry involved funding of aeronautical research, through institutions such as the National Advisory Committee for Aeronautics, the Office of Scientific Research and Development during World War II, and various university laboratories [20]. The government's other role in this field was to establish regulations on air traffic. The Air Commerce Act of 1926 assigned to the Secretary of Commerce the responsibility for "fostering air commerce, issuing and enforcing air traffic rules, licensing pilots, certificating aircraft, establishing airways, and operating and maintaining aids to air navigation;" over the following decades the

duties of this regulation were expanded and reassigned to newly formed organizations — the Civil Aeronautics Agency, the Federal Aviation Administration, and the Department of Transportation — as the perceived importance of such oversight increased [21]. The primary goal of such regulation was to ensure that air travel was safe for passengers, though it also had the effect of stimulating the growth of the air transport industry, as increasing safety helped encourage more people to fly, and government financing of safety activities "meant that the airlines did not have to [finance them], adding to their prosperity" [22]. In the case of air transport, the government's role encompassed both funding — through both military and scientific support — and regulation for safety.

Ruth Cowan classifies the influence of the government into "seven modes through which governmental agencies affect technological change: *patenting*, *tariffing*, *regulating*, *educating*, *researching*, *building*, and *consuming*" [23]. The examples explored above demonstrate each of these modes. Before manufacturing was a major portion of the national economy, the government decided to encourage manufacturing; this was done through the establishment of a patent system and the use of tariffs to promote domestic production over importing of goods. Government and military funding of technological development — as in the cases of the early firearms industry, scientific and research during World War II and the Cold War, and the military aircraft industry — represent the "researching, building, and consuming" aspects that Cowan refers to; in addition, since much of this research was done at universities, the educational aspect is represented as well. Finally, the electrification of rural America and air traffic safety oversight are examples of the government's use of its regulatory power. In total, the influence of the government on technology, which has been present from the earliest days of the history of the nation and has grown substantially since then, has been applied to promote the causes of national security, economic prosperity, and increased safety and quality of life.

References

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[19] Cowan, p. 257

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[23] Cowan, p. 250.

Dan: This essay is excellent, so far as it goes. But you leave out a number of important developments – for example: the General Survey Act of 1824 and its implications, the building of trans continental railroads, roads/highways & Automotive system, computers. ----

Content: good
Org: exc.
Analysis: exc.
Writing style: very good B+/A-