The Political Economy of Government Funded Defense R&D

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ABSTRACT

Since the second world war, research funded by the Department of Defense in the United States has led to advancements in technology generating spillovers into the private sector that have certainly benefitted people. Technology such as, computers, the internet, and communication satellites are presented throughout the literature on the subject to support the argument in favor of defense R&D as innovation policy. We argue that a lack of competitive markets and emergent prices for state funded defense R&D implies a lack of relevant economic knowledge for an efficient allocation of resources. We also discuss the incentives that state actors face and the impact this has on how resources are allocated under state direction.

Keywords: knowledge problem, incentives, defense, innovation

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1. Introduction

Since 1953 federally funded defense research and development (R&D) in the United States has been a significant portion of total federal spending on R&D. Before 1953, efforts to have the federal government fund research were typically linked to war efforts (Kealey 1996). Currently, the figure for federal spending on R&D within the Department of Defense (DoD) stands at over $59 billion, comprising just over 44% of total proposed federal spending on R&D for fiscal year 2020[3]. Just as R&D in markets is intended to enhance technological innovation thus increasing productivity the idea behind defense R&D funded by the government is to enhance technological innovation within the military to improve the state's ability to provide national security and increase economic growth[4].

Much of the literature on the economic effects on defense R&D argues that the growth-enhancing aspects of defense R&D come from positive spillovers to society (Solo 1962, Stowsky 2003, Ruttan 2006, Chu and Lai 2009, Eaglen and Pollak 2012, Mazzucato 2013, Steinbock 2014, Singer 2014, Moretti et al. 2016, Eliasson 2017). According to this logic, government funding of defense R&D has two related benefits. First, it contributes to national defense which is its primary purpose. Second, this R&D produces positive spillovers to the private, civilian sector that contribute to economic growth. Typical examples of positive spillovers include the

[3] https://www.whitehouse.gov/wp-content/uploads/2019/03/ap_21_research-fy2020.pdf

[4] From the 2015 DoD "Plan to Establish Public Access to the Results of Federally Funded Research" the goal is clearly stated, "A primary mission of Defense research is to safeguard national security and maintain technological superiority of the U. S. military through advances in science, technology and engineering.". (https://discover.dtic.mil/wp-content/uploads/2018/06/dod_public_access_plan_feb2015.pdf)

internet and communication satellites which are often used to illustrate the large economic benefits resulting from defense R&D.

The purpose of this paper is to use the tools of economics to analyze the core presupposition underlying the literature on government-funded military R&D. This literature assumes that decision makers can solve the core economic problem required for economic growth. This requires that decision makers begin with a given system of preferences and that they possess the relevant knowledge to produce the desired goods in an efficient manner. From this perspective defense R&D is a technical or engineering problem. As Hayek (1945) argued, however, this is not the economic problem facing society. Instead, the economic problem "is a problem of the utilization of knowledge which is not given to anyone in its totality" (Hayek 1945: 520).

Our central argument is that decision makers, acting outside of the market process, are unable to obtain the requisite economic knowledge to achieve the ends stated by proponents of government-funded R&D. From an economic perspective there is no way for government decision makers to efficiently sort through the array of technologically feasible projects to ensure that scarce resources are being used in their highest-valued uses (Mises [1949] 2007, Hayek 1945, and Lavoie [1985] 2016). From an economic perspective the question is not whether defense research generates observable outcomes but, rather, the opportunity cost of the resources used to produce those outcomes. Absent the market process, to determine and sort these opportunity costs, decision makers must rely on the knowledge generated through the political process. This political process is driven by a variety of dynamics that affect the kinds of projects that are pursued using defense R&D funds.

Our analysis integrates the literature on the economics of knowledge and the market process (Hayek [1968] 2002, Kirzner 1985, Lavoie [1985] 2016) with the literature on government-funded R&D focused on civilian spillovers (Solo 1962, Stowsky 2003, Ruttan 2006, Chu and Lai 2009, Eaglen and Pollak 2012, Mazzucato 2013, Steinbock 2014, Singer 2014, Moretti et al. 2016, Eliasson 2017). Our central contribution is to elucidate what government decision-makers can, and cannot, achieve with defense R&D. In delineating the range of possibilities, we clarify claims regarding the net benefits of defense R&D due to spillovers in the civilian space. We also counter the tendency in the literature to sample on the dependent variable by selecting instances where defense R&D resulted in civilian spillovers and then using those cases as general evidence of the relationship between defense R&D and positive spillovers.

We proceed as follows. In section two, we will summarize the variations of the spillover argument in the defense R&D literature. Section three will engage the knowledge problem in the context of defense R&D. Drawing on the theory of market process we will demonstrate that defense R&D is a case of noncomprehensive planning subject to issues of economic calculation central to the knowledge problem. Section four will discuss the issues of incentives that state actors face in allocating defense R&D funds. Through specific cases and regulations involved in the process of funding defense R&D we will show the dynamics of self-interested individuals responding to the regulatory structure and the outcomes that result. Section five concludes.

2. The Claims of the Literature on Defense R&D

The literature on the positive spillovers of defense R&D has three variations. The first recognizes the beneficial spillovers that have resulted from defense R&D, but makes no explicit argument for the use of defense R&D as innovation policy going forward (see Ruttan 2006, Singer 2014, Moretti et al. 2016). Ruttan (2006), who is representative of the literature in this area, argues that without defense R&D spending we would lack much of the technology that we enjoy today. In his discussion of the development of the computer industry, for example, he concludes that, "in the absence of the impetus for development and commercialization associated with military procurement, significant contributions of computer and related information technologies to the growth of the U.S. economy would have been delayed" (Ruttan 2006: 110). The implication that follows from this argument is that government is able to allocate resources to a higher valued use than the counterfactual where private actors are left to their own devices to decide on resources allocations.

The second variation of the spillover argument contends that the structure of defense R&D creates competition and mission orientation that explain the observed spillover benefits to civilian life (see Solo 1962, Mowery 2012, Mazzucato 2013, Rescher 2018). Mazzucato (2013), for instance, argues that the government took on the responsibility of technological innovation through defense R&D with the creation of the Defense Advanced Research Projects Agency (DARPA). By combining mission orientation and research freedom DARPA created an environment in which innovation could flourish (ibid.: 76). Mazzucato (2013) also argues that DARPA fostered competition among researchers, firms, and universities which aided in its success (77). This research led to advances in computer technology and the internet yielding significant benefits for civil life in the United States (ibid.: 76).

The final variation of the spillover argument explicitly identifies the technological and military superiority of the United States, and the defense R&D linked to that dominance, as a key determinant of prosperity. Goldman (2017) argues, "Renewing and improving defense R&D programs are not only essential to national security but can also become a critical driver of innovation and economic growth" (2). In order to achieve this goal, Eaglen and Pollak (2012) suggest several policy strategies for the state to effectively spend defense R&D dollars. They argue that stable funding, increased talent pool, and reframing defense R&D towards basic research will foster more innovation as was accomplished in the past. Steinbock (2012) also argues that the state is a necessary component for technological superiority which can be achieved by pursuing a "robust federal policy to restore defense-related innovation and production in the United States" (28). For those making this variation of the spillover argument, investments by government in defense R&D are necessary for long-term prosperity.

While the points of emphasis across these three variants differ, the unifying claim is that government decision makers can produce value-added innovations and spillovers through defense R&D. This claim implicitly assumes that government actors have access to the requisite economic knowledge and that state actors will be incentivized to pursue growth- enhancing research. In doing so, the economic question, of how scarce resources are allocated to their highest valued use is left unanswered, as is the question of incentive alignment between those involved in defense R&D and the interests of the civilian population.

3. The Knowledge Problem

How can resources be allocated to their highest valued use? In a market setting (i.e. a context in which there are private property rights and freedom of exchange), resources are employed in various lines of production, and individuals engage in exchange mediated through market prices that are generated in the process (Mises 1920, [1949] 2007, Hayek 1945). What consumers are willing to spend their money on ultimately determines whether a line of production is a success or failure driving "the competitive quest for profit" (Lavoie [1985] 2016:

38). Driven by profits, entrepreneurs strive to anticipate future market conditions and employ resources in profitable lines of production (Mises [1949] 2007: 291-294). Market prices and the resulting profits or losses from these activities allow entrepreneurs to engage in economic calculation. Guided by economic calculation, entrepreneurs update their plans allowing for resources to be employed in their highest valued use as the information reflecting relative scarcities is conveyed through market prices (Mises 1920, [1949] 2007, Hayek 1945, Lavoie [1985] 2016). The generation of relevant economic knowledge is contingent on the institutional context of the market (Lavoie [1985] 2016: 181). Therefore, when the institutional context of economic decisions differs from the market context, we can expect the knowledge that informs those decisions to differ as well.

In the case of defense R&D, resources are allocated through bureaucratic management. For the Department of Defense (DoD), a portion of its budget is dedicated to R&D activities. Primarily, R&D funding is allocated to the branches of the military and other DoD offices and then within those, further allocated among seven categories of research ranging from basic research to operational system development (Congressional Research Service 2018a). Individuals within those offices are then tasked with spending R&D budgets on new and existing research activities that will further the goals of the DoD. In the process, resources (e.g. researchers, research facilities, lab equipment) necessary for defense R&D must be purchased. As David Mowery (2012) notes, "Little if any defense-related R&D produces output that is priced in conventional markets, making it difficult to establish an economic value for the products of this enormous public investment" (1714).

Given that the economic decisions for defense R&D occur outside the context of the market, the information of relative scarcities that would be captured by prices in a market does not emerge. Thus, allocation of resources by bureaucratic management implies that establishing economic value to engage in economic calculation is not difficult, it is impossible (Mises 1944: 47-48). If economic calculation is not possible in this setting then the opportunity costs of resources are not accurately considered when decisions are made. The lack of economic calculation also indicates that policymakers will not be able to make *ex post* valuations of defense R&D projects' economic success (Klein 2013).

It is not the case that the DoD will be unable to increase research output and create technology. That problem is purely technical in nature. But increases in technology as such do not imply value-added innovation (Mises [1949] 2007: 207-208). To claim that the iPhone as it exists today would not exist absent defense R&D (Mazzucato 2013) does not demonstrate the economic benefits of defense R&D. What matters is whether or not consumer demands are better satisfied in the world where resources are allocated by the government for the purposes of defense R&D, or in the counterfactual world, where those resources were left to be allocated by market actors. Of course, we cannot say which situation resulted in larger benefits since we do not have the counterfactual but we can discuss the implications of economic decision making in the absence of economic calculation.

If economic calculation cannot be relied on, how are policymakers to determine the allocation of resources for defense R&D? They will rely on arbitrary measures decided and agreed upon within the DoD through the Planning, Programming, Budgeting, and Execution (PPBE) process (Congressional Research Service 2018b). Through the PPBE process the Under Secretary of Defense for Research and Engineering will participate in the planning of defense R&D programs to be budgeted with "the mission of advancing technology and innovation for the military services and DoD" (Congressional Research Service 2018b). As is the case in production on the market there is a range of possible options to achieve this mission. Rather than resources being allocated by entrepreneurs who are forced to consider the alternative uses of resources by facing market prices, the DoD relies on estimating how resources will best meet the mission, absent consideration of those alternative uses.

When allocating resources via the PPBE process, not only are opportunity costs of the resources not accounted for, the success or failure of defense R&D must be determined by other means than profit and loss. Performance for defense R&D (and the DoD in general) is reported in annual performance reviews conducted by the DoD[6]. These reports contain dozens of output metrics that convey the progress made towards broad goals outlined in the DoD National Defense Strategy. The knowledge of which research proved to be the most valuable cannot be ascertained in this manner as the metrics that the DoD cares about do not necessarily reflect economic value. Without the relevant economic knowledge, policymakers will not be able to determine how many researchers to hire, whether new labs should be built, if resources are being wasted, and how to approach other economic decisions.

In response to the inherent limitations on knowledge for defense R&D funded by the government, policymakers attempt to mimic market conditions in order to achieve better results. One of these attempts is to foster competition among researchers, companies, branches of the military, and other entities that receive defense R&D funds (see Mowery 2012, Mazzucato 2013). While it is true that researchers and companies must compete for research dollars the process is not reflective of market competition. Competition in a market setting selects on the ability to create value for consumers (Rothbard [1962] 2009, p.889-890). As a result, prices of

[6] For performance reports going back to 2015: https://cmo.defense.gov/Publications/Annual-Performance-Plan-and-Performance-Report/

goods and means of production are adjusted and rearranged through entrepreneurial decision making as market conditions change, facilitating the flow and exchange of resources (Hayek [1968] 2002). In contrast, the competition for research dollars is bounded by the parameters set by DoD goals and the portion of the budget dedicated to R&D. The competition for funds will select on the criteria decided during the PPBE process rather than the creation of value (Wagner 2016).

Policymakers also attempt to mimic market conditions by adopting the R&D practices of successful firms for use in defense R&D (see Government Accountability Office 2017). The idea behind this policy suggestion from the Government Accountability Office is that successful firms (e.g. Google and Amazon) structure their R&D spending such that money is spent on both "incremental" technology research and "disruptive" technology research. Thus, if this strategy works for these firms then it should work for the DoD as well. Not accounted for in this suggestion is the knowledge firms have access to that the DoD does not. Firms exist within a market setting and have the ability to adapt in response to profit and loss signals. The DoD on the other hand, will respond to the signals captured in performance reports and adjust accordingly. There is no way for policymakers to determine what mix of incremental and disruptive technology research will create the most value.

Absent the market process the DoD is unable to engage in economic calculation and determine the value of resources they employ in defense R&D. Therefore, policymakers cannot evaluate the economic success of defense R&D *ex ante* nor *ex post*. The claims of net benefits made by the advocates of the spillover argument are necessarily speculation. Resource scarcities still exist in this situation and the use of resources will impact market conditions. As more resources are diverted for use in defense R&D, "the competitive discovery procedure is subverted and politically favored projects succeed at the expense of others that may have been more economically efficient" (Lavoie [1985] 2016: 181). Limitations on the knowledge generated in the process will hinder the level of possible coordination in economic decision making carried out in the case of government funded defense R&D (Lavoie [1985] 2016: 52-65). Furthermore, policymakers and bureaucrats involved in decision making will be subject to the incentives set forth by the political process that replaces the market process in this setting.

4. Incentives

Policymakers and bureaucrats, like market actors, are self-interested individuals who respond to the incentives they face. The political knowledge generated by the process in which resources are allocated for defense R&D and the structure of bureaucratic agencies involved will determine the kinds of incentives these individuals face. In order to illustrate the dynamics of political process, we will analyze how incentives impact decision making at the level of budgeting for bureaucratic managers, individuals in conducting research trying to meet DoD goals, and outside parties such as private contractors and university researchers.

The budget-maximizing model of bureaucratic managers (see Niskanen 1968, 1971, 1975) demonstrates how self-interested bureaucrats will seek to increase their budgets when demand for their agency's services increases. Demand increases for defense R&D spending manifest themselves when perceived threats are heightened[7] as one of the goals of defense R&D is to increase military capabilities (Congressional Research Service 2018b). Thus, we should expect to observe increases in the defense R&D budget when demand for military innovation increases.

[7] See Higgs (1987) for his thesis on government expansion.

Throughout the twentieth century and into the twenty-first century there is evidence for this pattern. During the Cold War, the threat of Russian military dominance served as the impetus for increased defense spending, with defense R&D spending increasing over this period as a part of the "Star Wars" program (Kealey 1996: 157). After the attacks on September 11, 2001, defense R&D spending increased for several years reaching a peak of $83 billion in 2009 (Steinbock 2014: 7-8). Currently, both China and Russia are among the perceived threats that the United States faces (Department of Defense 2018). Those threats, and the lack of defense R&D spending in the last several years, both serve as reasons given by the DoD for the most recent increases in R&D spending. Spending on defense R&D increased from $52 billion in 2018 to a proposed $59 billion in 2020[8].

These observations are consistent with what the budget-maximizing model would predict and highlight the incentives that bureaucratic managers face. When perceived threats increase the demand for military innovation bureaucratic managers are incentivized to increase their budgets in order to increase observable outputs. Whether or not these spending increases actually result in value added increases in output is indeterminate because of the issues discussed in the previous section. The DoD will be more concerned with research projects that show progress on metrics they decide "such as whether the technology carries potential to reduce risk to the warfighter" (Government Accountability Office (GAO) 2017: 27).

Incentives for increased visible output will also have effects on the decisions made within the branches of the military who receive R&D funding. Each branch of the military has autonomy in deciding what projects to spend R&D funds on while still relying on DoD-wide

[8] https://www.whitehouse.gov/wp-content/uploads/2019/03/ap_21_research-fy2020.pdf

goals (GAO 2017: 28). But this autonomy does not avoid incentives to focus on research that will yield near-term results for pre-defined goals, as a result of the lengthy PPBE process associated with defense R&D project approval (GAO 2017: 28-30). Individuals who are more skilled in anticipating which projects are more likely to be approved according to those pre-defined goals will be more successful at bringing in funding to their department.

The implication of increased defense R&D budgets as a result of demand increases is that more resources are diverted from the market into the public sector where allocation is guided by the political process. Incentives involved in the political process are aligned towards improving observable outcomes and there is evidence that individuals working in defense R&D have little incentive to identify inventions with spillover potential (GAO 2018: 17-20).

Outside of defense R&D within the DoD, money is also spent on acquiring R&D services from private firms and universities (see, Gansler 1980, Rogerson 1994, Lichtenberg 1995). This spending creates rent seeking opportunities for those who compete over the awarding of contracts. The resources employed in trying to secure these rents by winning the contracts are wasted as they are not used in a productive capacity (Tullock 1967). Lichtenberg (1995) discusses two different ways in which private firms compete for R&D funds from the DoD. First, is through design competitions which consists “in the government’s simply revealing its demand for certain types of technological innovations, and encouraging private firms to sponsor the necessary R&D, the costs of which the sponsor will recover from profits on the sale of the product” (ibid.: 434). The fact that private firms compete in this space is not an indication that the market process is at work. The ends that firms compete over continue to be determined through the political process.

Second, the DoD also subsidizes private firm's R&D "expenditures dedicated towards winning prizes" (ibid.: 437). Subsidies lower the cost of attempts to secure rents for private firms incentivizing more resources to be employed in order to do so. Lichtenberg (1995) finds that, "marginal private R&D intensity of government (primarily defense) sales is much higher than the R&D intensity of non-government sales" (441). Similar to the incentives individuals in the military face when participating in R&D, private firms will face incentives to produce the technology that the government is looking for specifically. While the firms themselves will receive benefits from this activity there is no guarantee that anything of value will actually be produced.

University researchers also receive funding for R&D from the DoD[9]. Facing similar incentives as the private firms and branches of the military, universities will pursue research that will meet the goals of the DoD in order to secure funds. Researchers do of course benefit from receiving this funding, but just as is the case for the private firms, there is no guarantee that the research produced will be of any value outside the military context. Research funding aimed at defense-related outputs can also have distortionary effects on academic disciplines (see, Froman 1987, Leslie 1993, Mirowski 2002). The funding incentivizes researchers to move into topics that will be more likely to be approved by the DoD. Coyne and Bills (2018) conclude that this can result in lasting effects for academic disciplines "including the structure of the discipline, the type of questions that are asked by those in the discipline, the methods used to address those questions, and the policy implications derived from research" (431).

[9] See for example, Gansler (1982: 97) who estimates that during the 1970s up to one-third of all scientists in the U.S. were supported by the DoD.

The incentives created by the political process in defense R&D lead to resources being allocated towards visible outcome measures for the DoD. Resources are diverted from the private sector when defense R&D budgets increase into the public sector where economic calculation cannot be relied on, Further, the incentives in place make efforts to reach goals of innovation difficult to effectively implement as illustrated by reliance on the PPBE process for project approval in the military. Rent-seeking opportunities result in wasted resources as firms and researchers compete over R&D funding. And DoD funding can result in distortionary effects in academic disciplines.

5. Conclusion

We have demonstrated in the context of government funded defense R&D, economic decision making occurs outside the context of the market where the knowledge necessary to determine value is not generated. The implications of this are that the policymakers that engage in defense R&D cannot rely on economic calculation and thus are not able to determine the opportunity costs of resources employed in defense R&D nor are they able to determine the value of the outputs of defense R&D. This also means that analysts cannot determine whether or not defense R&D projects have yielded net benefits to society as the advocates of the spillover argument would contend. We do not have access to the counterfactual necessary to make these kinds of conclusions.

Our discussion of the incentives individuals face in the political process of defense R&D does, however, suggest that there are possible inefficiencies. Human physical capital resources will be diverted from the market leading to possible distortions that can have unforeseen consequences. Rent seeking involved with the competition for DoD funds will also lead to wasted resources. None of our conclusions are meant to take away from the historical interest found in the unfolding of events that led to any of the technology that was developed as a result of defense R&D. We mean only to stress the caution with which social scientists should make claims about the feasibility of defense R&D as innovation policy.

References

Bills, B.L., Coyne, C.J. (2018). Overlooked Costs of War-Related Public Research: A Comment on Nicholas Rescher's 'Early Rand as a Talent Incubator'. *The Independent Review, 22(3),* 429-434.

Chu, A., Lai, C. (2009). Defense R&D: Effects on Economic Growth and Social Welfare, *IDEAS Working Paper Series from RePEc*, 1-24.

Congressional Research Service (2018a). Department of Defense Research, Development, Test, and Evaluation (RDT&E): Appropriations Structure (CRS report R44711). Retrieved from https://crsreports.congress.gov/product/pdf/R/R44711.

___. (2018b). Defense Primer: Planning, Programming, Budgeting, and Execution (PPBE) Process (CRS report 7-5700). Retrieved from https://crsreports.congress.gov/product/pdf/IF/IF10429.

Coyne, C.J., Lucas, D. (2016). Economists Have no Defense: A Critical Review of National Defense in Economic Textbooks".

David, P.A., et al. (1999). Is Public R&D a Complement or Substitute for Private R&D?: A Review of the Econometric Evidence, *National Bureau of Economic Research*, Retrieved from www.nber.org/papers/w7373.

Department of Defense (2018). Summary of the 2018 National Defense Strategy of the United States of America: Sharpening the American Military's Competitive Edge. Retrieved from https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf

Eaglen, M., Pollak, J. (2012). US Technological Supremacy Under Threat, *American Enterprise Institute.*

Eliasson, G. (2017). *Visible Costs and Invisible Benefits: Military Procurement as Innovation Policy.* Switzerland: Springer International Publishing

Forman, P. (1987). Behind Quantum Electronics: National Security as a Basis for Physical Research in the U.S. *Historical Studies in the Physical Sciences 18,* 149-229.

Gansler, J.S. (1982). *The Defense Industry*. Cambridge, MA: MIT Press.

Goldman, D.P. (2017). The Digital Age Produces Binary Outcomes: Defense R&D and Innovation. *American Affairs, 1(1), 97-112.*

Goldman, D.P. (2019). You May Not Be Interested in War, but War is Interested in You. Retrieved from pjmedia.com/spengler/you-may-not-be-interested-in-war-but-war-is-interested-in-you/.

Government Accountability Office (2017). Defense Science and Technology: Adopting Best Practices Can Improve Innovation Investments and Management (GAO-17-499). Retrieved from https://www.gao.gov/assets/690/685524.pdf

___. (2018). Additional Actions Needed to Improve Licensing of Patented Laboratory Inventions (GAO-18-327). Retrieved from https://www.gao.gov/assets/700/692606.pdf.

Hayek, F.A. (1945). The Use of Knowledge in Society. *The American Economic Review, 35(4), 519-530*

-1968 (2002). Competition as a Discovery Procedure. *The Quarterly Journal of Austrian Economics 5(3)*, 9-23.

Higgs, R. (1987). *Crisis and leviathan : Critical Episodes in the Growth of American Government.* New York, NY: Oxford University Press.

Kealey, T. (1996). *The Economic Laws of Scientific Research.* New York, NY: St. Martin's Press, Inc.

Kirzner, I. (1985). *Discovery and the Capitalist Process*. Chicago, IL: University of Chicago Press

Klein, P.G. (2013). Without the State, Who Would Invent Tang?. *The Free Market 31(3),* 1-3.

Lavoie, D. (2016). *National Economic Planning: What is Left?.* Arlington, VA: Mercatus Center at George Mason University

Leslie, S.W. (1993). *The Cold War and American Science: The Military-Industrial Academic Complex at MIT and Stanford.* New York, NY: Columbia University Press.

Lichtenberg, F.R. (1995). Economics of Defense R&D. In K. Hartley & T. Sandler (Eds.), *Handbook of Defense Economic, Vol. 1 (432-457).* Netherlands: Elsevier Science.

Mazzucato, M. (2013). *The Entrepreneurial State: Debunking Public vs. Private Sector Myths.* New York, NY: Anthem Press

Mirowski, P. (2002). *Machine Dreams: Economics Becomes a Cyborg Science.* Cambridge: Cambridge University Press.

Mises, Ludwig von 1920 (1990). *Economic Calculation in the Socialist Commonwelath.* Auburn, AL: Mises Institute.

___. (1944). *Bureaucracy*. New Haven, CT: Yale University Press.

___. 1949 (2007). *Human Action: A Treatise on Economics.* Indianapolis, IN: Liberty Fund Inc

Moretti, E., Steinwander, C., and Van Reenen, J. (2016). The Intellectual Spoils of War? Defense R&D, Productivity, and International Spillovers. Working Paper

Mowery, D.C. (2012). Defense-related R&D as a Model for "Grand Challenges" Technology Policies. *Research Policy 41(10)*, 1703-1715

Niskanen, W.A. (1968). The Peculiar Economics of Bureaucracy. *The American Economic Review 58(2)*, 293-305.

___. (1971). *Bureaucracy and Representative Government.* Chicago, IL: Aldine.

___. (1975). Bureaucrats and Politicians. *The Journal of Law and Economics 18(3)*, 617-643.

Rescher, N. (2018). Early RAND as a Talent Incubator: An Extraordinary Experiment. *The Independent Review 22(3),* 417-427

Rogerson, W.P. (1994). Economic Incentives and the Defense Procurement Process. *Journal of Economic Perspectives 8(4)*, 65-90.

Rothbard, M.N. 1962 (2009). *Man, Economy, and State.* Auburn, AL: Mises Institute.

Ruttan, V.W. (2006). *Is War Necessary for Economic Growth? Military Procuremnt and Technology Development.* New York, NY: Oxford University Press.

Schmid, J. (2018). The Difussion of Military Technology. *Defence and Peace Economics 29(6),* 595-613.

Sempere, C.M. (2018). What is Known about Defence Research and Development Spill-overs?. *Defence and Peace Economics, 29(3),* 225-246.

Singer, P.L. (2014). Federally Supported Innovations: 22 Examples of Major technology Advances That Stem from Federal Research Support. Retrieved from http://www2.itif.org/2014-federally-supported-innovations.pdf.

Steinbock, D. (2014). The Challenges for America's Defense Innovation. Retrieved from http://www2.itif.org/2014-defense-rd.pdf?_ga=2.81855957.290356339.1573235688-1908564704.1573235688.

Stowsky, J. (2004). Secrets to Shield or Share? New Dilemmas for Military R&D Policy in the Digital Age. *Research Policy 33(2),* 257-269.

Tullock, G. (1967). The Welfare Costs of Tariffs, Monopolies, and Theft. *Western Economic Journal 5*, 224-232

Wagner, R.E. (2016). *Politics as a Peculiar Business: Insights from a Theory of Entangled Political Economy.* Northampton, MA: Edward Elgar Publishing, Inc.