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Military R&D: The Productivity Puzzle

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Abstract:

A number of very careful econometric studies have been interpreted as showing that publicly funded research and development conducted by private firms has had little discernable impact on firm level profits or productivity. In contrast historical studies have shown that military and defense-related research development and procurement conducted by private firms has been an important source of technology development across a broad spectrum of U.S. manufacturing industries. Careful narrative analysis represents a more effective way of capturing the complementarities between military and defense-related research, development, and procurement on commercial technology development than econometric analysis.

How important has publicly funded military research and procurement been as a source of technology development and productivity growth?[1] In a recent book I present historical case studies of the role of military and defense-related research, development and procurement of commercial technology development for a series of general purpose technologies.[2] These industries include interchangeable parts and mass production, military and commercial aircraft, nuclear energy and electric power, computers and microprocessors, the internet and the space industries.

The case studies demonstrate that military and defense related R&D has been a major source of technology development across a broad spectrum of industries that account for an important share of U.S. industrial production. These results are in direct contradiction to a number of very careful econometric studies that show that measured private and social rates of return to military R&D have been very low and have had no discernible effect on industrial productivity growth in the U.S.

Economic Benefits from Research

There is a long history of studies of private and social rates of return to R&D. These studies trace back to the now classic studies of rates of return to agricultural research by Griliches and to industrial research by Mansfield and Beardsley.[3] The results of the large body of firm-level, sector-level, and economy-wide studies, combined with studies of the sources of productivity growth, have supported a view that the social rates of return to R&D have generally exceeded by a substantial amount the rates of return on almost any other form of investment available to the U.S. economy.[4]

These high social rates of return contributed to a consensus that the U.S. was substantially under investing in R&D—and that this under investment was a substantial

constraint on economic growth. Because of the spillover of R&D benefits in the form of consumers and producers surplus, even privately funded R&D shared the characteristics of public goods—the economic unit that generates the new technology captures only a portion of the social benefits from its research. The policy implication that was generally drawn is that the U.S. should expand public sector support for R&D to correct private sector under investment.

The generality of the above conclusion has been challenged, however, by studies by Lichtenberg that have attempted to measure the private rates of return to firms that conduct publicly funded research and technology development.[5] These studies failed to find significant private or social rates of return from publicly funded R&D conducted by private firms. However, R&D in manufacturing industries more generally has been found to yield social rates of return that substantially exceed the private rate of return from 'own productivity improvements' derived from R&D performed with government funding."[6]

Bias in Measurement

It has been suggested that one explanation for these results may be that a high percentage of firm-level federally funded industrial research has been conducted by defense or defense-related firms. Neither the R&D nor the products resulting from such R&D are subject to a market test. The design of technology, firm-level costs, and returns are heavily influenced by bilateral bargaining. Research results and technology development information are usually classified. Prices and compensation are frequently renegotiated following project completion. A substantial share of the products derived from the federally funded R&D are often sold back to the government. Under these

institutional arrangements conventional measures of profitability and productivity may not be appropriate.[7]

Even if market transactions were not distorted by defense contract provisions the impact of federal funding on firm-level R&D or profitability of performing firms would not represent an adequate test of the effects of public sector, and particularly of defense sector, R&D on economic performance. Public funding is often a complement (rather than a substitute) for private R&D and thus may enhance sector-level or economy wide profitability and productivity. In addition, as Lichtenberg himself notes, defense or defense-related procurement of services and products resulting from R&D may represent a substantial stimulus to firm-level research and technology development.[8]

In an attempt to test the substitution hypothesis Paul David and his colleagues conducted a critical review of the large body of econometric research studies that attempted to shed some light on the issue of whether public sector R&D has been a substitute for, or a complement to, private sector R&D.[9] After sorting out the subset of studies that were adequately designed to test the substitution hypothesis, they found that the results from about one-third were consistent with the substitution hypothesis, while two-thirds were consistent with the complement hypothesis. I find it particularly significant that almost all of the higher-level aggregate studies were consistent with the complement hypothesis. The implication is that the more aggregate studies were able to capture elements of complementarity that could not be detected at the individual firm level.

Perspective

My own view is that we do not yet have, and perhaps cannot have, a body of rigorous econometric evidence against which to evaluate the economic impact of defense and defense-related R&D and procurement. David and his colleagues explicitly eschewed any effort to assess the magnitude of the economic effect of complementarity. What are the implications for attempts to assess the significance of military procurement on the development of commercial technology? My answer is that careful narrative analysis of individual cases is a more effective method of capturing the effects of complementarity than econometric analysis. David has also pointed out that narrative analysis may be better able to capture the long-term or lagged effects of the public R&D investments that are the source of major general purpose technologies.[10] In the late 1970s Robert Solow famously observed that "computers are found everywhere but in the productivity data."[11] It was not until the late 1990s that research by Dale Jorgenson and several colleagues were able to produce firm estimates of the contribution of computers to U.S. economic growth.[12]

It is particularly important to assess the extent to which military procurement has induced both demand and supply-side forces that have shortened the process of transition from initial concept to commercialization of new general purpose technologies. The Semi-Automatic Ground Environment (SAGE) program and the Apollo space mission drove computer and microprocessor technology and satellite communications and earth observing technology rapidly down their learning curves.[13] The effect in both cases was to advance the development and adoption of commercial technology by at least a decade. In the absence of defense and defense related R&D it is doubtful that I would have sent a

draft of my book manuscript to my editor in New York or have flown by wide bodied jet airplane to annual professional meetings to meet him.

[1] I am indebted to Frank R. Lichtenberg and Paul A. David for comments on an earlier draft of this paper.

[2] Vernon W. Ruttan. *Is War Necessary for Economic Growth? Military Procurement and Technology Development* (Oxford 2006).

[3] See, for example, Zvi Griliches, "Research Costs and Social Rates of Return: Hybrid Corn and Related Innovations." *Journal of Political Economy* 66 (October 1958): 419-439; Edwin Mansfield and George Beardsley, "Social and Private Rates of Return from Industrial Innovations." In *The Production and Application of New Industrial Technology*, pp. 144-146, Edwin Mansfield (ed.). New York, NY: Norton 1977.

[4] For an extensive literature review see Colin G. Thirtle and Vernon W. Ruttan, *The Role of Demand and Supply in the Generation and Diffusion of Technical Change.* Chur, Switzerland: Harwood, 1987.

[5] Frank R. Lichtenberg, "The Relationship Between Federal Contract R&D and Company R&D." *American Economic Review* 74 (May 1984): 73-78; "The Private R&D Investment Response to Federal Design and Technical Competitions." *American Economic Review* 78 (June 1988): 550-559; "Impact of the Strategic Defense Initiative on U.S. Civilian R&D and Industrial Competitiveness." *Social Studies of Scienc*e (May 1989): 265-82. For a more extensive literature review see Frank R. Lichtenberg, "Economics of Defense R&D," in *Handbook of Defense Economics.* Keith Hartley and Todd Sandler, (eds.), pp. 431-457. Amsterdam, Netherlands: Elsevier, 1995.

[6] Paul A. David, Brownwin H. Hall and A. Toole, "Is Public R&D a Complement or a Substitute for Private R&D? A Review of the Econometric Evidence." *Research Policy* 29 (April 2000): 497-529.

[7] Zvi Griliches, "R&D Productivity, Econometric Results and Measurement Issues." In *Handbook of Innovation and Technical Change,* ed. Paul Stoneman, pp. 52-89. Oxford, UK: Blackwell, 1995.

[8] Lichtenberg, op cit. 1984.

[9] Paul A. David, et al., "Is Public R&D a Complement?" pp. 497-529.

[10] Paul A. David, "Letter to Author." April 11, 2004.

[11] Robert M. Solow, "We'd Better Watch Out." *New York Times Book Review.* (July 12, 1987): 36.

[12] See particularly Dale W. Jorgenson and Kevin J. Stiroh, "Information Technology and Growth." *American Economic Review* 89 (May 1999): 109-115; Dale W. Jorgenson, "Information Technology and the U.S. Economy." *American Economic Review* 91 (March 2001): 1-32.

[13] Vernon W. Ruttan, *Is War Necessary for Economic Growth?* Chapters 2 and 7.