Venture Capital
and the Economics of Innovation

Lecture 4

The Failure of Market Failure

"How Much Should We Spend on Basic Research?"

"**From a given expenditure on science we may expect a given flow, over time, of benefits that would not have been created had none of our resources been directed to basic research**. This flow of benefits (properly discounted) may be defined as the social value of a given expenditure on basic research. However, if we allocate a given quantity of resources to science, this implies that we are not allocating these resources to other activities and, hence, that we are depriving ourselves of a flow of future benefits that we could have obtained had we directed these resources elsewhere. **The discounted flow of benefits of which we deprive ourselves…may be defined as the social cost of a given expenditure on basic research**. The difference between the social value and the social cost is net social value or social profit. **The quantity of resources that a society should allocate to basic research is that quantity which maximizes social profit**."

(R. R. Nelson, "The Simple Economics of Basic Scientific Research," *Journal of Political Economy*, 67(1959), P. 297.)

Market Failure Due to Externalities

"***If*** all sectors of the economy are perfectly competitive, ***if*** every business firm can collect from society through the market mechanism the full value of the benefits it produces, and ***if*** social costs of each business are exclusively attached to the inputs which it purchases, then the allocation of resources among alternatives uses generated by private-profit maximizing will be a socially optimal allocation of resources. But **when the marginal value of a 'good' to society exceeds the marginal value of the good to the individual who pays for it, the allocation of resources that maximizes private profits will not be optimal**. For in these cases private-profit opportunities do not adequately reflect social benefit, and in the absence of positive public policy, the competitive economy will tend to spend less on that good 'than it should.' Therefore, it is in the interests of society collectively to support production of that good." (Nelson, p. 298)

Logic for Increasing Basic Research

"…[**If**} basic research can be considered as a homogeneous commodity…the public can be assumed to be indifferent between the research results produced in government or in industry laboratories; **if** the marginal cost of research output is assumed to be no greater in non-profit laboratories than in profit-oriented laboratories, and **if** industry laboratories are assumed to operate where marginal revenue equals marginal cost, then the fact that industry laboratories do basic research *at all* is itself evidence that we should increase our expenditure on basic research.

"…Clearly then, **if** industry laboratories are in profit-maximizing equilibrium, society would benefit from an increase in basic-research expenditure in industry laboratories, holding research efforts elsewhere constant….

"…[A]nd **if** it is socially desirable that expenditure on basic research be increased in industry laboratories, then it is also socially desirable that research expenditure be increased in non-profit laboratories. For **if** marginal social benefit exceeds marginal cost in industry laboratories, so does it in non-profit laboratories." (Nelson, pp. 304-5)

When Gains from Invention are Large and Obvious

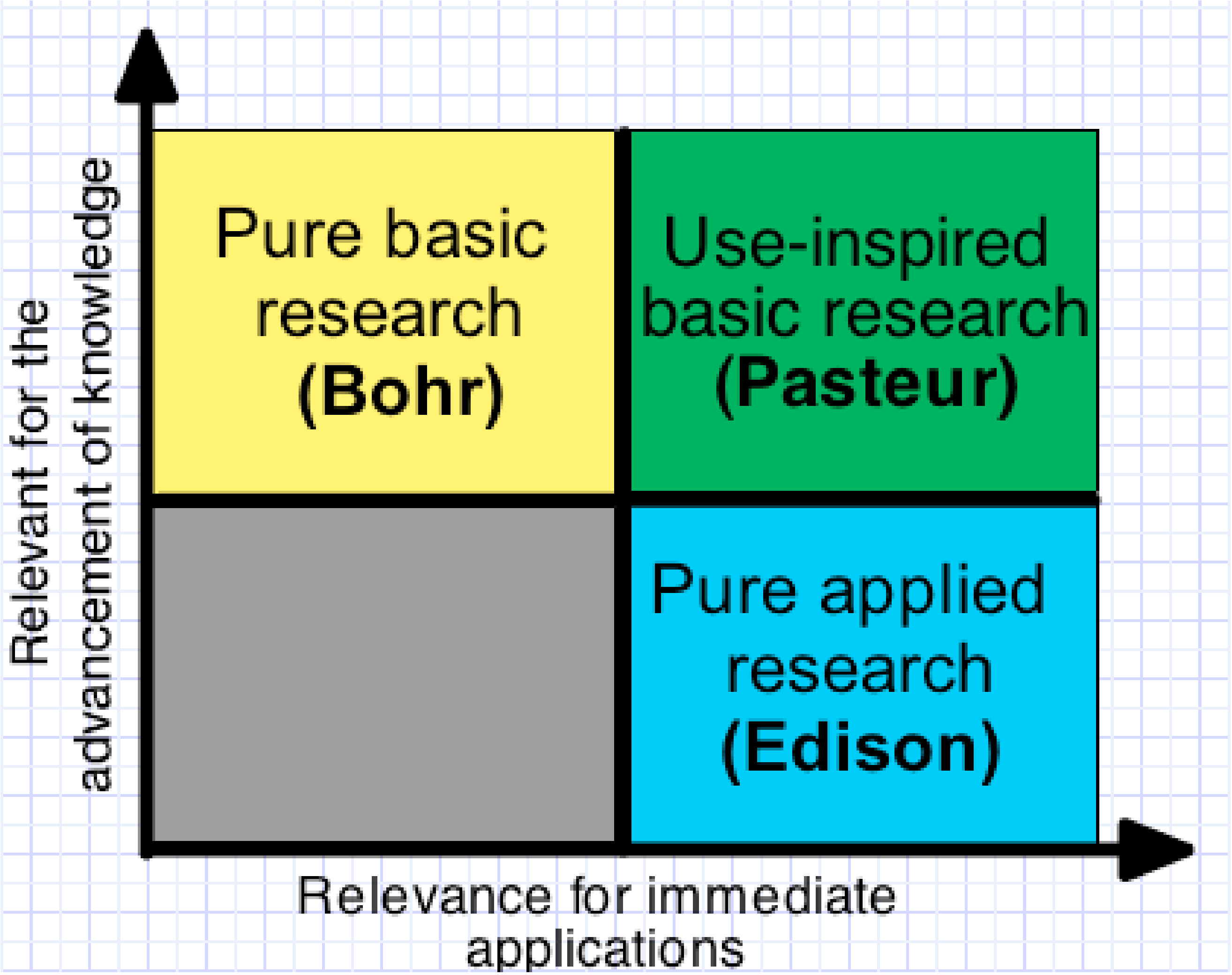
"**In many instances the economic utility of a particular invention is so great that an inventive effort is economically rational, even though the underlying scientific knowledge is scanty and hence the expected cost of making the invention is great**. Edison's attempt to develop an incandescent lamp and Goodyear's attempt to improve the characteristics of rubber are cases in point. In these cases, since there was little useful scientific knowledge, the invention procedure was trial and error, the next trial being roughly – but only roughly – indicated by a very loose theory formulated as the research proceeded. **But though the inventors knew that it would probably be costly to achieve their objective, they believed that that the gains, if they were successful were sufficiently great to make the effort profitable**." (Nelson, p. 300)

Investing in Science under Uncertainty: Applied *versus* Basic Research

"**Often, though the inventor believes there is great demand for a particular invention, it is not rational for him to attempt the invention, given the state of scientific knowledge.** Expected cost will exceed revenue unless additional scientific knowledge can be obtained….To the extent that the results of applied research are predictable and relate only to a specific invention desired by a firm, and to the extent that the firm can collect through the market the full value of the invention to society, opportunities for private profit through applied research will just match social benefits of applied research….

"**Moving from the applied-science end of the spectrum to the basic science end, the degree of uncertainty about the results of specific research projects increases, and the goals become less clearly defined and less closely tied to the solution of a specific practical problem or the creation of a particular object…." (Nelson, p. 300)**

(See: Rothschild Report, *The Organisation and Management of Government Research and Development*, Cmnd. 4814 (London: HMSO), in Parliamentary Papers (House of Commons and Command), Session 2, November 1971–October 1972, vol. XXXV, pp. 747–775.)



(Donald E. Stokes, *Pasteur's Quadrant: Basic Science and Technological Innovation,* Washington D.C.: Brookings Institution Press, 1997.)

The Role of the Broad-based Technology Firm: Nelson and Schumpeter Mark II

"It is clear that for significant advances in knowledge we must look primarily to basic research; the social gains we may expect from basic research are obvious. **But basic research efforts are likely to generate substantial external economies. Private-profit opportunities alone are not likely to draw so large a quantity of research into basic research as is socially desirable.**

"…A firm producing a wide range of products resting on a broad technological base may well find it profitable to support research toward the basic end of the spectrum.

"…It is not just the size of the companies that makes it worthwhile for them to engage in basic research. Rather **it is the broad underlying technological base, the wide range of products they produce or will be willing to produce if their research efforts open possibilities**…." (Nelson, p.p. 302-3)

Market Failure Due to Increasing Returns, Externalities, Uncertainty

"The classic question of welfare economics will be asked here: to what extent does perfect competition lead to an optimal allocation of resources? We know from years of patient refinement that competition insures the achievement of a Pareto optimum under certain hypotheses. **The model usually assumes…that, (a) the utility functions of consumers and the transformation functions of producers are well-defined functions of the commodities in the economic system, and (b) the transformation functions do not display increasing returns**….The second condition needs no comment. The first seems to be innocuous but in fact conceals two basic assumptions of the usual model. It prohibits uncertainty in the production relations and in the utility functions, and **it requires all the commodities relevant either to production or to the welfare of individuals to be traded in the market….**

"We have then three of the classical reasons for the possible failure of perfect competition to achieve optimality in resource allocation: ***increasing returns***, ***inappropriability***, *and* ***uncertainty***…."

(K. Arrow, "Economic Welfare and the Allocation of Resources for R&D," in K. Arrow (ed.), *Essays in the Theory of Risk*-Bearing (New York: American Elsevier, 1971 [1962]),pp. 144-5)

The Optimal Allocation of Uncertainty

"The role of the competitive system in allocating uncertainty seems to have received little systematic attention. I will first sketch an ideal economy in which the allocation problem can be solved by competition….

"…**Let us define a 'commodity-option' as a commodity in the ordinary sense labelled with a state of nature**….The production of a given commodity under uncertainty can then be described as the production of a vector of commodity-options.

"**Suppose…we have a market for commodity-options. What is traded on each market are contracts to buy or sell quantities of a given commodity *if* a given state of nature prevails**.

…[T]he markets for commodity-options in this ideal model serve the function of achieving an optimal allocation of risk-bearing among the members of the economy….

"**But our economic system does not possess markets for commodity-options**…." (Arrow, pp. 145-6)

The Optimal Supply of Information

"…**The cost of transmitting a given body of information is in many cases very low**. If it were zero, then optimal allocation would obviously call for unlimited distribution of the information without cost. In fact, a given piece of information is by definition an indivisible commodity, and the classical problems of increasing returns or indivisibilities appear here. **The owner of the information should not extract the economic value which is there, if optimal allocation is to be achieved; but he is a monopolist, to some small extent, and will seek to take advantage of this fact**.

"In the absence of special legal protection, he cannot…simply sell information on the open market. Any purchaser can destroy the monopoly….

"**With suitable legal measures, information may become an appropriable commodity….However, no amount of legal protection can make a thoroughly appropriable commodity of something so intangible as information**…" (Arrow, p. 151)

The Optimal Demand for Information

"**The demand for information also has uncomfortable properties. In the first place, the use of information is certainly subject to increasing returns….In the second place, there is a fundamental paradox in the determination of the demand for information; its value to the purchaser is not known until he knows the information, but then he has in effect acquired it without cost.** Of course, if the seller can retain property rights in the use of the information, this would be no problem, but given incomplete appropriability, the potential demander will base his decision on less than optimal criteria….

"It should be made clear that from the viewpoint of efficiently distributing an existing stock of information, the difficulties of appropriating information are an advantage….**The chief point made here is the difficulty of creating a market for information if one should be desired for any reason**." (Arrow, p. 152)

Invention and Research as Risky Processes: Arrow and Schumpeter Mark II

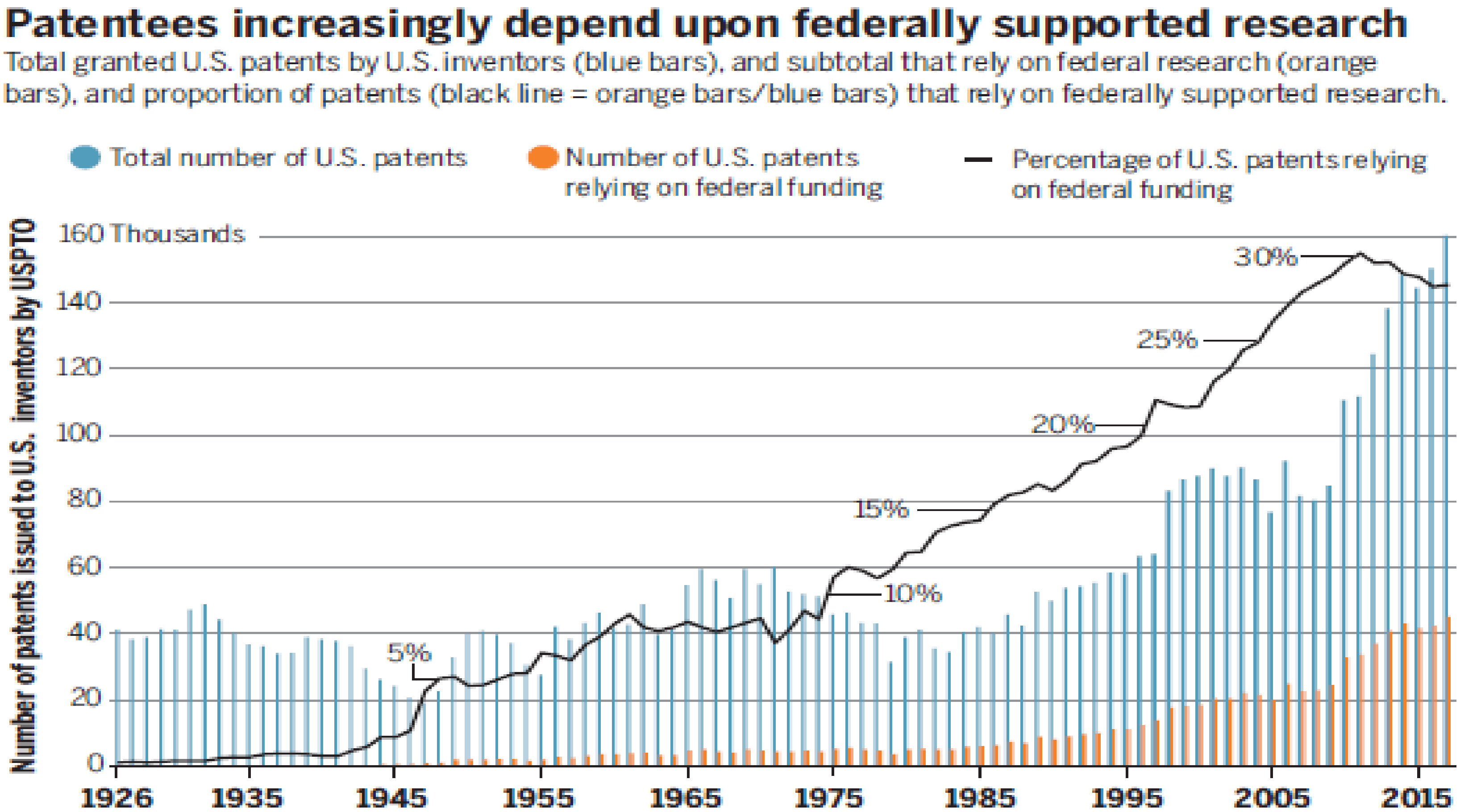
"**As a risky process, there is bound to be some discrimination against investment in in inventive and research activities**. In this field, especially, the moral factor will weight heavily against any kind of insurance or equivalent form of risk-bearing….**The only way, within the private enterprise system, to minimize this problem is the conduct of research by large corporations with many projects going on, each small in scale relative to the net revenue of the corporation. Then the corporation acts as its own insurance company**. But clearly this is only an imperfect solution." (Arrow, p. 153)

"**The only ground for arguing that monopoly may create incentives to invest is that appropriability may be greater under monopoly than under competition**. Whatever differences may exist in this direction most of course still be offset against the monopolist's disincentive created by his pre-invention monopoly profits." (Arrow, p. 159)

Arrow's Summary

"To sum up, we expect a free enterprise economy to underinvest in invention and research (as compared with an ideal) because it is **risky**, because **the product can be appropriated** **only to a limited extent**, and because of **increasing returns in use**. This underinvestment will be greater for more basic research. **Further, to the extent that a firm succeeds in engrossing the economic value of its inventive activity, there will be an underutilization of that information as compared with an ideal allocation**." (Arrow, p. 156)

Private R&D Reliance on Public Sector



21 JUNE 2019 • VOL 364 ISSUE 6446 1139

"Killing the Golden Goose? The Decline of Science in Corporate R&D"

"Scientific knowledge is believed to be the wellspring of innovation. Historically, firms have also invested in research to fuel innovation and growth. **In this paper, we document a shift away from scientific research by large corporations between 1980 and 2007. We find that publications by company scientists have declined over time in a range of industries. We also find that the value attributable to scientific research has dropped, whereas the value attributable to technical knowledge (as measured by patents) has remained stable.** These effects appear to be associated with globalization and narrower firm scope, rather than changes in publication practices or a decline in the usefulness of science as an input into innovation. **Large firms appear to value the golden eggs of science (as reflected in patents) but not the golden goose itself (the scientific capabilities).** These findings have important implications for both public policy and management.

(A. Arora et. al., NBER Working Paper 20902, January 2015, Abstract)

Tech Spillovers and Market Rivalry

"…**R&D generates at least two distinct types of "spillover" effects**. The first is ***technology* (or knowledge) *spillovers***, which may increase the productivity of other firms that operate in similar technology areas. The second type of spillover is the ***product market rivalry effect*** of R&D. Whereas technology spillovers are beneficial to other firms, R&D by product market rivals has a negative effect on a firm's value due to business stealing. Despite much theoretical research on product market rivalry effects of R&D (including patent race models), there has been little econometric work on such effects, in large part because **it is difficult to distinguish the two types of spillovers using existing "empirical strategies**."

(N. Bloom, Schankerman, M., and Van Reenen, J., "Identifying Technology Spillovers and Product Market Rivalry," *Econometrica* 81:4 (2013), 1347-1393, pp. 1347-8)

Tech Spillovers and Market Rivalry: Methodological Innovations

"**First**, using a general analytic framework, **we develop the implications of technology and product market spillovers for a range of firm performance indicators (market value, citation-weighted patents, productivity, and R&D**). The predictions differ across performance indicators, thus providing identification for the technology and product spillover effects. **Second, we empirically distinguish a firm's position in *technology* space and *product market*** space using information on its patenting across technology fields, and its sales activity across different four-digit industries. **This allows us to construct distinct measures of the distance between firms in the technology and product market dimensions**. We show that the significant variation in these two dimensions allows us to distinguish empirically between technology and product market spillovers. **We also develop a methodology for deriving the social and private rates of return to R&D, measured in terms of the output gains generated by a marginal increase in R&D over heterogeneous firms**."

(Bloom et. al., p. 1348)

Tech Spillovers and Market Rivalry: Model and Empirical Results

Comparison of Empirical Results to Model With Technological Spillovers and Product Market Rivalry

(1)	(2) Partial Correlation	(3) Theory	(4) Empirics Jaffe	(5) Empirics Mahalanobis	(6) Empirics Jaffe, IV	(7) Consistency?
$\partial V_0/\partial r_\tau$	Market value with *SPILLTECH*	Positive	0.381**	0.903**	1.079***	Yes
$\partial V_0/\partial r_m$	Market value with *SPILLSIC*	Negative	−0.083**	−0.136**	−0.235**	Yes
$\partial k_0/\partial r_\tau$	Patents with *SPILLTECH*	Positive	0.417**	0.530**	0.407**	Yes
$\partial k_0/\partial r_m$	Patents with *SPILLSIC*	Zero	0.043	0.053	0.037	Yes
$\partial y_0/\partial r_\tau$	Productivity with *SPILLTECH*	Positive	0.191**	0.264**	0.206**	Yes
$\partial y_0/\partial r_m$	Productivity with *SPILLSIC*	Zero	−0.005	−0.007	0.030	Yes
$\partial r_0/\partial r_\tau$	R&D with *SPILLTECH*	Ambiguous	0.100	−0.176*	0.138	
$\partial r_0/\partial r_m$	R&D with *SPILLSIC*	Ambiguous	0.083**	0.224**	−0.022	

Bloom et. al., p. 1375, Table VII

Tech Spillovers and Market Rivalry: Private and Social Returns to R&D-Caveat

"…[W]e use our coefficient estimates to calculate the private and social returns to R&D….In doing this, **we are making the stronger assumptions that the coefficients we estimated in the empirical work have a structural interpretation and can be used for policy purposes**. This goes beyond the simple qualitative predictions of the model that we tested….We are assuming here that the functional forms are correct, the distance metrics can be interpreted quantitatively, and the estimated coefficients are causal. **For all these reasons, this discussion is inherently more speculative**."

(Bloom et. al., p. 1381)

Tech Spillovers and Market Rivalry: Private v. Social Returns to R&D - Simplified

…**[W]e define the marginal social return (MSR) to R&D for firm *i* as the increase in *aggregate output* generated by a marginal increase in firm *i*'s R&D stock (taking into account the induced changes in R&D by other firms). The marginal private return (MPR) is defined as the increase in *firm i's output* generated by a marginal increase in its R&D stock**….

"Using our baseline parameter estimates, assuming symmetric firms and no amplification, and evaluating these expressions at the median value of [the ratio of output to the R&D stock], **we obtain an estimate of the MSR of 58%..., and an estimate of the MPR of 20.8%....**This calculation shows that, for the sample of firms taken together, **the marginal social returns are between two and three times the private returns, indicating under-investment in R&D**…."

(Bloom et. al., pp. 1381, 1383)

Tech Spillovers and Market Rivalry Revisited

"This paper has updated the results of Bloom, Schankerman and Van Reenen (2013). We include an additional 15 years of data in our analysis of the effects of spillovers on firm value, productivity and R&D, and an additional 6 years of data in our analysis of the effects of spillovers on firm patenting, increasing our sample size by two to three fold. **The updated estimates are broadly similar to the original findings**. We show that there are **large positive spillovers among technologically-close firms, and negative spillovers from product market rivals due to the business stealing effect**. In contrast to [BSV](2013) **we find a negative effect of rivals' R&D on firm knowledge production** as measured by citation-weighted patents. **Back-of-the-envelope welfare calculations confirm the earlier paper's findings of a sizable wedge between the social and private returns to R&D. Indeed, our estimates suggest that the wedge may be even larger**."

"…[T]he marginal social return to R&D (57.7%) exceeds the marginal private return to R&D (13.6%) by 44.1%."

(B. Lucking, Bloom, N., and Van Reenen, J., "Have R&D Spillovers Changed?" NBER Working Paper 24622 May 2018 p. 26-7, 3-4.)

The Role of the State: Demand Side "War Made the Industrial Revolution"

"**Britain was in major military operations for eighty-seven of the [127] years between 1688 and 1815….War was the norm in this period. And it shaped the economy…**

"[T]he British state did much more than minimalistically provide the financial and transportation infrastructure for industrial revolution;…it consumed metal goods in the mass quantities that industrial revolution necessary and possible. Just its bulk demand for guns alone stimulated innovations in industrial organization and metallurgical technology with enormous ripple effects. **At the start of the eighteenth century, it contracted for tens of thousands of guns; by the early nineteenth century its needs were in the millions.** That shift in magnitude signifies industrial revolution in the metallurgical world…."

(P. Satia, *Empire of Guns: The Violent Making of the Industrial Revolution* (Penguin Press, New York: 2018),pp. 1, 6)

The Role of the State: Supply Side
The American Version

"**The history of the United States is no different from that of other modern countries; fighting wars and preparing for wars have been an absolutely critical spur of economic growth and development**. Many of the key industrial and organizational breakthroughs of the late eighteenth and nineteenth centuries came in industries that were developing weapons or other supplies, such as ships or uniforms, that were being procured on a large scale by the military. Starting with the Revolutionary War, continuing with the War of 1812, the wars against the Native Americans, and the Civil War, some of the most important innovations in production and organizational technologies came in the manufacture of guns and other weapons. In fact, **the rifle figures prominently in manufacturing history as one of the first instances of the use of interchangeable parts to facilitate expanded production. Moreover, the machine tools developed for weapons production then migrated to industries producing sewing machines, bicycles, and ultimately automobiles**."

(F. Block (2011), "Innovation and the Invisible Hand of Government" in F. Block and Keller, M.R. *State of Innovation: The U.S. Government's Role in Technology Development*, Boulder CO: Paradigm Publishers, p. 6)

The Role of the State: Both Sides US DoD and the Digital Revolution

"One mechanism through which defense-related R&D investments can aid innovation is **military funding for new bodies of scientific or engineering knowledge that supports innovation in both defense-related and civilian applications**….This channel…is likely to produce the greatest benefits…in basic and applied research, rather than development.

"A second important channel through which defense-related R&D affects civilian innovative performance are **the classic 'spin-offs**,'…[C]ivilian spin-offs…appear to be most significant in the early stages of development of new technologies…[before] civilian and military requirements…diverge….

"A third important channel…is **procurement**….The US military services…have played a particularly important during the post-1945 period as 'lead purchaser'….

"Defense-related research spending contributed to **the creation of a university-based US 'research infrastructure'** during the postwar period that has been an important source of civilian innovations, new firms, and trained scientists and engineers…."

(D. C. Mowery, "Military R&D and Innovation," in B. W. Hall and Rosenberg, N., *Handbook of the Economics of Innovation* (Amsterdam: Elsevier, (2010), pp. 1236-7)

Defense R&D and Private R&D

"Empirically, we find strong evidence of…. **Increases in government-funded R&D generated by variation in predicted defense R&D translate into significant increases in privately-funded R&D expenditures, with our preferred estimates of the elasticity equal to 0.43**. Our estimate implies that defense-related R&D is responsible for an important part of private R&D investment in some industries. For example, in the US "aerospace products and parts" industry, defense-related R&D amounted to $3,026 million in 2002 (nominal). Our estimates suggest that this public investment results in $1,632 million of additional private investment in R&D. **Our estimates also indicate that cross-country differences in defense R&D might play an important role in determining cross-country differences in overall private sector R&D investment**….

"**The increases in private R&D expenditures appear to reflect actual increases in R&D activity, not just higher wages and input prices** caused by increased demand. We uncover significant positive effects on employment of R&D personnel…with limited wage increases. This is consistent with a fairly elastic local supply of specialized R&D workers within an industry across countries, or across industries.

(E. Moretti, Steinwender, C., and Van Reenen, J., "The Intellectual Spoils of War? Defense R&D, Productivity and International Spillovers," NBER Working Paper 264893, November 2019, p. 4.)

Public/Private Partnership

"In short, the market fundamentalist history of the U.S. economy before the New Deal is basically fanciful. **Leaving warfare and armaments out of the history of U.S. industry is like the proverbial production of Hamlet without the prince**. But even beyond that, economic development in the nineteenth century and in the first decades of the twentieth depended on an ongoing partnership between the government and business. **Government provided necessary infrastructure such as roads, canals, railroads and harbors, and helped train the labor force and build the society's technological capabilities; government agencies worked to facilitate the diffusion of productive innovations in agriculture, industry, and services**."

(F. Block (2011), "Innovation and the Invisible Hand of Government" in F. Block and Keller, M.R. *State of Innovation: The U.S. Government's Role in Technology Development*, Boulder CO: Paradigm Publishers, p. 6)

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

Friederich List: *The National System of Political Economy* (1841)

List "was probably the first economist to argue consistently that industry should be linked to the formal institutions of science and education: 'There scarcely exists a manufacturing business which has no relation to physics, mechanics, chemistry, mathematics, or the art of design, etc. No progress, no new discoveries and inventions can be made in these sciences by which a hundred industries and processes could not be improved or altered"….List's main concern was with the problem of how Germany could overtake England. **For underdeveloped countries…, he advocated not only protection of infant industries but a broad range of policies designed to accelerate or to make possible industrialization and economic growth. Most of these policies were concerned with learning about new technology and applying it**…."

(Soete, Verspagen, B. and ter Weel, B., "Systems of Innovation" in Hall and Rosenberg, N., pp. 1161-2)

.

National Security as the Liberal Rationale for State Investment in R&D

"**For reform liberals the war seemed at first to be a golden opportunity to create technological capabilities for the federal government that peacetime Congresses had rejected**. In a total war anything that stretch materials in short supply or raised productivity might be justified on the basis of national security. Peacetime industrial R&D had demonstrated convincingly that it could do both….**That this R&D might create new postwar growth industries and break the grip of prewar monopolists was never far from the minds of such advocates**. Federally funded civilian industrial R&D, they hoped, might not only help win the war abroad, but the peace at home, too."

(D.M. Hart, *Forged Consensus, Science, Technology and Economic Policy in the United States, 1921-1953* (Princeton University Press, 1998) p. 130.)

The Postwar Boom: Schumpeter Mark II in Action

"The boom…continued unabated for more than three years, took a slight dip in 1949, and then resumed. Under these conditions of 'exhilaration,' rather than 'stagnation,' the government could cheer on private enterprise, put its books in order, even begin to retire the war debt….**The large firms that had won the war were now winning the peace, in part…by making R&D a routine component of their investment….**

"….The war redeemed the reputation of business and brought R&D unprecedented prestige….Starting from the foundations provided by wartime R&D contracts (and maintained to some extent by continued military R&D), many large firms dramatically expanded their central research laboratories, building lavish campus-like facilities to attract technical talent in some cases….**A 1947 survey by *Business Week* found that 87 percent of firms had expanded their research since before the war and 72 percent expected to expand it further**."

(Hart, pp. 152-3)

The Postwar Convergence on Policy

"**In science and technology policy, too, a convergence occurred**….A conducive macroeconomic environment, in which private actors could have the expectation of sufficient demand to invest in R&D and technological innovation was the essential goal of this policy. **The state needed to develop the analytical capability to monitor this private investment, so that it could compensate in case of failure, although the ways and means of compensation were matters of dispute**. Beyond this the government would have an investment policy in a couple of areas in which markets appeared to fail, academic science and small business start-ups. **The convergence on the boundaries of market failure were slow and painful in coming. Ironically, just when it seemed to have been achieved in the spring of 1950, the Korean War erupted, subordinating the fledgling NSF and the nascent venture capital program to the demands of the national security state**." (Hart, p. 148)

Mission R&D *versus* Market failure and the "[Vannevar] Bush Social Contract"

"**Defense-related R&D is an example of "mission R&D,"** that is, R&D funded by public agencies to support their activities. Despite its significance…, this class of R&D is largely overlooked by the welfare economics of R&D….

"**Although the market failure rationale retains great rhetorical influence in justifying public investments in R&D programs, casual empiricism suggests that it influence over such public investments is modest**…. 'Market failure' underpins less than 50% of public R&D spending in most [OECD] economies.

"…Rather than 'scientists' choosing the fields in which large investments of public R&D funds were made, allocation decisions were based on assessments by policymakers of the research needs of specific agency missions ranging from national defense to agriculture….To a surprising extent, **scholarly analysis of the 'new context' of science and technology policy fails to acknowledge the prominence of mission-oriented R&D programs** that have few of the hallmarks of the idealized 'Bush Social Contract.'"

(D. C. Mowery, "Military R&D and Innovation," in Hall and Rosenberg, *Handbook of the Economics of Innovation* (Amsterdam: Elsevier, pp. 1221-3)

The Korean War

"The Korean War exploded the barriers to the expansion of the national security state....Even as the conventional battle stalemated in Korea, the United States committed itself fully to technological military superiority, especially in strategic weapons...."

Military R&D spending benefitted from a rearmament program that emphasized high-technology weaponry. It more than tripled during the Korean War, stabilizing at about $1.8 billion."

Fiscal 1951 Defense Budget = $13 billion

First Supplemental Budget = $12 billion

Second Supplemental Budget = $17 billion

Third Supplemental Budget = $6 billion

Fiscal 1952 Defense Budget = $60 billion

(Hart, pp. 194-5)

NOTE: US GDP 1951 = $339 billion

The Counterfactual

"…[O]ne should question the counterfactual that if the national security state had not been so large and powerful, the federal government would have embarked on a significant civilian technology development program….{The} reform liberal program was rejected well before the explosion of military R&D that followed the outbreak of the Korean War. **Keynesians would certainly have mounted initiatives to expand federal spending, but without examples of military spillovers, it is far from clear they would have placed much weight on R&D**….**Congress would have weighed more heavily in making a domestically oriented science and technology policy than it did in making one that emphasized national security**, further reducing the prospects for an outcome that deviated dramatically from the status quo…." (Hart, p. 221)

Inflection Point: 1957

"**Two separate events…in 1957 established [an] inflection point in the development of the innovation system in the United States. The first was the Soviet Sputnik launch in October 1957**. This created considerable panic in U.S. policy circles….[T]he most significant change was the creation of the Defense Advanced Research Projects Agency (DARPA) in the defense Department….

"**The second key event was the 1957 revolt by a group of scientists and engineers who were working for a firm started by William Shockley**….

"…[I]n the 1960s…DARPA's program officers began to exploit the possibilities of this new innovation environment…[which] made it much easier for program officers to generate real competition among different groups of researchers since those running the start-up firms understood that their firm's future viability rested on meeting ambitious benchmarks.

"…[A]s the possibility of creating spin-offs became institutionalized, established firms also had to adapt to the new environment…." (Block, p. 9)

"National Systems of Innovation": Significance for State Policy

"**The main implication of the systems of innovation concept from the point of view of policy is that it provides a much broader foundation for policy as compared to the traditional market failure-based policy perspective**. In the market failure-based perspective, every policy measure must be justified both by the identification of some form of market failure, and by an argument that explains how the policy can bring the system closer to its optimal state. Government failure might be more serious than market failure, so not all market failures merit government interventions.

"**In a systems view of innovation, markets do not play the overarching role of generating an optimal state. Instead, nonmarket-based institutions are an important ingredient in the 'macro' innovation outcome**….[T]he innovation systems approach rejects the idea of an optimal state of the system as a target….Innovation policy is just like innovation, continuously on the run….[with] two major consequences:

"…[**T]here is a broader justification of the use of policy instruments as compared to market failure-based policies….**

"…[T]he government or policymaking body is part of the system with its own aims and goals being endogenous."

(Soete, Verspagen, B. and ter Weel, B., "Systems of Innovation," pp. 1169-70.)