10 WHERE IS THE STATE?

The history of financial bubbles and crashes – and of the banality yet necessity of the former, and the inevitability of the latter – fits nicely with Schumpeter's vision of economic development through waves of creative destruction. Speculation in the financial markets from time to time finances discontinuous innovation that transforms the market economy, redistributing monopoly profits while generating and liquidating transient financial gains. However, for a theorist-practitioner of entrepreneurial finance who has spent well over three decades performing on a stage constructed by government investment in innovation, the game so summarized is incomplete. Where is the state in this story?

From the First Industrial Revolution on, the state has served as an enabler – sometimes as the engine – of economic development, subsidizing if not directing the deployment of transformational technology and, more recently, taking responsibility for funding the advanced science and engineering from which economically significant innovation has come to be derived. Even in liberal nineteenth-century Britain, where the state played no role in planning or funding the build-out of the railways, Acts of Parliament were required to reassign property rights from landowners to entrepreneurial "projectors," and the state subsequently acted to promote cartels to limit the destructive competition that followed.[1] Elsewhere – in the United States, across the continent of Europe and throughout Asia – the state has played a central

[1] F. Dobbin, *Forging Industrial Policy: The United States, Britain and France in the Railway* Age (Cambridge University Press, 1994), pp.167–171, 200–205.

role in sponsoring emergent market economies in an uncertain and competitive world. As Dietrich Rueschemeyer and Peter Evans wrote over twenty-five years ago in their contribution to the foundational collection of essays *Bringing the State Back In*:

> Effective state intervention is now assumed to be an integral part of successful capitalist development . . . Once the assumption of a competitive market is relaxed . . . there are strong theoretical reasons for believing that state intervention is necessary if capitalist economies are to sustain capital accumulation and reach higher levels of productivity.[2]

Two other responsibilities have intersected the state's role in enabling competitive markets and promoting economic development. Both are the consequences of crises: those that arise endogenously within the evolving capitalist system of markets and those that arise from conflict between nation-states. As far back as London's banking crisis of 1825, the central bank, as the agent of the state, has acted to save the financiers of the market economy from their own folly. From the Great Depression of the 1930s through recent events, and never without controversy, the state has acted more broadly and directly to protect the market economy from the consequences of financial collapse. Outside of the fantasies of Ayn Rand's libertarian heroes, it is not possible to imagine a modern economic and financial world that does not depend on effective state initiatives to protect its participants from the collective consequences of their own actions. As Dani Rodrik has written, the "dichotomy between markets and states . . . is false and hides more than it reveals."[3]

I learned about the intersection of economics and politics in wartime – the second domain of state responsibility – at my father's knee. Eliot Janeway was an acute student of their codependency. His one book of scholarly stature, *The Struggle for Survival: A Chronicle of Economic Mobilization in World War II*, is an exhaustive yet enthralling account of FDR's triumph in presiding over the incoherent and inefficient process through which he "inspired and provoked" the home

[2] D. Rueschemeyer and P. B. Evans, "The State and Economic Transformation: Toward an Analysis of the Conditions Underlying Effective Intervention," in P. B. Evans, D. Rueschemeyer and T. Skocpol (eds.), *Bringing the State Back In* (Cambridge University Press, 1985), pp.44–46.

[3] D. Rodrik, *The Globalization Paradox: Why Global Markets, States, and Democracy Can't Coexist* (New York: Norton, 2011), p.9.

front to win the war by "the momentum of production."[4] Thus I was educated from childhood in this dimension of the Three-Player Game

Arguments have persisted for centuries over the extent to which markets should determine how resources are allocated and returns are distributed versus the degree to which the state should intervene to regulate, even direct, the process and to control or cushion its outcomes. By the time I read *The Great Transformation*, Karl Polanyi's summation of this struggle from the time of Adam Smith to the onset of World War II, I knew his concept of "the double movement" in my bones. It took active state action to clear out the weight of traditional practices that confined commercial activity and protected the poorest from starvation. But the accomplishment was unsustainable:

> The idea of a self-regulating market implied a stark utopia. Such an institution could not exist for any length of time without annihilating the human and natural substance of society: it would have physically destroyed man and transformed his surroundings into a wilderness. Inevitably, society took measures to protect itself, but whatever measures it took impaired the self-regulation of the market, disorganized industrial life, and thus endangered society in yet another way.[5]

Bernard Harcourt, formerly Chair of the University of Chicago political science department and now at Columbia, argues that the distinction between the self-regulating free market and state direction of economic activity is false. The very existence of a competitive "free" market such as the Chicago Board of Trade presupposes enabling state action. In his detailed critique of the "Chicago School" of economics and its extension into the legal arena, Harcourt writes:

> [O]nce a market has been determined to be a "competitive market," then it is efficient. Efficiency now attaches to competitive markets . . . In that newly defined space . . . there is no need for regulation, no need for government intervention – because there the market will regulate itself . . . [But] massive government intervention (the kind necessary to make possible a wheat pit at the Chicago

[4] E. Janeway, *The Struggle for Survival: A Chronicle of Economic Mobilization in World War II* (New Haven, CT: Yale University Press, 1951), p.18.

[5] K. Polanyi, *The Great Transformation: The Political and Economic Origins of Our Times* (Boston: Beacon, 2001 [1944]), pp.3–4. Central to Polanyi's argument is the historical role of the state in actively working to free markets from traditional restraints.

> Board of Trade) is necessary to achieve what we call a "free" market.[6]

Harcourt goes further, reviewing the legal context in which markets operate:

> When all these layers of legal entitlements, technical rules, and criminal prohibitions are exposed, it is clear that the notion . . . of market efficiency is pure fiction. The idea of a self-regulated market is preposterous. It would be like a competitive sporting event without a referee: it would not work, nor has it ever worked.[7]

No wonder that those who are inescapably dependent on the markets of the economy and who also have access to the political process seek to invent or invoke powers of the state to counter the impact of market forces. Throughout the western world, the progressive extension of the franchise to the propertyless during the nineteenth and twentieth centuries shifted this aspect of the game and extended its scope. In this light, protective tariffs and unemployment benefits are both evidence of the same dimension of the Three-Player Game in process.

In the new Conclusion to this second edition, we will explore in depth the reconfiguration of the Three-Player Game over the last generation: in particular, the delegitimization of the American state as an economic actor in the context of a radical shift in the balance of market power. I follow Mark Blyth, who wrote in 2002, extending Polanyi's argument and reflecting on the Reagan–Thatcher counter-revolution of the 1980s:

> If . . . labor demanded protection . . . then was it not reasonable to expect another reaction . . . by . . . capitalists? The contemporary neoliberal economic order can be seen as merely the latest iteration of Polanyi's double movement. It is an attempt once again to disembed the market from society, to roll back the institutions of social protection and replace them with a more conforming institutional order.[8]

[6] B. Harcourt, *The Illusion of Free Markets* (Cambridge MA: Harvard University Press, 2011), pp.145–146. Note that Donald MacKenzie cites this same legitimizing power of "efficient markets" in his analysis of how modern finance theory transformed the capital markets: D. MacKenzie, *An Engine Not a Camera: How Financial Models Shape Markets* (Cambridge, MA: MIT Press, 2008).

[7] *Ibid*. 196.

[8] M. Blyth, *Great Transformations: Economic Ideas and Institutional Change in the Twentieth Century* (Boston: Beacon, 2002), p.4.

That very success in "liberating" the market economy from the encroachment of the state has potentially dire consequences for the Innovation Economy, reducing the reach of the state in a domain where its enabling role has been critically required. For the state has time and again been mobilized to play a positive role, undertaking and underwriting investments in furtherance of national development and national security, from Jean-Baptiste Colbert's seventeenth-century France to the strategic role of the US Department of Defense in the construction of the digital economy after World War II.

The Hamiltonian Tradition

In the history of the Innovation Economy in the United States, Alexander Hamilton stands as the iconic founding father. His *Report on Manufactures*, delivered to Congress in 1791, is the urtext for those seeking to mobilize public support for private enterprise. Hamilton did provide arguments for protective tariffs, export bounties and improvements of the nascent transportation system, but the *Report* itself was not the blueprint of legend for comprehensive state intervention.[9] Hamilton's *Report* was tabled by Congress, and even in diluted form it proved to be no program of action. Although it was adopted in principle by the Whigs under Henry Clay and John Quincy Adams, no major national commitment followed; at the federal level, the one component that came to be embedded in the American political economy was the protective tariff. Only at the level of the individual states, engaged as they were in "rivalistic mercantilism," was the rest of Clay's "American System" widely adopted.[10]

Hamilton's initiative that did prove transformational was directed toward the other player in the Three-Player Game, financial capitalism, whose dynamics he discerned with extraordinary insight. As early as 1779–1781, he had defined the need for a privately owned central

[9] J. R. Nelson Jr., "Alexander Hamilton and American Manufacturing: A Reappraisal," *Journal of American History*, 65(4) (1979), pp.993–994.

[10] Dobbin, *Forging Industrial Policy*, p. 24. For a deep analysis of the relatively unlimited Hobbesian "police power" of the individual American states versus the limited, enumerated powers of the federal state under the Constitution, see G. Gerstle, *Liberty and Coercion: The Paradox of American Government from the Founding to the Present* (Princeton University Press, 2015).

bank modeled on the Bank of England and had envisioned the national debt as a "national blessing" because it bonded, quite literally, the interests of the "monied" class to the survival, indeed the prosperity, of the new republic.[11] At the end of the Revolution, Hamilton not only won the argument within Washington's cabinet for establishing the Bank of the United States. He also won the opportunity to make the "bold gamble" of nationalizing the debts of the newly federated states – although at the cost of moving the capital from New York to a malarial swamp on the banks of the Potomac River.[12]

Hamilton's "financial revolution" was accompanied by the proliferation of state-chartered banks: by 1825, the United States had 330 incorporated banks in addition to the 25 branches of the Second Bank of the United States, at a time when Britain was limited to the Bank of England plus several hundred banking partnerships, each of which was legally restricted to no more than six partners, all exposed to unlimited liability.[13] Richard Sylla summarizes:

> By 1795, the United States had all the institutional components of a modern financial system – strong public finances and debt management, a national dollar monetary unit based on precious metals, a central bank, a banking system, thriving securities markets ... When the industrial and transportation revolutions of early U.S. history took place, a modern financial system was there to finance them.[14]

Sylla's enthusiasm may overstate the modernity of the early American financial system, much of whose focus was on the provision of short-term commercial credit and unproductive speculation in land. But, as Naomi Lamoreaux has documented for New England in her study *Insider Lending*, family-controlled, state-chartered banks did provide the capital critical to the rapid development of manufacturing in early

[11] R. Sylla, "The Political Economy of Early US Financial Development," in S. Haber, D. C. North and B. Weingast (eds.), *Political Institutions and Financial Development* (Palo Alto, CA: Stanford University Press, 2008), pp.64–66.

[12] *Ibid.* 66. There is an obvious resonance between Hamilton's effective exercise in nation building through financial and fiscal integration and the stalemate crippling the Eurozone since 2009, for, unlike the creators of the euro, Hamilton understood that financial integration could survive only if backed by fiscal integration.

[13] *Ibid.* 79. This was a lingering consequence of legislative response to the South Sea Bubble.

[14] *Ibid.* 61–62.

nineteenth-century America.[15] More generally, Hamilton's vision encompassed the deliberate state sponsorship of financial capitalism as the critical enabler of both economic growth and political stability. There may be no more explicit, institutionally embodied statement of one thesis of this book in its most positive form. However, Hamilton's program would be crippled at its core in barely a generation when the Jacksonian Revolution threw the Three-Player Game into reverse.

With respect to state promotion of innovation, Hamilton (like Benjamin Franklin) was an advocate of prizes and subsidies, support for which "in the United States has always been sporadic and limited in scope."[16] But from early days Americans were pioneers in exploiting the most obvious opportunity available to technological followers: "appropriation" of the intellectual property already developed by others. Samuel Slater was the signal vector, emigrating by stealth from Britain in 1790, at a time when the export of machinery was prohibited by law. Slater was master of the most advanced textile manufacturing technique, "Arkwright's Patents." Backed by Moses Brown of Providence, he reproduced from memory a state-of-the-art mill on the Blackstone River in Pawtucket, Rhode Island.[17]

A generation later, neighboring Fall River, Massachusetts, was launched on its path to becoming the largest locus of textile manufacturing in the world through the success of two native sons, William C. Davol and Bradford Durfee, in smuggling a state-of-the-art "self-acting mule" out of England through France.[18] Nonetheless, respect for the returns to original invention was evident in the Constitution's remarkable injunction to Congress in Article I, Section 8: "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."

In direct and conscious contrast with the prevalent European patent systems, characterized by extremely high fees and subject to

[15] N. R. Lamoreaux, *Insider Lending: Banks, Personal Connections, and Economic Development in Industrial New England* (Cambridge University Press, 1994).

[16] B. Z. Khan, "Premium Inventions: Patents and Prizes as Incentive Mechanisms in Britain and the United States, 1750–1930," p. 24. Available at www. international .ucla.edu/economichistory/conferences/khan.pdf.

[17] J. Connell, *Biographical Sketches of Distinguished Mechanics* (Wilmington, DE: Porter and Eckel, 1852), pp.41–42.

[18] S. Koorey, *Images of America: Fall River Visited* (Charleston, SC: Arcadia Publishing, 2012), p.40.

pervasive political influence, the American system was open and accessible, dedicated to

> providing broad access to a well-specified and enforceable property right to new technology [which] would stimulate technical progress and nearly all of the innovations they made in the design of the patent institutions aimed to strengthen and extend inventive activities to a much broader range of the population than would have enjoyed them under traditional intellectual property institutions.[19]

Not only were fees set at a level less than 5 percent of those prevailing in Great Britain. In addition, the early laws also provided for public dissemination of patented innovations and for the examinations of applications prior to grant, thus reducing uncertainty about the validity of issued patents and increasing their value as financial assets for sale or licensing. "By 1810, despite its lag in industrial development, the United States far surpassed Britain in patenting per capita."[20] Alongside the protective tariff and the subsidies provided by the federal and state governments for constructing the transportation infrastructure, patent policy would serve as the third public policy initiative that fueled the technological engine of economic growth in the United States.

In 1989, Arthur Schlesinger Jr. reflected on the Hamiltonian tradition as he considered the role of the state relative to the national economy. Schlesinger's own initial and formidable contribution to scholarship had been *The Age of Jackson*,[21] published forty-four years earlier. In direct challenge to the long-prevailing dogma that Jackson's presidency had represented the entry of the trans-Appalachian frontier into American politics, Schlesinger's thesis was that the politics of Jackson's time had been class-based. Jackson's triumph depended on decisive support from Eastern working men and shopkeepers rebelling against the privileges of legislatively chartered corporations as most visibly and despisedly embodied in the Second Bank of the United States. Now, Schlesinger offered a balanced view of what had been at stake:

[19] N. R. Lamoreaux and K. L. Sokoloff, Introduction to N. R. Lamoreaux and J. L. Sokoloff (eds.), *Financing Innovation in the United States: 1870 to the Present* (Cambridge, MA: MIT Press, 2007), p.9.

[20] *Ibid.* 5.

[21] A. M. Schlesinger Jr., *The Age of Jackson* (Boston, MA: Little, Brown, 1945).

> The tradition of affirmative government was the tradition of Hamilton . . . Subsequent statesmen in that tradition, especially John Quincy Adams and Henry Clay, elaborated the Hamiltonian Vision into what Clay called the American System – a great dream of economic development under the leadership of the national state . . .
>
> The American System, with its program of internal improvements, a protective tariff and Biddle's Bank of the United States was designed to benefit the business classes; but this was not the whole truth. The Whig program was also designed to benefit the nation and so accelerate the pace of economic growth. In retrospect, the Hamiltonians had a sounder conception of government and a more constructive policy of economic development than the anti-statist Jacksonians.[22]

The mercantilism represented by the Hamilton–Clay tradition transcends the history of the American political economy in its significance. Prior to the Industrial Revolution, France stood out for state commitment to internal improvements: in 1666, Colbert had convinced Louis XIV to finance the Canal du Midi as one aspect of the generations-long campaign to establish centralized state authority over the still feudal French nation.[23] Since time immemorial, however, the public credit of the state had been predominantly devoted to the financing of war, whether the state was in the hands of a feudal king, an absolute monarch, a republican city-state, or the conflation of royal power circumscribed by parliamentary representatives of the propertied classes and tempered by "the mob" that emerged in Britain from 1688. The game between the financial markets and the state was played out over the terms on which the owners of liquid capital would fund the state's armies relative to the problematic likelihood of their being repaid.

The economic consequences of wars so financed could be substantial – and certainly had been during the Napoleonic Wars – both in the state's exceptional demand for resources and in the inflation regularly generated by military consumption of scarce commodities and disruption of their supply, but these were unintended consequences. The American System, by contrast, was explicitly statist, emulating the French tradition of mobilizing public credit in pursuit of economic

[22] A. M. Schlesinger Jr., "The Ages of Jackson," *New York Review of Books*, 36(19) (1989), pp.49–50.

[23] Dobbin, *Forging Industrial Policy*, p. 101.

development for its own sake, thereby triangulating the relationships between the state, the market economy and financial capitalism for positive gain, not for reciprocal destruction. Although the implementation of the American System was limited at the national level, at the state level it produced the salient success of the Erie Canal, and it attracted capital from abroad to fund an extensive array of other canals and turnpikes and then the railroads. But, consistent with state engagements in support of the emerging market economies that followed, it also produced rampant corruption that fed the Jacksonian assault on financial interests.[24]

Jacksonian Reversal

Jackson's successful war against the Bank of the United States and the east coast financiers reversed the dynamic of the Three-Player Game, as a most energetic president mobilized the government to limit the reach of financial capitalism. Liberation came at a cost for the market economy. As Sylla notes, "The United States without a central bank ... suffered more financial instability than other leading nations into the twentieth century."[25] Jackson's activism was succeeded by a generation of passivity, as the emerging sectoral conflict paralyzed the political processes. Richard Franklin Benzel has comprehensively argued that

> the state that early American nationalists had previously attempted to establish ... had become a mere shell by 1860 – a government with only a token administrative presence in most of the nation and whose sovereignty was interpreted by the central administration as contingent on the consent of the individual states.[26]

The Hamilton–Clay tradition of mobilizing public resources, including the public credit, for national economic development was renewed in the program of the Whigs' institutional successor, the Republican Party of Lincoln. The Republicans added to the traditional protective tariff and broad program of internal improvements the grand project of

[24] *Ibid.* 44–47, and J. Macdonald, *A Free Nation Rich in Debt* (New York: Farrar, Straus and Giroux, 2003), pp.385–386.

[25] Sylla, "The Political Economy of Early US Financial Development," p. 86.

[26] R. F. Benzel, *Yankee Leviathan: The Origins of Central State Authority in America, 1859–1877* (Cambridge University Press, 1990), p. ix.

a Pacific Railroad. But any such initiatives were blocked by the Southern-controlled Senate, since their direct effect would be to strengthen the northeastern industrial economy and to tie the developing agrarian economy of the Midwest more closely to it, at the expense of the Southern plantation economy. Decisively, because the initiatives legitimized the central state's intervention into the institutions of the market economy, their potential indirect consequence was even more threatening: federal action directed against slavery as and when the South lost its grip on national power.

The only federal initiative sanctioned by the South was enforcement of the Fugitive Slave Act, especially after the Southern-controlled Supreme Court opened the entire country to property rights in human beings with the Dred Scott decision in 1857.[27] Contrariwise, one result of Southern secession was removal of the roadblocks to state support of economic development, whose need was both legitimized and amplified by the North's mobilization for war. By the summer of 1862, the key components were in place: protective tariffs against foreign manufactures; the Pacific Railway Act, which provided for land grant subsidies on a massive scale; and the Morrill Act to finance agricultural colleges on public lands in the developing West.[28]

The land grants to the railroads subsidized a massive mobilization of private financial capital to construct the foundations of the new economy that emerged in the decades after the Civil War. The availability of such capital at unprecedented scale was itself a consequence of the institutional innovations required to pay for the war in the North.[29] In turn, the history of corruption at the state level was replicated at the national level, most notoriously in the Credit Mobilier scandal surrounding the financing of the Union Pacific. This galvanized antistatist sentiments "by fulfilling the Constitution's prophecy that state power breeds corruption."[30] Of the American System, only protective tariffs remained when state subsidies to the construction of infrastructure were abandoned. However, with their powerful assistance and as a model for future rising economies, the United States moved into a substantial and sustained trade surplus beginning in the

[27] *Ibid*. 63–64. [28] *Ibid*. 69 n. 1, 173–174, 178.
[29] *Ibid*. 238, and Macdonald, *A Free Nation Rich in Debt*, pp. 382, 396–399.
[30] Dobbin, *Forging Industrial Policy*, pp. 55–56.

mid-1870s.[31] In the future, national development would no longer legitimize direct interventions in the market economy by the American state. Such initiatives would need to be explicitly justified in the name of national security.

Technology's Emerging Dependence on Science

The requirements of war induced the first exercise in mobilizing science for national needs. On March 3, 1863, Lincoln signed the act of incorporation of the National Academy of Sciences (NAS), chartered as a private, nonprofit organization to "investigate, examine, experiment, and report upon any subject of science or art" when called upon by any department of the government. During the Civil War, the Navy Department was the most significant client of the NAS, asking for guidance on protecting the bottoms of its new iron-hulled vessels against corrosion and on correcting magnetic deviations of compasses on iron ships.

After the end of the war, when its principal project was to evaluate the longevity of metal headstones for the countless graves of dead soldiers, the NAS faded into irrelevance. Beyond generating reports on such subjects as "Means of Distinguishing Calf's Hair from Woolen Goods" (1875) and "The Restoration of the Declaration of Independence" (1880), its only two lasting contributions were recommendations that led to the creation of the US Geological Survey in 1878 and the Forestry Service in 1905.[32] Apart from the NAS, direct investment in the scientific and technological sources of economic growth was modest: in the armories that perfected the "American system of manufactures," characterized by interchangeable mechanical parts,[33] and in the experimental stations of the Department of Agriculture, founded through the same impulse that led to passage of the Morrill Act .[34]

[31] Historical Statistics of the United States Millennium Edition Online, table Ee362–375. Available at http://hsus. cambridge.org/HSUSWeb/index.do.

[32] The National Academies, "The NAS in the Late Nineteenth Century" (Washington, DC: The National Academies, n.d.). Available at www7.nationalacademies. org/archives/late19thcentury.html.

[33] D. C. Mowery and N. Rosenberg, *Technology and the Pursuit of Economic Growth* (Cambridge University Press, 1989), p.27.

[34] R. R. Nelson, M. J. Peck and E. D. Kalacheck (eds.), *Technology, Economic Growth and Public Policy* (Washington, DC: The Brookings Institution, 1967).

It was by indirection that public policy contributed to technology-driven economic growth. Preceding the mercantilist policies that extended the war's massive stimulus to industrial expansion and accompanying them through the remainder of the nineteenth century, a vibrant market for technology developed in the United States. As documented by Naomi Lamoreaux and Ken Sokoloff, this was the offspring of the distinctively accessible American patent system, especially after the process of examination by professionals was introduced by the Patent Act of 1836.[35] By 1870, the emergence of a class of professional inventors in association with an active trade in patent rights is evident in the data. This market mechanism for transforming invention into commercializable innovation expanded through the early years of the twentieth century, increasingly intermediated by professional agents operating on an increasingly national scale.[36]

By World War I, a new institution was emerging to serve as the nexus of technological innovation: the industrial research laboratory. The relevance of science to industry had been discovered by that most entrepreneurial of capitalists, Andrew Carnegie, who reflected on the economic benefits of systematic assays of iron ore by a trained chemist:

> What fools we had been! But then there was this consolation: we were not as great fools as our competitors . . . Years after we had taken chemistry to guide us [they] said they could not afford to employ a chemist. Had they known the truth then, they would have known they could not afford to be without one.[37]

The more general recognition, a generation later, of science-based research and development as a source of competitive advantage may be read as an indirect impact of the railroads in the context of the American version of *laissez-faire*. As we saw in Chapter 7, the creation of a national market, along with the radical decline in manufacturing costs as companies exploited the "economies of scale and scope" analyzed by Alfred Chandler, engendered the merger movement enabled by the trust bubble. Not only did companies have a need and an

[35] N. R. Lamoreaux and K. L. Sokoloff, "Inventive Activity and the Market for Technology in the United States, 1840–1920," National Bureau of Economic Research Working Paper 7107 (1999), p.8.

[36] *Ibid*. 22, 30–33.

[37] Quoted in Mowery and Rosenberg, *Technology and the Pursuit of Economic Growth*, p. 30.

opportunity to rationalize "the facilities and skills of the constituent companies by making concentrated investments in manufacturing, marketing and management,"[38]

> the mergers and corporate reorganizations of the late nineteenth and early twentieth centuries hastened the growth of industrial research . . . In firms such as American Telephone and Telegraph, General Electric, U.S. Steel or Du Pont, the development of a strong central office was closely associated with the establishment or significant expansion of a central research facility.[39]

Thus, the great corporations moved into a space that previously had been haphazardly funded, principally by wealthy individuals guided by motives that combined curiosity and philanthropy. Darwin, for example, was the beneficiary of a rentier father whose highly successful angel investments in the First Industrial Revolution were accompanied by dynastic alliances with the enormously wealthy Wedgwood family. The Cavendish Laboratory at Cambridge University, founded in 1874 under the initial Cavendish Professor James Clerk Maxwell, was a gift of William Cavendish, Seventh Duke of Devonshire. A distant echo of such initiatives can be found in the extraordinary story of Alfred Loomis: having sold out of his successful investment banking firm before the Crash of 1929, he created a physics laboratory on his estate in Tuxedo Park, New York, where he personally financed and participated actively in work that contributed to the invention of radar in time for World War II.[40] What links these and a host of other instances is the funders' utter lack of interest in financial return.

By the early twentieth century, regional stock exchanges had opened up to fund entrepreneurial companies, especially in the Midwest, but the first generation of high-tech industries mobilizing the sciences of chemistry and electricity were embodied in the large-scale industrial enterprises of the mid-Atlantic region.[41] From the 1920s through the 1970s, central research laboratories were funded by the

[38] A. D. Chandler, *Scale and Scope: The Dynamics of Industrial Capitalism* (Cambridge, MA: Harvard University Press; Belknap Press, 1999), p.229.

[39] Mowery and Rosenberg, *Technology and the Pursuit of Economic Growth*, p. 71.

[40] J. Conant, *Tuxedo Park: A Wall Street Tycoon and the Secret Palace of Science that Changed the Course of World War II* (New York: Simon & Schuster, 2002).

[41] N. R. Lamoreaux, K. L. Sokoloff and D. Sutthiphisal, "Reorganization of Inventive Activity in the United States during the Early Twentieth Century," National Bureau of Economic Research Working Paper 15440 (2009), pp.24–25.

monopoly profits of the great corporations. Whether established by formal agreement with the federal government (AT&T's), based on patent monopolies (RCA's and Xerox's) or generated from a combination of innovative research and commercial dominance (DuPont's and IBM's), the leading research laboratories could afford to invest upstream in the fundamental science from which technological innovations of commercial significance might evolve. Seemingly secure monopolies created environments in which science for its own sake could be indulged and pursued within the for-profit enterprise.[42]

Prior to World War II, federal support of research remained trivial in terms of both absolute dollars and scientific impact. Only agriculture was favored for federal research support, thanks to the Morrill Act and the Agriculture Department's Extension Service: in 1940, the $30 million of research funding for agriculture exceeded that for the combined departments that would make up the postwar Department of Defense.[43] Although the original National Institute of Health emerged from the combined Public Health and Marine Hospital Service in 1930, public funding of life sciences research remained marginal.[44]

State Support of Science

World War I did leave a legacy that lingered through the interwar decades. In 1916, as the United States was drawn more deeply into the European conflict, the NAS "could not keep up with the volume of requests for advice regarding military preparedness." In response, Wilson asked the NAS to establish the National Research Council, whose purpose would be:

[42] Of course, the role of the great corporations in the American social economy transcended investment in science and engineering. Beyond Social Security and before Medicare, they also became the principal vehicles for delivering the haphazard and incomplete welfare state – specifically, pensions and medical insurance – whose fragile base was thus also vulnerable to the same loss of entrenched competitive power that terminated the scientific mission of the central industrial research labs.

[43] Mowery and Rosenberg, *Technology and the Pursuit of Economic Growth*, pp. 92–93.

[44] National Institutes of Health, "Chronology of Events" (Bethesda, MD: National Institutes of Health, n.d.). Available at www.nih.gov/about/almanac/historical/chronology_of_events.htm.

> to bring into cooperation government, educational, industrial, and other research organizations with the object of encouraging the investigation of natural phenomena, and increased use of scientific research in the development of American industries, the employment of scientific methods in strengthening the national defense, and such other applications of science as will promote the national security and welfare.[45]

Wilson perpetuated the Council by executive order, and its general mission enjoyed the support of the most activist member of the Republican cabinets of the 1920s, Herbert Hoover, whose Commerce Department worked broadly to promote the application of science and technology for the benefit of American business.

As David Hart has documented, Hoover's "associationalism," which looked to voluntary cooperation among industrial competitors and between industry and the academic research community, collapsed under the weight of the Depression.[46] Its progressive faith was challenged from the right and the left. On the right, Frank Jewett, President of the Bell Telephone Laboratories and of the NAS from 1938, argued that "federal meddling with patent laws and research funding would slow the pace of scientific and technological progress."[47] On the left, although one faction of New Dealers argued for job-creating investment in technology-enabled enterprise, exemplified by the Tennessee Valley Authority, others sought to curb the potential job-destroying impact of productivity-enhancing innovation.[48]

Jewett's fear that government bureaucrats would distort research priorities exemplified a more general rejection of state intervention in the market economy. In *Business Cycles*, published in 1939, Schumpeter stated the case in the most comprehensive terms:

> What we know from experience is not the working of capitalism as such, but of a distorted capitalism which is covered with the scars of past injuries inflicted on its organism . . . The very fundaments of the industrial organisms of all nations have been politically shaped. Everywhere we find industries which would not exist at all but for

[45] The National Academies, "Organization of the National Research Council" (Washington, DC: The National Academies, n.d.). Available at www7.nationalacademies. org/archives/nrcorganization.html.

[46] D. M. Hart, *Forged Consensus: Science, Technology and Economic Policy in the United States, 1921–1953* (Princeton University Press, 1998), pp.30–61.

[47] *Ibid*. 18. [48] *Ibid*. 66.

> protection, subsidies and other political stimuli, and others which are overgrown or otherwise in an unhealthy state because of them . . . Such industries and assets are of doubtful value, in any case a source of weakness and often the immediate cause of breakdowns or depressive symptoms. This type of economic waste and maladjustment may well be more important than any other.[49]

It was strictly to the private sector and increasingly to the large-scale firm that Schumpeter looked for innovation. In the "perennial gale of creative destruction," the restrictive practices and price-setting power of monopolists and oligopolists were "incidents of a long-run process of expansionism which they protect rather than impede."[50] As specific evidence, anticipating Mowery and Rosenberg's research, Schumpeter remarked:

> The first thing a modern concern does as soon as it feels that it can afford it is to establish a research department every member of which knows that his bread and butter depends on his success in devising improvements. This practice does not obviously suggest aversion to technological progress.[51]

By the time that Schumpeter wrote these sentences in 1943, the dynamics of the Innovation Economy had been transformed by the advent of World War II. The profit-seeking monopolistic enterprise that funded applied research for immediate economic reward, as characterized by Schumpeter, was supplanted by the national security state funding research that extended all the way back upstream to quantum physics in its struggle for survival.

Beginning in 1939, as the threat of war grew imminent, Vannevar Bush came to play a decisive role in the mobilization of science for war. As President of the Carnegie Corporation and Chair of the National Advisory Committee for Aeronautics, Bush joined with Harvard President James Conant, MIT President Karl Compton and Frank Jewett, who was no longer resistant to a role for the state in the allocation of resources to research for national security. Jointly, they urged creation of a central directing authority in the federal government. Bush was the

[49] J. A. Schumpeter, *Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process*, 2 vols. (London: McGraw-Hill, 1939), vol.1, p.13.

[50] J. A. Schumpeter, *Capitalism, Socialism and Democracy*, 4th edn. (London: Allen & Unwin, 2010 [1943]), pp.87–88.

[51] *Ibid*. 96.

author of the proposal for the National Defense Research Committee (NDRC), which secured the President's approval in May 1940 as the German armies swept through France. When, a year later, the NDRC was subsumed into the OSRD, Bush moved from serving as Chair of the former to serving as Director of the latter. Under his leadership, OSRD directed the work of some 30,000 scientists and technologists in the development of sonar, radar, the proximity fuse, the Norden bombsight and, until administration of the Manhattan Project was transferred to the Army in 1943, the atomic bomb.[52]

Once again, the direct mobilization of science ended with the termination of hostilities, and OSRD was wound down. As noted in Chapter 2, the national science research institution proposed by OSRD's Director, Vannevar Bush, did not provide the road map for a strategic commitment to state underwriting of science. After five years of Washington in-fighting, the Korean conflict triggered the reconstruction in nominal peacetime of the national security state. Small as it was militarily in comparison with World War II, the Korean War had a massive economic impact. The defense budget was originally set at $10 billion for fiscal year 1951, a year when GDP amounted to $339 billion. It was increased by emergency appropriations to $42 billion, and the following year reached $60 billion. Military R&D tripled to $1.8 billion. By the mid-1950s, the defense budget amounted to some two-thirds of total federal spending and about 9 percent of GDP.[53] This spending massively augmented the nascent and incomplete welfare state initiated by Social Security. The United States had found its own path to big-state capitalism.

Well before the mid-1970s, when I began my education in the disciplines that underlay computing, "most of the basic electronic development that made digital technology feasible was in place."[54] By the mid-1950s, the Department of Defense had already funded some twenty research projects to construct digital computers,[55] even before the

[52] G. P. Zachary, *The Endless Frontier: Vannevar Bush, Engineer of the American Century* (New York: The Free Press, 1997), pp.171–203.

[53] Hart, *Forged Consensus*, pp. 195, 203.

[54] H. Kressel, *Competing for the Future: How Digital Innovations are Changing the World* (Cambridge University Press, 2007), p.56.

[55] K. R. Fabrizio and D. C. Mowery, "The Federal Role in Financing Major Innovations: Information Technology During the Postwar Period," in Lamoreaux and Sokoloff (eds.), *Financing Innovation*, table 7.2 (p. 296).

Soviet launch of Sputnik catalyzed creation of the Defense Advanced Research Projects Agency (DARPA). From microelectronics and semiconductor devices through computer hardware and software and on to the internet, development of all of the components of digital information and communications technology reflected state policies for both R&D and procurement that

> encouraged the entry of new firms and interfirm technology diffusion. In addition, federal procurement supported the rapid attainment by supplier firms of relatively large production runs, enabling faster rates of improvement in product quality and cost than otherwise would have been realized. Finally, federal support of innovation in IT contributed to the creation of a large-scale R&D infrastructure in federal laboratories and, especially, in U.S. universities.[56]

The deployment of the SAGE air defense computer network served both to accelerate the development of relevant technologies by its prime contractor, IBM, and as a "software university" for hundreds of programmers, "laying the foundations for the software industry's development within the United States." As the dominant source of demand for computers, the Defense Department was able to establish standards such as the COBOL programming language, in which business applications would be written for a long generation.

Even as commercial demand for semiconductor devices and computers began to outstrip military demand, the Defense Department extended its innovative investment in IT to communications, including the foundation of the internet through DARPA. With its principal design objective specified as survival in the event of nuclear war, by 1975 the packet-switched network initially deployed as ARPAnet linked more than 100 nodes at universities and other major research sites. In keeping with its commitment to open standards in IT, the Defense Department sponsored the TCP/IP suite of protocols for digital communications. These won out over a variety of proprietary alternatives and contributed decisively to the open architecture of the internet as it evolved into a universal medium for digital communications and transactions.[57]

During prior technological revolutions that have defined the succession of new economies since roughly 1750, large-scale government support of the deployment of more or less proven technologies had

[56] *Ibid.* 286–287. [57] *Ibid.* 301–302, 305–306.

been significant, even at times decisive, most notably in the United States, where state credit was used to fund canal building and where the gift of public lands subsidized railroad construction. But the post-World War II engagement of the US Department of Defense to finance both fundamental research at the frontier of scientific experimentation and the technological development necessary to produce reliable devices and systems was entirely unprecedented. Much of the funding was directed to the major industrial research labs of the great corporations – AT&T, IBM, RCA – whose monopoly rents had funded scientific advance and innovative engineering from the late nineteenth century to World War II. But much was distributed more broadly as well, especially to universities. Moreover, the major corporations were required to share the results of research not only with each other but with new entrants. When their monopoly profits came under pressure beginning in the 1970s and all the industrial sponsors pressured their central labs for product-oriented, applied R&D, the new academic networks of research and innovation were in place.[58]

By the mid-1960s, the commercial applications of IT had begun to exceed the government's share. When, in the early 1960s, IBM made its enormous commitment to construct System 360, the first comprehensive line of computers that would open wide the commercial market, the company's CEO, Tom Watson Jr., had to fight free from the operational and cultural constraints imposed by its military projects, especially SAGE.[59] On the other hand, IBM's education in the new science and technology of silicon semiconductors was accelerated through collaboration with Texas Instruments, one of the emerging innovators that had been sponsored by the military in the previous decade.[60]

By the end of the 1970s, the "milspec" (military specification) market for semiconductors and computers had become a marginally relevant niche, where requirements were dictated by absolute performance regardless of cost, and by the ability to function in extreme

[58] For an authoritative summary of the rise and fall of the industrial research laboratory as the locus for technological innovation, see Kressel, *Competing for the Future*, chap. 3. For an updated overview of the impact of military investment, see D. C. Mowery, "Military R&D and Innovation," in B. H. Hall and N. Rosenberg (eds.), *Handbook of the Economics of Innovation*, 2 vols. (Amsterdam: North-Holland, 2010), vol. 2, pp. 1219–1256.

[59] S. W. Usselman, "Learning the Hard Way: IBM and the Sources of Innovation in Early Computing," in Lamoreaux and Sokoloff (eds.), *Financing Innovation*, p. 337.

[60] *Ibid.* 341–342.

environments. When the Defense Department announced its Very High Speed Integrated Circuit program in 1980, I recall learning that Intel chose not to participate lest its star designers be distracted from the exploding demand for commercial microprocessors as the personal computer revolution gathered momentum.

Collectively, the American approach stood in sharp contrast to the European model of tight security and concentration on "national champions." Decoupled from any direct concern with economic return, the Defense Department could fund numerous alternative research agendas, underwriting the "wasteful" search for solutions that inevitably accompanies any effort to push back the frontiers of knowledge. Moreover, the defense establishment insisted on an intellectual property rights regime that was scandalously – and productively – loose relative to what preceded it and what has evolved over the three decades since then.

Legitimized by considerations of national security, postwar US policy fostered a complex of commercial industries whose products and services would, some forty years on, combine to create another new economy. In doing so, the federal government also enabled the generation of a host of investment opportunities that would first feed a new class of professional venture capitalists whose work product – the firms they founded – would, in time and in turn, fuel the great dotcom/telecom bubble of 1998–2000. In the meantime, the American model was emulated globally: as Josh Lerner summarizes, "virtually every hub of cutting-edge entrepreneurial activity in the world today had its origins in proactive government intervention."[61]

Soon after Vannevar Bush's vision of institutionalized state funding of science became public policy due to the contingency of the Cold War, the economists Kenneth Arrow and Richard Nelson separately provided a theoretical rationale for state investment in research and development. Both emphasized that the social return to discovery and invention exceeds its private return, as the cost of sharing information is minimal. Arrow emphasized how private firms are inhibited by the inevitable uncertainty that besets such investment, especially when potential returns depend on long-term, indivisible efforts to generate

[61] J. Lerner, *Boulevard of Broken Dreams: Why Public Efforts to Boost Entrepreneurship and Venture Capital Have Failed – and What to Do About It* (Princeton University Press, 2009), p.42.

new knowledge, which, in turn, can only be partially appropriated and monetized by individual firms.[62] Nelson identified the long lag between initiation of research and commercially relevant application and focused on the conditions of emergent industries, where business success usually turned on investment in fundamentally new technologies whose economic value was difficult for the pioneering firms to estimate, let alone capture.[63]

A major academic research program has sought to quantify the extent of the shortfall in private-sector R&D relative to the "social optimum." Bloom, Schankerman and Van Reenen estimate the magnitude of 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.

The authors find "the [net] marginal social returns are between two and three times the private returns."[64]

Despite the theoretical demonstration of market failure in the funding of invention and innovation, now empirically buttressed, arguments for state intervention to address such market failures have proved only marginally compelling. Rather, it has been mission-oriented state investments that have, time after time and across national boundaries, proved effective in driving the individual sectors of the Innovation Economy. David Mowery summarizes the historical record:

> Although the market failure rationale retains great rhetorical influence in justifying public investments in R&D programs, casual empiricism suggests that its influence over such public investments is modest at best . . .

[62] K. J. Arrow, "Economic Welfare and the Allocation of Resources for R&D," in K. J. Arrow (ed.), *Essays in the Theory of Risk-Bearing* (New York: American Elsevier, 1971 [1962]), pp.144–163.

[63] R. R. Nelson, "The Simple Economics of Basic Scientific Research," *Journal of Political Economy*, 67 (1959), pp.297–306.

[64] N. Bloom, M. Schankerman and J. Van Reenen, "Identifying Technology Spillovers and Product Market Rivalry," *Econometrica*, 81(4) (2013), pp.1347–1348, 1383 (emphasis in original).

> Also noteworthy . . . is the relatively small share of central-government R&D spending accounted for by the "Bush–Arrow" form of R&D spending, nonmission-oriented R&D . . . Rather than "scientists" choosing the field 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 in fields ranging from national defense to agriculture.[65]

Writ large, the strategic state interventions that have shaped the market economy over generations have depended on grander themes – national development, national security, social justice, liberation from disease – that transcend the calculus of welfare economics and the logic of market failure.

[65] D. C. Mowery, "Military R&D and Innovation," pp.1222–1223.