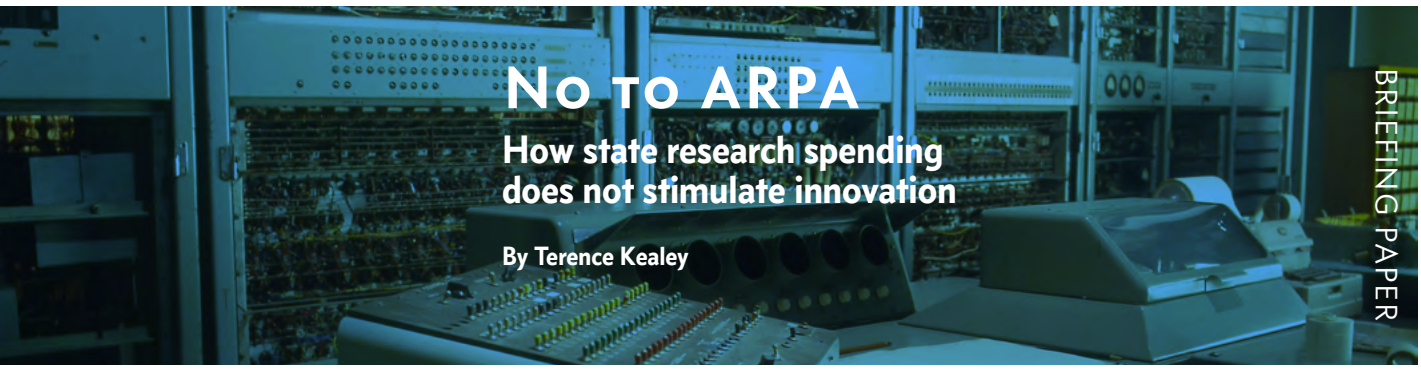

No to ARPA

How state research spending does not stimulate innovation

By Terence Kealey

BRIEFING PAPER

EXECUTIVE SUMMARY

- The UK Government has allocated £800 million to create a British Advanced Research Projects Agency (ARPA) in the March 2020 budget.
- ARPA was originally established by the US Government in 1958 to fund especially pure, especially unrestricted research.
- The supporters of ARPA assert it created the modern world by supporting key advancements in semiconductors, personal computing and the internet.
- But ARPA was perceived by lawmakers to be a waste of money. The Mansfield amendments repurposed ARPA exclusively for defence applications and renamed it to the Defense Advanced Research Projects Agency (DARPA) in 1972.
- After the Mansfield amendments, key figures left ARPA to join Xerox PARC, the research and development arm of printer manufacturer Xerox. It was PARC who pioneered the likes of the mouse, laser printer and the Ethernet network. Therefore, the United States' technological success came *after* ARPA's wings were cut and the key staff had left – not because of the organisation.
- ARPA, along with other state-funded research spending, is justified by claims of a "market failure" in science funding: that private companies under produce "public good" basic science research.
- However, the history of technological progress since the Industrial Revolution demonstrates that private businesses invest in beneficial innovations without state assistance.
- State spending on research and development, in both the United States and Britain, does not contribute to economic growth.
- Substantial science funding in post-war Britain did not revolutionise the economy as was hoped.
- The industrialised East Asian countries, such as South Korea, Taiwan and Japan, have achieved substantial economic growth through business-sector led research and development spending.
- It is a myth that ARPA created the modern world. It is also a myth that state research spending stimulates innovation or economic growth. The UK Government is making a mistake by creating British ARPA.

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The original Advanced Research Projects Agency (ARPA), subsequently renamed Defense Advanced Research Projects Agency (DARPA), was created in the US in 1958. ARPA funded especially pure, especially unrestricted research; and it recruited scientists on unusually free contracts, and with unusually large budgets, to essentially do what they wanted.[1]

Its supporters claim that ARPA delivered the modern world: so Mariana Mazzucato, Professor of Economics of Innovation and Public Value at University College London, has claimed that ARPA is responsible for key advancements in semiconductors and personal computing,

> "Going way beyond simply funding research, DARPA funded the formation of computer science departments, provided start-up firms with early research support, contributed to semiconductor research and support to human computer interface research, and oversaw the early stages of the internet." [2]

This view has been echoed on the Conservative side of politics, and on January 28, 2020, Policy Exchange released Visions of ARPA, which argued that a vast government investment in pure, undirected science, would help transform the economy.

This argument had been adumbrated a year earlier, on March 11, 2019, in a blog by Prime Minister Boris Johnson's chief adviser Dominic Cummings:

> "I have repeated this theme *ad nauseam* on this blog:
>
> 1) We KNOW how effective the very unusual funding for computer science was in the 1960s/1970s—ARPA-PARC created the internet and personal computing … [emphasis in the original]" [3]

Later in 2019, he wrote that:

> "As Bill Gates said, he and Steve Jobs essentially stole into PARC, stole their ideas, and created Microsoft and Apple."[4]

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1 William Bonvillian A summary of the Darpa model (January 28, 2020). In Iain Mansfield and Geoffrey Owen eds, Visions of ARPA. Policy Exchange, London. https://policyexchange.org.uk/wp-content/uploads/Visions-of-Arpa.pdf. pp 27-33.

2 https://www.demos.co.uk/files/Entrepreneurial_State_-_web.pdf

3 Dominic Cummings (March 11, 2019) On the referendum #32: Science/productivity—a) small teams are more disruptive, b) 'science is becoming far less efficient.' Dominic Cummings's Blog. https://dominiccummings.com/tag/darpa

4 Dominic Cummings (June 27, 2019) In Iain Mansfield and Geoffrey Owen (January 28, 2020) Visions of ARPA. Policy Exchange, London. https://policyexchange.org.uk/wp-content/uploads/Visions-of-Arpa.pdf. p 25

According to Cummings, therefore, Britain needs an ARPA so Britain, too, can lead the world technologically. And, as Prime Minister Boris Johnson said during the 2019 election campaign, his government was committed to spending taxpayers' money on 'blue skies' research.[5]

This sentiment was echoed in the Queen's Speech on October 14, 2019, which stated that the British government would:

> "… significantly boost public R&D … modelled on the US Advanced Research Projects Agency …"[6]

Which was followed by the announcement of £800 million for a British ARPA in the March 2020 budget, which in turn was intended to be only the first instalment in doubling the British government's expenditure on research, from £11.4 billion to £22 billion a year, over the next 5 years.[7]

This paper seeks to reassess the accuracy of claims that ARPA/DARPA is responsible for substantial technological progress.

THE EVOLUTION OF US SCIENCE POLICIES

Since the UK is to copy the US's ARPA model, it is worthwhile putting the organisation in the context of the US's science policy history.[8]

Until 1958, the US was *laissez faire* in research. The only research the federal government funded was so-called 'mission' research: federal agencies such as the military, the Coast Survey or the Surgeon General funded research to support their missions; but there was no belief the federal government needed to fund science for its own sake or to compensate for market failure.

So, during the Civil War, the National Academy of Sciences (NAS) was created by the federal government as an independent agency to help develop military technologies such as ironclad ships, and its original research projects were funded by the federal government. But after 1865 the NAS was left to fund itself privately, and it soon survived primarily as a club for distinguished scientists, not dissimilar from the American Philosophical Society in Philadelphia (1743) or the Royal Society in London (1660).

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5 Iain Mansfield and Geoffrey Owen (January 28, 2020) Visions of ARPA. Policy Exchange, London. https://policyexchange.org.uk/wp-content/uploads/Visions-of-Arpa.pdf. p 23

6 The Queen (14 October 2019) The Queen's Speech and Associated Background Briefing, On the Occasion of the Opening of Parliament on Monday 14 October 2019. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attatchment_data/file/839370/Queen_s_Speech_Lobby_Pack_2019_.pdf

7 Kalyeena Makartoff (March 11, 2020) Budget 2020: UK to launch £800m 'blue skies' research agency. The Guardian. https://www.theguardian.com/uk-news/2020/mar/11/budhet-2020-uk-800m-blue-skies-research-agency

8 Terence Kealey (1996) The Economic Laws of Scientific Research. London. Macmillan. pp 140-163.

During the First World War, the federal government looked again to temporary ad hoc science arrangements, and because the NAS was by then only an academy, the government created the National Research Council, which acted as an executive agency of the NAS and which employed researchers who were not members of the NAS. But, again, on the resumption of peace, the NRC was left to fund itself privately, though it was occasionally commissioned by government departments to engage in particular projects.

During the Second World War, in a further iteration of this pattern of ad hoc but only temporary funding by the federal government of military research, the Office of Scientific Research and Development (OSRD) was created to sponsor the Manhattan and other projects. And, again, that was disbanded post-war.

That disbanding was a personal grief to Vannevar Bush, who directed the OSRD (which by 1945 was employing over 6,000 scientists), so in 1945 he wrote *Science: The Endless Frontier* to argue that government-funded pure science would generate better military technologies than would private companies' research and development (R&D). Initially the federal government ignored him, but after the Cold War broke out, and after President Truman had announced his Doctrine, the National Science Foundation (NSF) was established in 1950. The NSF, as another now-familiar defence initiative, was designed to train the extra scientists for the military. Its one novelty, however, was that—in deference to Bush's book—it funded pure as well as applied research.

Then, in 1957, the USSR launched *Sputnik*, the first artificial satellite—and America was traumatised. Had the Russians pulled ahead? In the words of Wernher von Braun:

> "*Sputnik* triggered a period of self-appraisal rarely equalled in modern times. Overnight, it became popular to question the bulwarks of our society; our public education system, our industrial strength, international policy, defense strategy and forces, the capability of our science and technology. Even the moral fiber of our people came under searching examination."[9]

The US responded by copying the Russians' science policies, and in 1958 the federal government launched three vast initiatives: (1) National Aeronautics and Space Administration (NASA), (2) the National Defense Education Act, and (3) ARPA. Yet this uptick in state action presented the federal government with an ideological problem: did communism actually work?

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9 Robert D Lapidus (1970) Sputnik and its repercussions: a historical catalyst. Aerospace Historian: 17. p 89.

THE MARKET FAILURE JUSTIFICATION FOR STATE-SCIENCE FUNDING

As part of his lobbying campaign, Bush had persuaded the US Air Force and the Douglas Aircraft Company to establish a think tank to petition the federal government for money for science; and the organization they created, in 1945, was called Project RAND (Project ***R***esearch ***AND D***evelopment, now the RAND Corporation). So when, in 1957, the federal government needed a free-market justification for copying the USSR's science policies, RAND sprang into action, funding two major economists, Richard Nelson and Ken Arrow (the latter to become a Nobel laureate) to write the appropriate papers. According to RAND's official historian:

> "RAND's economics-of-R&D project also yielded two of the foundation papers in the field: Richard Nelson's 'The Simple Economics of Basic Scientific Research' [1959] and Kenneth J Arrow's 'Economic Welfare and the Allocation of Resources for Invention' [1962] ...
>
> … Nelson's and Arrow's papers provided appealing economic theories as to why the nation would systematically underinvest in basic research. Their theories had clear policy implications: the U.S. government should invest more in basic research owing to "market failures" in the private sector. These theories have been largely internalized within the now dominant neoclassical economic tradition…"[10]

And Nelson and Arrow's claims that markets fail in science have indeed been so internalised.

Nelson and Arrow made two arguments, and since those remain the bases by which all subsequent governments, not just in the US but universally, justify their funding of science, it behoves us to examine them.

Nelson's and Arrow's arguments
(1) the perfectly competitive market

Nelson and Arrow argued that only perfectly competitive markets maximise economic efficiency. i.e., only if there were an infinite number of companies providing an infinite number of products to an infinite number of consumers—all under circumstances of perfect knowledge, whereby nobody knew anything that was not also known by everyone else—would economic efficiency be maximised. Therefore, Nelson and Arrow said, no company should do research, as that would provide it with an unfair advantage and would thus disrupt the perfect market. In Nelson's words, companies with market power must therefore …

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10 David Hounshell (1998) The Cold War, RAND, and the Generation of Knowledge, 1946-1962. RAND History Project, Santa Monica, CA. https://www.rand.org/pubs/reprints/RP729.html

> "… undermine many of the economic arguments for a free-enterprise economy."[11]

Instead, the government should do all research, and its discoveries should be shared equally with all companies. As Nelson wrote:

> "The fact that industry laboratories do basic research at all is itself evidence that we [ie, the government] should increase our expenditure on basic research."[12]

This argument is of course preposterous, and presumably was made only ironically (by which I mean that other economists would recognise the argument as preposterous in practice but interesting in theory). It is of course true that, in neoclassical theory, a perfect market would optimise the production and distribution of existing goods (in formal language, only a perfect market will achieve Pareto optimality); but, in practice, only markets that are competitive in the classical rather than the neo-classical sense will actually generate new goods (aka economic growth). In an Economic Brief published by the Cato Institute, Martin Ricketts and I have further dissected this argument of Nelson and Arrow's.[13]

(ii) SPILLOVERS

Because research generates technical knowledge, and because technical knowledge, once marketed, cannot be kept secret (in formal language, technical knowledge is non-rivalrous and non-excludable), Nelson and Arrow argued that the private sector would underprovide it: why, they asked, would a company fund research to produce an innovation or invention when it knows its competitors will copy it easily? Therefore governments have to fund research.

But when their assertion that research can be easily-copied was tested in real life, it failed. When a team from the University of Pennsylvania examined 48 products that had been copied within the major industries of New England during the 1970s, it reported the direct costs of copying were on average 65 percent of the costs of innovation.[14] Another survey of 650 R&D managers provided similar results for the direct costs of industrial copying.[15]

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11 Richard Nelson (1959) The simple economics of basic scientific research. Journal of Political Economy 67: 297-306 p 306.

12 Richard Nelson (1959) The simple economics of basic scientific research. Journal of Political Economy 67: 297-306 p 304.

13 Terence Kealey and Martin Ricketts (April 6 2020) Innovative Economic Growth: Seven Stages of Understanding. Washington DC. The Cato Institute. The Nelson/Arrow thesis goes unchallenged because it meets the needs of every vested interest: the universities and the scientists will always lobby for more research money; politicians enjoy disbursing those funds as Medici-like latter-day patrons of the arts and sciences; and companies are always looking for corporate welfare. William Baumol's Free-Market Innovation Machine (2004, Princeton, Princeton University Press) provides a good description of classically-competitive markets generating innovation.

14 Mansfield, Edwin et al (1981) Imitation costs and patents: an empirical study. The Economic Journal, 91: 907-918

15 Levin, Richard et al (1987) Appropriating the returns from industrial research and development Brookings Papers on Economic Activity, 3: 783-820.

But the direct costs do not cover all the costs of copying. Knowledge is tacit (could you, the reader, reverse engineer a cloned gene or a mobile phone or a plastic?).[16] So, companies seeking success in the market, need first to sustain the fixed costs of a research staff who maintain their own expertise or tacit knowledge by conducting research.[17] Therefore, those fixed costs need to be added to the marginal costs of copying particular innovations. Companies also need to bear the costs of information and the costs of failed imitation attempts.[18] In practice, therefore, industrial knowledge is fully excludable, and it is open only to those who have themselves invested in research—which creates knowledge that, itself, inexorably enters into the public domain. In formal language, therefore, research is not a public good, and though it is not a conventional private good, it is a contribution good, which thus requires no public subsidies.[19]

Which was how the British and Americans created the Industrial Revolution under *laissez faire*. In the words of Phyllis Deane, professor of economic history at Cambridge:

> "The first industrial revolution occurred in Great Britain and is of particular interest in that it occurred spontaneously, without the government assistance that has been characteristic of most succeeding industrial revolutions."[20]

And the US was to be as *laissez faire* as the UK.

Vannevar Bush had asserted that government funded pure science would galvanise military technology. But when, in 1969, the Office of the Director of Defense Research and Engineering published Project Hindsight, which analysed 700 research 'events' that had led to the development of twenty weapons systems, it found that only 2 of those 700 research events had been of pure science.[21] Bush was wrong: the government funding of pure science did not strengthen the US's defence capabilities.

In defence of its grants, the NSF published *Technology in Retrospect and Critical Events in Science (TRACES)*, which found examples of science feeding military technology, but which had to go back 50 years, to when pure science was funded

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16 Knowledge being tacit, it cannot be fully codified, only experienced. As Michael Polanyi wrote in Personal Knowledge: Towards a Post-Critical Philosophy (1958) University of Chicago Press, Chicago, p 4, "we can know more than we can tell."

17 Rosenberg, Nathan (1980) Why do firms do basic research (with their own money)? Research Policy 19: 165-174. Cohen, Wesley; Daniel Levinthal (1989) Innovation and learning: the two faces of R&D. Economics Journal 99: 569-96

18 Stigler, George (1961) The economics of information The Journal of Political Economy 69: 213-225.

19 Terence Kealey and Martin Ricketts (2015) Modelling science as a contribution good. Research Policy 43: 1014-1024.

20 Deane, Phyllis (1979) The First Industrial Revolution. Cambridge. Cambridge University Press. 2nd ed. p 2.

21 Office of the Director of Defense Research and Engineering (1969) Project Hindsight. Washington DC. Office of the Director of Defense Research and Engineering.

privately, to find them.[22] Unintentionally, therefore, the NSF's response only confirmed the Department of Defense's finding that the government funding of pure science did not feed into useful technology.

Project Hindsight and the fiasco of *TRACES*, moreover, had confounded Senator Mike Mansfield (D-MT, Senate Majority Leader 1961-1977), who could recognise a waste of public money when he saw it. So in 1969/70 and 1973 respectively he pushed through his famous amendments to the Military Authorization Acts to stop ARPA from doing any more pure research. Mansfield, in short, was an ARPA-denier.[23]

WHO REALLY INVENTED PERSONAL COMPUTING?

This history has not stopped some from claiming that they "KNOW" ARPA was key to the development of computer science.[24] But do we KNOW that?

Advocates of ARPA are of course right to recognise PARC, or XeroxPARC (the Xerox Palo Alto Research Center), as one of Silicon Valley's foundational institutions. It invented the mouse, windows, pop-up menus and the trash can—indeed, the graphical user interface—as well as the laser printer. XeroxPARC, in short, invented the personal computer. Moreover, it pioneered an Ethernet network and sent things called 'emails.' This is why it is claimed that Microsoft's Bill Gates and Apple's Steve Jobs "essentially stole into PARC [and] stole their ideas."[25]

So, according to ARPA advocates, the US high tech revolution was born of ARPA. As indeed it was—*but in ways diametrically opposite from they suppose*. The great advancements in personal computing came precisely after ARPA's wings were cut by the Mansfield amendment and after key figures had left the organisation. In his 2002 book *Digital Culture*, Charlie Gere told the story.

> "The first head of XeroxPARC was Bob Taylor [of] ARPA's computing research arm… The Mansfield amendment and the presence of Taylor at XeroxPARC meant that many talented computer scientists and researchers who had been ARPA-funded were drawn to the Centre [ie, the Xerox Palo Alto Research Center]."[26]

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22 National Science Foundation (1968) Technology in Retrospect and Critical Events in Science. Washington DC. National Science Foundation. This was published after the release of early drafts of Project Hindsight.

23 Mansfield was also a defence denier, and his amendments also sought to halve the U.S. military's overseas commitments. The link between the federal government's funding for science and defence could not have been made more explicit.

24 Dominic Cummings (March 11, 2019) On the referendum #32: Science/productivity—a) small teams are more disruptive, b) 'science is becoming far less efficient.' Dominic Cummings's Blog. https://dominiccummings.com/tag/darpa

25 Dominic Cummings (June 27, 2019) In Iain Mansfield and Geoffrey Owen (January 28, 2020) Visions of ARPA. Policy Exchange, London. https://policyexchange.org.uk/wp-content/uploads/Visions-of-Arpa.pdf. p 25

26 Charlie Gere (2002) Digital Culture. London. Reaktion Books. pp 130-131.

The Mansfield amendment Gere cites was the more famous of Senator Mansfield's two amendments, for it was the one that in 1973 stopped ARPA (then named DARPA[27]) from doing any further pure research. At the time the amendment, for making so many pure D/ARPA scientists redundant, was widely blamed for destroying American science; but in the meantime D/ARPA's newly-redundant researchers streamed out to XeroxPARC to invent modern personal computing.

So it was because the US's D/ARPA was neutered that the US pioneered today's high tech revolution.

WHAT DOES THE GOVERNMENT FUNDING OF RESEARCH ACHIEVE?

Following the publication of the Nelson and Arrow papers, the federal government's support for R&D surged. By 1964 it was funding over two-thirds (67%) of all US R&D. Companies wanting to do R&D would write grant applications as if they were charitable not-for-profit foundations needing public support. And the economic consequences of the vast federal funding of US research and development were… zero. The long-term rate of US GDP *per capita* growth did not rise.[28] Nor did the long-term rate of US growth in total factor productivity, which actually declined.[29]

Those zero consequences were not limited to the US federal government's funding of research; they are seen universally. Thus in 2007 Leo Sveikauskas of the US Bureau of Labor Statistics, on reviewing the literature on R&D across the industrialised countries, concluded that:

> "The overall rate of return to R&D (research and development) is very large ... However, these returns apply only to privately financed R&D in industry [Sveikauskas's underline]"[30]

In 2003 the Organisation of Economic Cooperation and Development (OECD), which is an inter-governmental economics research unit, used a different methodology to studying the growth rates of the 21 leading world economies between 1971 and 1998, and it found that it is:

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27 In 1972 ARPA, traumatised by Mansfield's first amendment, changed its name to DARPA, the Defense Advanced Research Projects Agency, in the hope Mansfield would spare it. He didn't. In his 2009 Dominion From Sea to Sea: Pacific Ascendancy and American Power (New Haven: Yale University Press. p 434) the Chicago historian Bruce Cumings would have approved of Dominic Cummings's use of the word 'essentially,' for he wrote "It wasn't so much that Apple stole PARC's technology, it was more like … now they knew what they were working on—worked." But Cumings also described how, when they saw the PARC technology, "the eyes of the Apple engineers nearly popped out of their skulls," so Dominic Cummings's interpretation of that particular history is not wrong.

28 Terence Kealey (1996) The Economic Laws of Scientific Research. London. Macmillan. p 162. Terence Kealey (2009) Sex, Science and Profits. London. Random House. p 249.

29 Alexander Field (2008) The most technologically progressive decade of the century. American Economic Review 93: 1399-1414.

30 L Sveikauskas (2007) R&D and Productivity Growth: A Review of the Literature. Bureau of Labor Statistics. Washington, D.C. www.bis.gov/osmr/pdf/ec070070.pdf

> "Business-performed R&D that... drives the positive association between total R&D intensity and output growth... The negative results for public R&D are surprising and deserve some qualification. Taken at face value they suggest publicly funded R&D crowds out... private R&D."[31]

Even earlier, Walter Park of the American University at Washington, DC and I had independently made the same discovery, namely that the public funding of research and development crowds out its private funding.[32,33]

THE HISTORY OF BRITISH SCIENCE POLICY

Until recently the UK was also *laissez faire* in science research, and the British government funded only mission or geopolitical research. So, for example, the Royal Observatory was founded in 1675 by King Charles II with a clear mission. Its director, the Astronomer Royal, was to:

> "apply himself with the most exact care and diligence to the rectifying of the tables of the motions of the heavens, and the places of the fixed stars, so as to find out the so much desired longitude of places for perfecting of the art of navigation."

It was in that mission tradition that, in 1913, the British government created its first modern institution of research, the Medical Research Committee, later Medical Research Council (MRC), with an initial annual budget of £56,000. But it was not funded out of general taxation. Two years earlier, in 1911, Lloyd George had driven the passage of the National Insurance Act, and the MRC was supported from the workers' contributions to the national insurance fund. The MRC was thus another mission-orientated government institution, dedicated to improving the workers' health.

In 1916, the government created the Department of Scientific and Industrial Research (DSIR), with an initial annual budget of £1 million, to (a) help industry supply the military's needs such as poison gas and explosives, but also (b) to help train more scientists for the defence industries. Unlike the equivalent war-time research bodies in the US, however, the DSIR survived post-war—but only in a modest form. As Sabine Clarke has shown, it eschewed any grandiose vision of rescuing the market from failure in research; rather it saw itself only as a useful facilitator of government and industrial research in ways that might help both government and industry achieve the goals they had set themselves.[34]

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31 OECD (2003) The Sources of Economic Growth in OECD Countries. Paris. OECD.

32 Terence Kealey (1994) The economic laws of research, Science and Technology Policy, 7: 21-27; reproduced in Terence Kealey (1996) The Economic Laws of Scientific Research, Macmillan, London, pp 238-251.

33 W Park (1995) International R&D spillovers and OECD economic growth. Economic Enquiry, 33: 571-590.

34 Sabine Clarke (2010) Pure science with a practical aim: the meaning of fundamental research in

The Second World War led to a huge intensification of government-funded research, which continued into peacetime with a series of hubristic projects that were designed to promote the British state as a leader in technology—but which actually showed the exact opposite. Those projects included the world's first commercial mainframe computer (sold in 1951 by Ferranti), the world's first civil jet aircraft (Comet, in service in 1952), and the world's first nuclear power station (Calder Hall, commissioned in 1956). All were commercial failures, as was the world's first civil supersonic jet aircraft, a joint British-French state project (Concorde, commissioned in 1962). The British government had been wasting vast sums of money.

But Sputnik's orbit in 1957, and Nelson's and Arrow's papers in 1959 and 1962 respectively, had the same electrifying effect in Britain as in the US. Sputnik's orbit had, by 1959, persuaded Arrow that an "ideal socialist economy" would outstrip a free enterprise economy in generating technological and thus economic growth,[35] and Harold Wilson, the Labour leader who had been educated in economics, immediately understood Arrow's point:

> "This is our message for the Sixties—a Socialist-inspired scientific and technological revolution releasing energy on an enormous scale."
>
> Harold Wilson to the 1960 Labour Party conference in Scarborough.[36]

Three years later, at another Labour Party conference in Scarborough, Harold Wilson announced the White Heat of the Technological Revolution, by which titanic government spending on research would revolutionise the economy: the DSIR was replaced by a set of science funding councils (to fund pure science purportedly to correct for market failure), while a new ministry of technology was created to translate those putative advances in pure science into wealth-creating technology.

Over the next few years the government indeed spent money on research titanically, yet—as in America after 1958—the expenditure yielded no economic benefit. By 1971, therefore, the prominent Labour politician Shirley Williams announced "for the scientists the party is over," (simultaneously, Mansfield was pushing through his amendments, thus showing how similar were the British and US disillusionments with their parallel experiments with the Arrow-inspired government funding of science).

By 1976, moreover, Britain's economy was so weak that it had to apply to the IMF for an emergency loan—Britain being the first major industrialised nation to be so humiliated. The White Heat of the Technological Revolution had been a sprite's light, deceiving the nation into financial peril.

Britain, circa 1916-1950. Isis 101: 285-311.

35 Robert van Horn and Matthias Klaes (2011) Chicago neoliberalism versus Cowles planning: perspectives on patents and public goods in cold war economic thought. Journal of the History of the Behavioral Sciences 47: 302-321. p 309.

36 Quoted in Christopher Booker (1969) The Neophiliacs. London. Wm Collins. p 132.

Since the 1970s, Britain's science policies have been unexceptional, chastened, and largely indistinguishable from those of most western countries, in that the government funds basic or pure science within the universities and research institutes capaciously (though the absolute sums of money are relatively modest). The state also funds research into particular missions such as defence, medicine or climate change adequately, but it is increasingly wary of 'picking winners' by funding commercial technology.

THE WORLD'S SCIENTIFIC LEADERSHIP HEADS EAST

Policy Exchange released *Visions of ARPA* on January 28, 2020. The previous day, on January 27, twenty South Korean biotech companies had convened with representatives of the government in a conference room at Seoul's central railway station to coordinate the development of a diagnostic test for COVID-19.[37] And by February 10, the Korean Centers for Disease Control and Prevention (KCDC) was reporting its findings on the first 2,776 people to be tested.[38]

Meanwhile, Public Health England would keep testing in-house for months to come. In late January, PHE's Covid-19 testing was limited to a single facility and capacity was less than a hundred tests per a day.[39] There are many reasons why countries like South Korea, Taiwan and Japan managed the virus so much better than did the US or UK, but one reason is that their research is privatised, so their private sector developed large numbers of diagnostic tests efficiently and swiftly.

The East Asian countries had, post-war, initially industrialised by doing little more than copying western technology, which was a function their governments devolved to industry. Yet, over the years, as they enriched themselves, and as their need for innovative R&D grew, so those successful countries inadvertently discovered that their industrial-based research model was also allowing them to equal US or UK or EU rates of innovation. They therefore did not discard their model of *laissez faire* science, and they never converted to the Nelson/Arrow model of *dirigiste* science.

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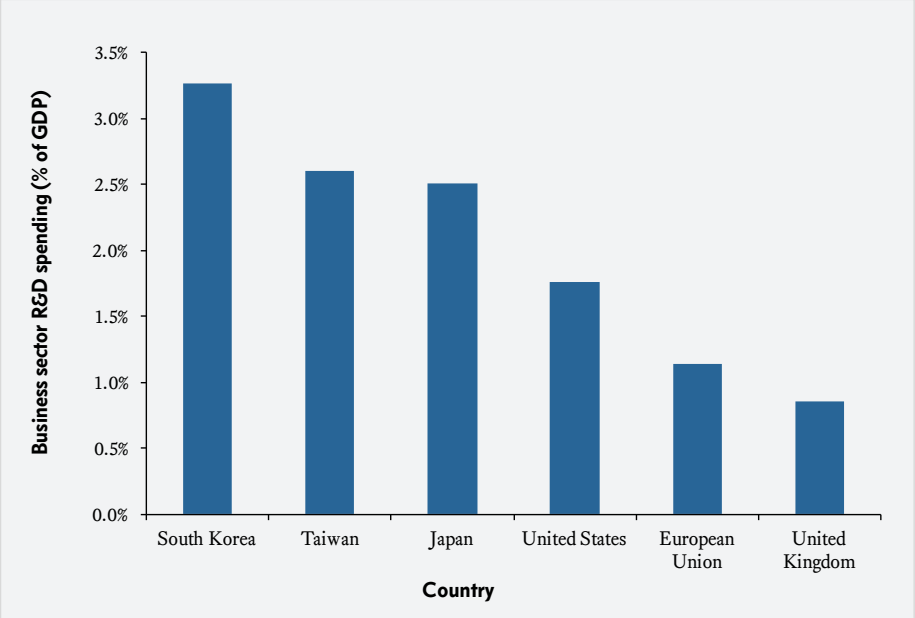
37 Chad Terhune et al (March 18, 2020) Special report: How Korea trounced the U.S. in race to test people for coronavirus. Reuters. https://www.reuters.com/article/us-health-coronavirus-testing-specialrep/special-report-how-korea-trounced-the-us-in-race-to-test-people-for-coronavirus-idUSKBN2153BW

38 KCDC News Room (updated daily) Press release. https://www.cdc.go.kr/board/board.es?mid=a30402000000&bid=0030

39 Matthew Lesh, "Testing Times: The urgent need to decentralise COVID-19 diagnostic testing in the United Kingdom," 2 April 2020, (London, UK: Adam Smith Institute), https://www.adamsmith.org/research/testing-times

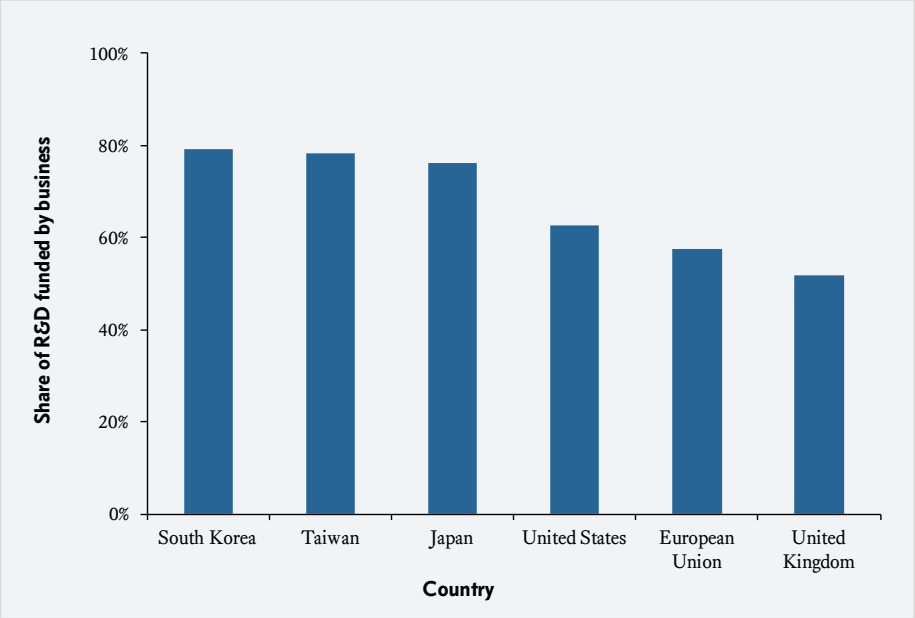
And because the government-funding of research crowds out its private funding, the industrialised eastern countries' business sectors consequently outspend the business sectors of the US, EU or the UK (see Figure 1).

Figure 1: Business sector R&D spending (% of GDP)[40]



Equally, the share of R&D that is funded by business is much higher in the industrialised East Asia (see Figure 2). The rest is largely supported by government, though foundation, philanthropic and university funding are not trivial.

Figure 2: Share of R&D funded by business[41]

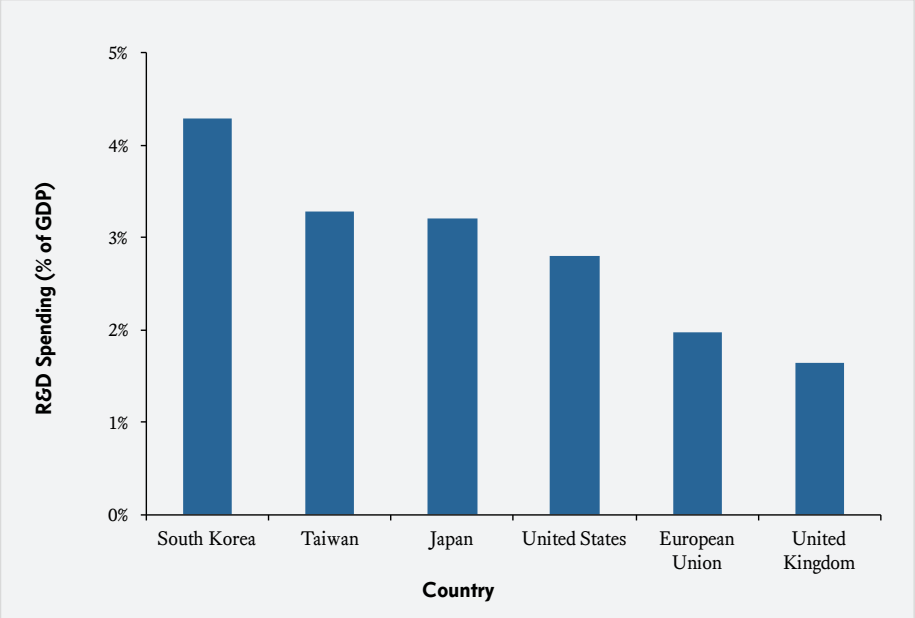


40 OECDiLibrary (2019) Main Science and Technology Indicators. OECD. Paris. Table 11 https://read.oecd-ilibrary.org/science-and-technology/business-financed-gerd-gross-domestic-expenditure-on-r-d-as-a-percentage-of-gdp_58ab04cf-en Israel also has large industrial R&D budgets but, remarkably, half of those are supplied by companies from abroad, so those unusual data are not included here.

41 OECDiLibrary (2019) Main Science and Technology Indicators. OECD. Paris. Table 13 https://read.oecd-ilibrary.org/percentage-of-gross-domestic-expenditure-on-r-d-gerd-financed-by-the-business-enterprise-sector_f9d39968-en Israel also has large industrial R&D budgets but, remarkably, half of those are supplied by companies from abroad, so those unusual data are not included here.

Consequently, the industrialised countries of East Asia have the largest R&D budgets in the world (See Figure 3).

Figure 3: R&D Spending (% of GDP)[42]



We can see, therefore, that the eastern miracle economies enjoyed their miracles because their governments did not fund research.

Table 1: Research and development (R&D) spending in East Asia and the West

Country	Business sector R&D spending (% of GDP)	Share of R&D funded by business	R&D Spending (% of GDP)
East Asia			
South Korea	3.27%	79.2%	4.29%
Taiwan	2.60%	78.3%	3.28%
Japan	2.51%	76.2%	3.21%
The West			
United States	1.76%	62.5%	2.81%
European Union	1.14%	57.6%	1.98%
United Kingdom	0.86%	51.8%	1.65%

Source: OECD

42 OECDiLibrary (2019) Main Science and Technology Indicators. OECD. Paris. Table 2 https://read.oecd-ilibrary.org/gross-domestic-expenditure-on-r-d-gerd-as-a-percentage-of-gdp_226a7e59-en Israel also has large R&D budgets but, remarkably, half of those are supplied by companies from abroad, so those unusual data are not included here.

The latest calls for state-funding of R&D in Visions of ARPA and elsewhere are not in fact visionary. They are simply a repeat of a failed history, parroting the Bush/Nelson/Arrow story that the more money the government spends on research, the better it will be for the economy. And the uncritical nature of *Visions of ARPA* was revealed in its very opening sentence, which described how ARPA was modelled on the USSR, as if—somehow—the USSR provided an economic example we should follow:

> "The Soviet Union shocked the world with three technological surprises during 1957 and 1958; the successful orbiting of its 56 cm/88-kg Sputnik artificial earth satellite in 1957, followed in less than a year by adapting its space launch vehicle to the ICBM, and its breach of the nuclear testing moratorium in March 1958."

Visions thus continued

> "Following the dramatic events of 1957-58, the Congress created ARPA in 1958 (and since 1966, DARPA)"[43]

Nowhere in this document was it explained why ARPA became DARPA, nor anywhere did the term 'crowding out' appear, nor did the names of Senator Mike Mansfield or of Project Hindsight appear, nor was any reference made to the White Heat of the Technological Revolution nor to its evisceration by Shirley Williams. *Visions* was a totally unreflective document that simply asserted that recreating the US's ARPA in Britain, to give scientists great freedom and large sums of public money, would transform the economy. It could have indeed have been written by Marianna Mazzucato (though, being on the left, she is embedded in the science policy lobbying units at University College London) whose 2013 book The *Entrepreneurial State* is as unreflective.[44]

CONCLUSION

The original ARPA was a mistake; and because the British government has not learnt the lessons of the past, we are apparently condemned to repeat it. This is folly.

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43 William Schneider Jr (January 2020) Foreword. In Iain Mansfield and Geoffrey Owen (January 28, 2020) Visions of ARPA. Policy Exchange, London. https://policyexchange.org.uk/wp-content/uploads/Visions-of-Arpa.pdf. p 5.

44 Terence Kealey (28 May 2014) The scientific state. Standpoint. https://standpointmag.co.uk/issues/june-2014-open-season-june-14-scientific-state-terence-kealey-private-funding. Alberto Mingardi (2015) A critique of Mazzucato's Entrepreneurial State, Cato Journal 35: 603-625. Terence Kealey (2016) Marianna Mazzucato: The Entrepreneurial State. The Journal of Prices and Markets 2: 78-80.