RE-IGNITING PUBLIC AND PRIVATE INVESTMENTS IN INNOVATION

Mariana Mazzucato
R.M. Phillips Professor in the Economics of Innovation
SPRU University of Sussex, United Kingdom
www.marianamazzucato.com

Middle Class Prosperity Forum
July 27, 2015.
Hart Building, US Senate, Washington DC USA

The 5 minute oral presentation by Prof. Mazzucato will summarize and discuss key points from the written statement below, which she been prepared for the sole purpose of this Forum.

1. Introduction
Thank you Senator Elizabeth Warren and Congressman Elijah Cummings for inviting me today to discuss American R&D spending and its impact on the opportunities for US economic growth and middle-class prosperity. It is an honor to be here.

Economists don't agree on many things, but one thing they do tend to agree on is the positive role that investments in innovation, such as R&D, have on long-run economic growth[1] (Nelson and Winter, 1982; Grossman & Helpman, 1991). When the profits from this growth are re-invested back into the economy—on future innovation and human capital formation—this helps to increase the possibility that jobs and innovation go hand in hand. When those profits are either hoarded, or used on short-run measures that boost stock prices, the relationship is much more problematic. For this reason, it is great news that this *Forum on Middle Class Prosperity* is focusing on the role of innovation.

Indeed, for much of the 20th century, American economic growth has been fuelled by innovation, with US businesses and public agencies together playing an important role—interacting dynamically across the entire innovation chain. Public investments in both basic and applied R&D were often driven by societal and technological 'missions'. The 'man on moon' mission created many different 'homework' problems for a diverse set of actors to work on, and affected innovation in a dozen different sectors, from IT to robotics and textiles.

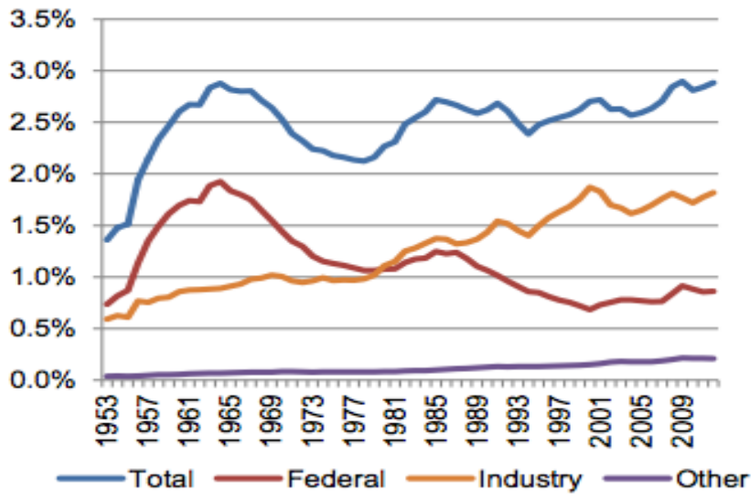
But that is changing. Today we have public sector institutions that are constantly asked to prove their 'economic value', forgetting that some of the greatest benefits to business from public R&D emerged when the goal of the investments was not commercialization *per se*, but solving grander societal and technological challenges. Narrowing the purpose of the public sector to simply 'leveling the playing field' or 'de-risking' the private sector, ignores some of the greatest feats of the US innovation model (during both Democratic and Republican eras), which were guided by *mission oriented* investments, creating and shaping markets not only 'fixing them'. Short-termism in the public sector, is mirrored by an increasing short-termism in the private sector, with many companies being overly 'financialized' i.e. spending more on areas that boost share prices (like share buybacks), than on R&D. And those that do spend on R&D, are increasingly spending in narrow applied areas.

The numbers are worrying. While the total amount of US R&D investment (public and private) as a % of GDP (GERD) is still relatively high, at about 2.8%, there has been a clear drop in Federal funding (Figure 1). Federal spending on R&D as a % of total (public and private) R&D spending peaked at 67 percent of GDP in 1964, it dropped as low as 25 percent in 2000, and increased to 30 percent in 2012 due mainly to the temporary ARRA stimulus (SSTI, 2014). And while it looks like private R&D is making up for the difference, business is increasingly concentrating on *applied* R&D areas, that are narrower in scope (Arora et al. 2015). While the share of basic research carried out by industry (as a % of total US basic research) was between 33-35% in the 1950s, it has consistently dropped, falling to between 15-20% in the 2000s (SSTI, 2015). The increasing focus of business on applied research means that there has been a fundamental shift in the *composition of R&D* (Muro and Andes, 2015), which may reduce future innovation opportunities which have always been driven by a strong interaction between basic and applied R&D in both industry and government[2].

[1] Bassanini and Scarpetta (2001) study 17 OECD countries between 1981-1998, and find that a 0.1 percentage point increase in R&D could boost "output per capita growth by some 0.3-0.4 per cent.

[2] In 2011, basic research was about 18% ($75 billion) of total U.S. R&D; applied research was about 19% ($82 billion); and development was about 63% ($267 billion). (NSF-SEI, 2014). A clear summary of the trends in basic research is found in SSTI (2015): *"From 1953 to 2012, federal sources comprised more than half of all basic research spending in the United States in every year, though this share has decreased from the more than 70 percent share it held from 1964 to 1980 to 52.6 percent in 2012 – the smallest share on record for federal sources. During that same time period, universities and colleges have gone from representing just 1 percent of basic research expenditures in 1956 to 11 percent in 2012, while other nonprofit sources have gone from representing 6 percent to 12 percent of basic research spending. The share*

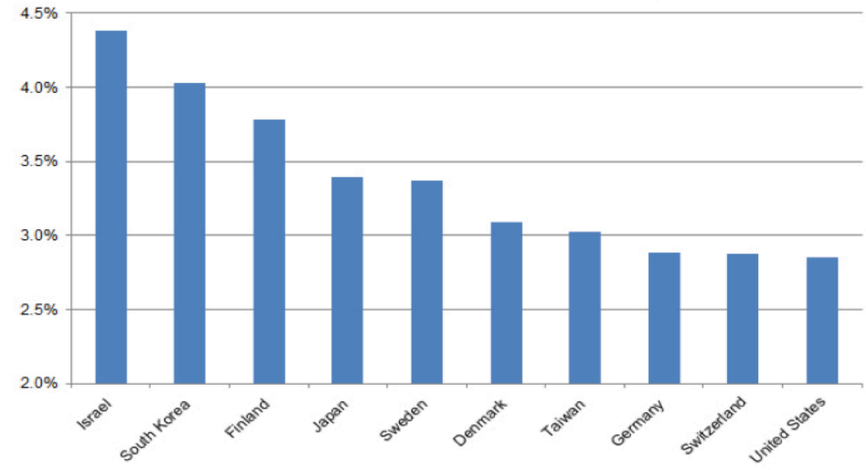
Figure 1. R&D as a share of GDP by funder



Source: National Science Foundation, 2011

Furthermore, the US' international position as a leader in innovation is under threat as the US is now spending less than *nine* other OECD countries on R&D (as % of GDP) (Figure 2). And China of course is catching up: while the annual growth in R&D spending in OECD countries between 2009-2012 was 1.6% (half the rate of 2001-08 as both public and private R&D budgets stagnated), China's R&D spending *doubled* from 2008- 12[3].

Figure 2. Top 10 Countries for R&D as % of GDP, 2011



Source: NSF data, from Muro and Andes (2015)

My contribution to this forum will focus on three related issues which I believe threaten future US innovation, growth and competitiveness: (1) an increasingly timid public sector that is being forced to cut back its investments in innovation (most recently with the America COMPETES Reauthorization Act of 2015[4]), and also seems to be no longer able to *think big*—around different types of societal and technological *missions*; (2) the dangers posed today to US industrial competiveness of an increasingly *financialized* private sector, that to a large extent fails to reinvest its profits in long run innovation opportunities, worried more about how to boost short-term share prices through practices like share buybacks; and (3) a dysfunctional narrative about 'wealth creation'—concerning who the "innovators" and "risk takers" are—which has allowed a small group of economic actors to reap an increasingly large share of the rewards from innovation—with the effects of increasing inequality and hurting future innovation.

2. The Division of Innovative Labor between public and private actors

Innovation has always been a product of a variety of organizations in both the public and private sectors working together in dynamic ways. This has *not* been through a strict division of labor where the public sector does only basic scientific research (a typical 'public good' causing what economists call a 'market failure'), and the private sector focuses only on downstream applied and development areas. Indeed, public actors have been responsible for investments along the *whole* innovation chain (basic research, applied research, and the provision of high risk *patient* finance to innovative companies), and private businesses have historically been involved in doing not only applied research but also basic research (e.g. R&D labs inside GE, AT&T and Xerox). Furthermore, the existence of feedback loops between different parts of the innovation chain, mean

---

of basic research spending sourced from industry has, for the most part, declined since reaching its all-time high of 35 percent in 1956."

[3] According to the 2014 OECD Outlook, R&D (GERD) in 2012 was USD 257 billion in China, USD 397 billion in the United States, USD 282 billion for the EU28 and USD 134 billion in Japan.

[4] This bill will see an increase in spending by 5% on basic science in fundamental discovery areas, while reducing spending by the same amount in downstream areas, such as later-stage technology development, commercialization activities, and research on climate, social, and geo-science.

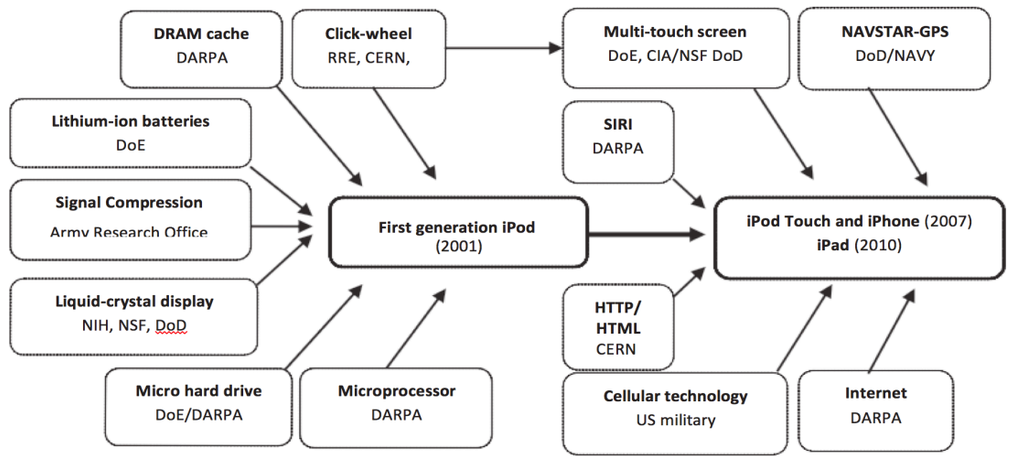
that policies that assume a linear progression from basic science to commercialization tend to fail. Stokes' "Pasteur's Quadrant" teaches us clearly the way in which basic science and concrete technological problems feed off each other in dynamic ways.[5]

The work on national *systems of innovation*, pioneered at the research center where I work in the UK, the *Science Policy Research Unit (SPRU)* at the University of Sussex, has been fundamental for highlighting the need to build key linkages between public and private institutions, and for developing justifications for public sector investments that go beyond the strict 'market failure' theory in economics (Freeman, 1995). Indeed, the *systems of innovatio*n approach helps explain why R&D is important but *is not enough*: in the 1980s Japan grew more than the USSR even though it had a lower R&D/GDP ratio. Why? Because it had a host of different horizontal institutions which created dynamic links between science and industry (which the USSR didn't have) that allowed new knowledge to diffuse across the entire economy. It also highlights why the structure and nature of the (public and private) organizations involved are fundamental. Lets now turn to these.

a. *Public sector* actors in the US innovation system

Although the US has liked to portray itself as a country that relies on business and markets, it has had one of the most active public sectors when it comes to innovation. One could say that the US government has liked to talk like Thomas Jefferson, but act like Alexander Hamilton. In almost every sector, from IT to biotech, nanotech and clean-tech, it has been US government funding that has led the way, investing in key areas across the entire innovation chain, with the private sector often entering only *after* new markets were created. Indeed, some of the greatest entrepreneurs, like Steve Jobs and Bill Gates, surfed intelligently on waves of publicly funded technology. What could an iPhone do 'smartly' without the internet, GPS, touchscreen display, and a SIRI voice activated system?—*all* financed heavily in the early stages through public funds, from a host of different types of public organizations (Figure 3).

Figure 3. The State behind the technology that makes the iPhone 'smart'



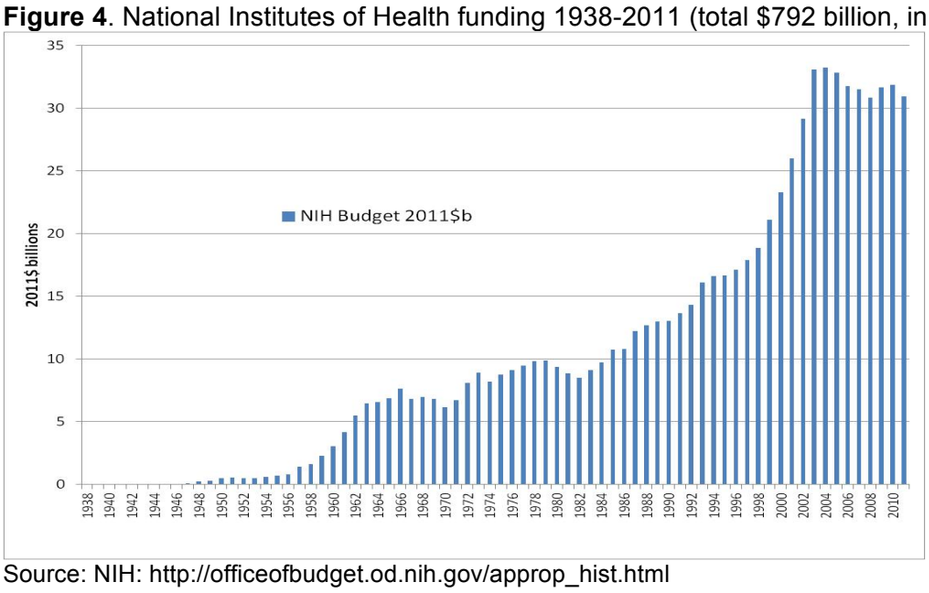
Source: Mazzucato (2013, p. 109)

Indeed, the striking aspect of US funding of innovation has been that it has been its active engagement across the whole innovation chain, creating markets not only 'fixing' them. For this reason I referred to the US in my recent book as *The Entrepreneurial State* (Mazzucato, 2013). Block and Keller (2011) refer to it as the decentralized (and networked) *developmental state* (Block and Keller, 2011) due to the large number of public organizations involved in this strategic activity, from NASA, to the NSF, SBIR, DARPA, ARPA-E etc. And others have emphasized the *mission-oriented* nature of these agencies, not only in defense but also in energy and health (Mowery, 2010; Foray et al. 2012). Indeed, a key aspect of these agencies is how they have been able to attract talent and expertise by making it an honor for scientists to work on grand challenges. Building public organizations in ways that allow them to welcome the trial and error explorative process behind innovation, rather than to fear the underlying risk and uncertainty, is challenging and a key part of the success of organizations like DARPA, and ARPA-E (Mazzucato and Penna, 2015).

While the Department of Defense continues to account for more than half of annual Federal R&D spending, health-related R&D accounts for the majority of federal *nondefense* R&D. Figure 4 shows just how much the National Institutes of Health (NIH) have spent in the last decades (in 2011 dollars). With the work of Angells (2004), ex-editor of the New England Journal of Medicine, highlighting the massive impact this funding has had on basic and applied research behind some of the most important breakthrough drugs (new molecular entities with priority rating), while private pharmaceutical companies spend an increasing share on development, and marketing (rather than on basic research). The US government doesn't 'meddle' in people's health care, it co-creates it every year through the NIH.

[5] Stokes (1997) showed the constant interaction between basic and applied research, for example the way that the miniaturization of semi-conductors, aimed at the discovery of the transistors during World War Two, later fed back into key basic research around quantum physics.

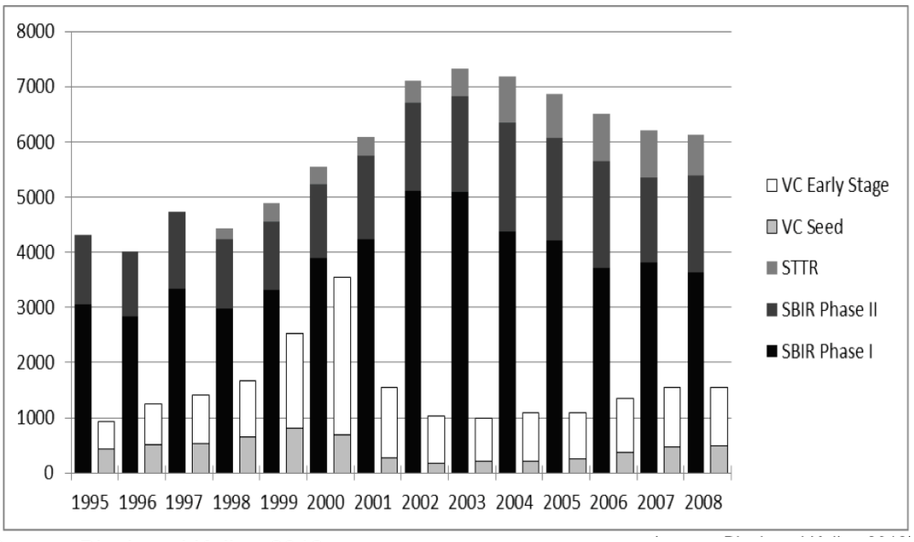
Figure 4. National Institutes of Health funding 1938-2011 (total $792 billion, in 2011 dollars)



Source: NIH: http://officeofbudget.od.nih.gov/approp_hist.html

Public funds have been important not only for research but also for providing patient long-term committed finance to innovative small companies. As venture capital has become increasingly speculative and short-termist, seeking exits in 3-5 years (through buyouts or an IPO), patient capital has had to come increasingly from the public sector. Figure 5 below shows a comparison between public and private provision of early stage high risk finance, with a clear steady rise in public funds provided by the Small Business Innovation Research (SBIR) Program (Block and Keller, 2012). And of course the guaranteed loans provided to innovative projects by different Departments, such as the recent one provided by the Department of Energy to Elon Musk's Tesla S car ($465 million), are another type of early stage financing, that often goes un-noticed.

Figure 5. Number of SBIR and STTR grants compared to private venture capital



Source: Block and Keller, 2012

What these figures show clearly is the role that public funding agencies have played in the US across the *whole innovation chain*, not just in classic 'public good' areas defined by 'market failure' theory in economics (which guides policy makers). They are about shaping and creating markets, alongside the private sector, not only 'fixing markets'. And crucially, they reveal that the division between basic and applied research is a false one.

It is fundamental to consider how recent cuts to public financing of R&D will fundamentally change the ability of the US to compete through innovation. While the fall in federal funding has been partially offset by the rise of industry R&D (more below), the latter has been focused increasingly on applied research—with negative impact on the dynamic interaction between basic and applied.

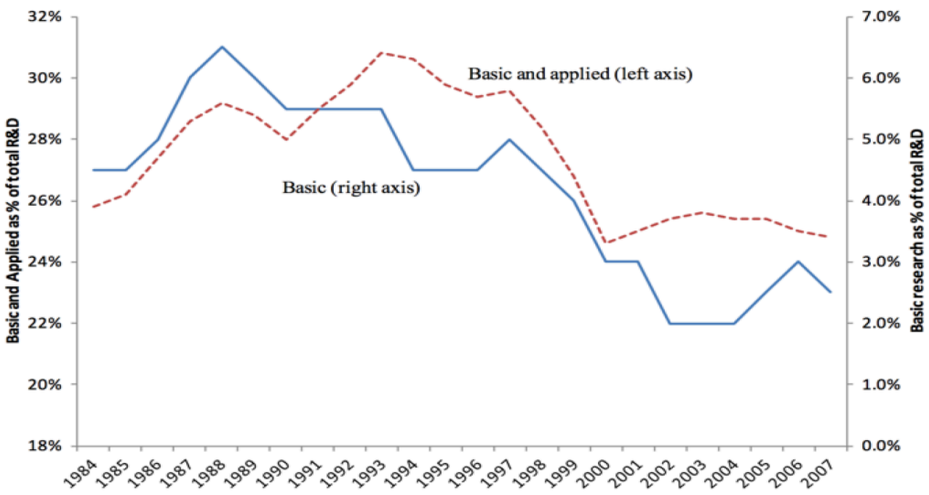
b. *Private sector* actors in the US innovation system

Of course the State has not and cannot operate alone. Private companies doing basic research and applied research have been fundamental to the US innovation system, including not only the host of small innovative startups, but also (and some would say especially) the important research and innovation done in large American corporations such as Bell Labs in AT&T and Xerox Parc in Xerox.

Recent work has highlighted the way in which business sector commitment to innovation is changing. While total R&D figures for business look like they are rising, this is mainly due to the rise in *applied research*. Basic research inside industry has been falling steadily. In a recent study, Arora et al (2015) document a shift away from basic scientific research by large corporations between 1980 and 2007. Figure 6 from Arora et al shows that the share of research in the total non-federal investment in R&D (which they claim is a rough

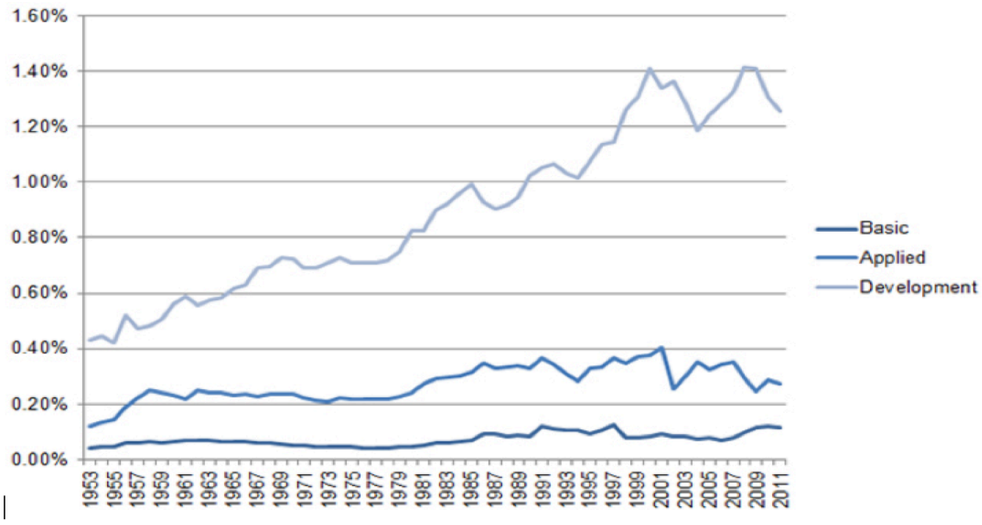
approximation for the share of research in private R&D), has steadily declined since the 1990s. They have been engaged in more D and less R (Figure 7).

Figure 6. Share of research in total non-Federal R&D



Source: NSF/Division of Science Resources Statistics, Survey of Industrial R&D: 2007 (from Arora et al. 2015)

Figure 7. Industry investment in R&D as a share of GDP, by type 1953-2011



Source: National Science Foundation, Science and Engineering Indicators, 2015 (from Muro and Andes, 2015)

These studies look at changes in globalization, and the narrowing scope of firms, but another reason often overlooked is the *financialization* of US businesses, increasingly concerned with their quarterly returns, rather than with long run growth areas. The path-breaking work of Lazonick (2014) has found that between 2003 and 2012, publicly-listed companies in the S&P 500 used 54% of their earnings ($2.4 trillion!) to buy back their own stock. Why? Buybacks have an immediate effect on stock prices, and of course stock options, and executive pay (as stock options are the main way CEOs are compensated). Indeed, between 1978 to 2013, CEO compensation increased by 937 %, while the typical worker's compensation grew by only 10 percent (Lazonick, 2014).

The combination of an increasing financialization of US corporations, which negatively affected their commitments to long run investments in innovation (Lazonick, 2014), and the increasing emphasis on applied research with respect to basic research (Arora et al. 2015), present great challenges to the US innovation system. It is a key reason why debates about innovation policy, financial reform and corporate governance should go hand in hand (Mazzucato and Perez, 2015).

3. Building better innovation 'eco-systems'

Admitting this history of *market creating* public investments suggests a reframing of key policy questions. Not whether or not to 'pick winners' and make choices on the direction of change, but how to better learn from successes and failures when such directions have been picked in the past, and how to build the kind of public sector organizations that are willing to explore, and welcome risk-taking, in the process.

Risk, however, implies high rates of failure. Yet, when the state fails we blame it for being *stupid*. When a $536 million guaranteed government loan to Solyndra ended in bankruptcy, this caused outcry and accusations of government's failure to 'pick winners'. Yet when a similar $465 million guaranteed loan went to Tesla for the

Tesla S car, little was made of this 'smart' investment. Losses are seen as public failures, while successes are seen as solely private affairs.

Indeed, the state as investor is like any other type of venture capitalist: it will sometimes succeed but also often fail. Precisely because it is investing in the areas of highest uncertainty that private capital fears, it will probably fail even more. But while private investors are able to use returns from the upside to cover losses on the downside, by not admitting the lead 'investor' role of the public sector, we have not allowed it to do the same. Economists tend to argue that tax revenue is the way for the state to reap back a return. Yet this ignores the well-known problems of tax evasion/avoidance as well as the way in which it has been precisely the narrow *narrative* around innovation, that has allowed successful lobbying to reduce tax rates by those calling themselves the 'innovators' and 'wealth creators'. It is no coincidence that it was the National Venture Capital Association that was key in getting capital gains tax to fall by 50% in the late 70s—a policy that Warren Buffett has rightly claimed had no effect on investment or innovation—only on inequality (Buffett, 2011). And lets not forget that NASA, responsible for some of the key investments that today make the iPhone so smart (Figure 3), was founded in a period in US history when the top marginal tax rate was over 90%.

So given that the tax system has both changed drastically and is also full of loopholes, in order to continue to be able to finance future innovation opportunities, should the public purse get a more direct reward for its investments? This would help ensure a return comes into a public innovation fund to fund the next wave of technologies. This could be done in various ways: equity could be retained in some downstream investments (through shares or royalties, as is done in various OECD countries); business' repayment of public loans could be made *income contingent* as is done with student loans; government could retain a 'golden share' of the IPR for those innovations that are clearly government funded (e.g. most drugs); it could also cap the prices of drugs that are funded by the NIH, so the tax payer does not *pay twice*[6]. The point is not to decide on any one measure, but to open the conversation on different mechanisms that can ensure that the rewards from 'smart' growth are shared as much as the risks are (Lazonick and Mazzucato, 2013). Relatedly, it is also critical to remember that those important private sector laboratories, like Bell Labs, were often results of healthy tensions between business and government. Indeed, to retain its monopoly status, AT&T had to prove that it would reinvest its profits into long-run radical innovation—which it did through the creation of Bell Labs. While some like to claim that today we are in a new era of collaborative, and *open-innovation*, where those old style laboratories are not needed—I would argue that the kind of 'deal' between the state and business that led to the creation of Bell Labs, is today needed more than ever, given the record level of hoarding rates in US businesses today, and the complaints about 'secular stagnation'.

What is needed to both fuel innovation and to limit inequality is a change in the narrative about the role of the state in the innovation driven, wealth-creation process. A narrative that doesn't just describe the state as regulating and re-distributing the pie, but gives tax payers the credit for having co-created the pie in the first place, through strategic public investments of the kind that led to the technology behind the iPhone. Alongside, of course, an active innovative business sector that invests in both basic and applied research. Then, perhaps, we can have the courage to debate the really big questions about how to get public and private actors in the US to build together the future foundations of growth, through long-run investments aimed at new missions—whether they be around climate change, ageing, or even the mission to Mars—galvanizing innovation in many different sectors. Only through such a new conversation can 'secular stagnation', which some wrongly treat as *inevitable*, be combatted head on. Thank you.

References

Angell, M. (2004). *The Truth about the Drug Companies*. New York: Random House.

Arora, A, Belenzon, S., and Patacconi, A., 'Killing the Golden Goose? The decline of science in corporate R&D, NBER, January 2015

Bassanini, A. and Scarpetta, S. (2001), 'The Driving Forces Of Economic Growth: Panel Data Evidence for OECD Countries', OECD Economic Studies No. 33, 2001.

Block, F., & Keller, M. (2011). *State of innovation: the U.S. government's role in technology development*. Boulder: Paradigm.

Buffett, W. (2011), 'Stop Coddling the Rich', *New York Times*, 15/8/2011, p. A21. http://www.nytimes.com/2011/08/15/opinion/stop-coddling-the-super-rich.html?_r=0

Grossman & Helpman (1991), Grossman, G. And E. Helpman, Innovation And Growth In The Global Economy, Cambridge: Mit Press, 1991

Keller, M. R., & Block, F. (2012). Explaining the transformation in the US innovation system: the impact of a small government program. *Socio-Economic Review*, mws021.

Foray, D., Mowery, D., & Nelson, R.R. (2012). Public R&D and social challenges: What lessons from mission R&D programs? *Research Policy, 41*(10), 1697-1902.

Freeman, C. (1995). The 'National System of Innovation' in historical perspective. *Cambridge Journal of economics*, *19*(1), 5-24.

Lazonick, W. (2014), 'Profits Without Prosperity' *Harvard Business Review*, 47-55.

Lazonick, W., & Mazzucato, M. 2013. 'The Risk-Reward Nexus in the Innovation-Inequality Relationship: Who Takes the Risks? Who Gets the Rewards?' *Industrial and Corporate Change,* 22(4), 1093-1128.

Mazzucato, M. (2013). *The Entrepreneurial State: Debunking the Public vs. Private Myth in Risk and Innovation*. London: Anthem

Mazzucato, M. (2015) The Creative State, *Foreign Affairs*, Jan-Feb 2015 issue

Mazzucato, M. and Penna, C. Eds (2015) Mission-Oriented Finance for Innovation: New Ideas for Investment-Led Growth, Rowman & Littlefield

[6] Indeed, the Bayh-Dole Act allows for such capping—yet government has never exercised this right (Mazzucato, 2015).

Mazzucato, M. and Perez, C. (2014), “Innovation as Growth Policy,” in *The Triple Challenge: Europe in a New Age*. J. Fagerberg, S. Laestadius, and B. Martin (eds.) Oxford University Press: Oxford, forthcoming
Mowery, D.C. (2010). Military R&D and innovation. In B. H. Hall & N. Rosenberg (Eds.), *Handbook of the Economics of Innovation* (Vol. 2, pp. 1219-1256).
Muro, M. and Andes, S (2015), ‘U.S. R&D: A Troubled Enterprise’, Metropolitan Policy Program, Brookings Institution, May 28, 2015
Nelson, R. R., & Winter, S. G. (2009). *An evolutionary theory of economic change*. Harvard University Press.
Science and Engineering Indicators (SEI), National Science Foundation (NSF), 2014
Shellenberger, M., Nordhaus, T., Jenkins, J. & Trembath, A. (2012). ‘US Government Role in Shale Gas Fracking History: An Overview and Response to Our Critics’. The Breakthrough, March 2. Available at http://thebreakthrough.org/archive/shale_gas_fracking_history_and (accessed 13/7/2015).
SSTI (2015), ‘The Changing Nature of U.S. Basic Research: Trends in Funding Sources’ http://ssti.org/blog/changing-nature-us-basic-research-trends-funding-sources (accessed 20/7/2015)
Stokes, D. E. (1997). *Pasteur's quadrant: Basic science and technological innovation*. Brookings Institution Press.