Innovation in government in the era of the new digital GPT
a comment
Manuel Trajtenberg[1]
June 14, 2020

1. Introduction

Ever since Vaanevar Bush's groundbreaking report to President Roosevelt "Science – the Endless Frontier" (Bush, 1945), the Government has played an increasingly prominent role in the realm of R&D and innovation. This includes funding of research through the NSF and NIH, mission-oriented research in Defense, Space and Energy, support of commercial R&D by small and medium size businesses through the SBIR and STTR programs, and the like.

However, the impact of Government (just "G" henceforth) on innovation goes much further, reflecting the size of G in the economy,[2] procurement policies, the impact of taxation, and the deliberate or unintended effects of regulation. Thus for example, setting standards for fuel economy or energy conservation incentivizes innovation in automobiles and in construction, banning hazardous materials prompts the search for safer substitutes, and immigration policies may affect the extent to which innovations are labor saving. Well before the era of "big G" there are plenty of examples of the unintended impact of G action on innovation: from the invention of the tabulating machine to process data for the 1890 U.S. Census (which eventually gave rise to IBM), to the contribution of G procurement of firearms to the development of the "American System of Manufactures."

Of course, innovation in the provision of public and quasi-public goods, be it in education, health care, or transportation, is directly and indirectly impacted by G policies, not always for the better. In fact, G inertia, inaction, political meddling, unions, and plain ineptitude often

[1] The Eitan Berglas School of Economics, Tel Aviv University, the NBER, and the Samuel Neaman Institute at the Technion, Israel.
[2] The average G/GDP ratio for 36 OCED countries stands now at 43%, with the US being at the lower end with 38%.

preclude the adoption of innovative methods and procedures. This is often the case also in the realm of housing, zoning and building codes, and in the delivery of welfare assistance.[3] In view of the growing size and importance of these public goods and services in the economy and for our wellbeing, the fact that G may play a retarding role in innovation is particularly troubling.

The centrality of innovation for economic growth has been well established long ago, as well as its accelerated pace since WWII. This has happened in tandem with the expanding role and share of G in the economy and, as already suggested, these two parallel and all important trends are not quite independent. Yet, the study of innovation has not paid sufficient attention to the full extent of the interaction between the two, that is, the multiple channels through which G impacts innovation, and the way innovation in turn affects the conduct of government activities and the provision of public goods.

The paper by Bruce and Figueiredo (2020) constitutes an important step in that direction, providing an excellent overview of a particular area in that regard: intramural technological innovation done by the US Federal Government. More precisely, Bruce and Figueiredo examine both the "inputs" to intramural Federal R&D by mapping the scientists employed in R&D by the federal government, and the "outputs" of R&D in the form of patents. To the best of my knowledge this is the first time that such an endeavor has been undertaken, thus providing a much needed picture of the extent and type of direct, intramural government innovative activity.

Bruce and Figueiredo are well aware of the limitations of their work, both in terms of the sort of R&D inputs and outputs examined, and the way by which they are measured. But again, their contribution provides an important piece of the wider puzzle, allowing us to push further and examine other areas in the innovation ⇔ government space, which is my intention here.

[3] A great deal has been said about the failures of bureaucracy, but this usually refers to “static inefficiencies”, which is what frustrated citizens typically complain about in their encounters with G. Here we shall refer mostly to “dynamic inefficiencies”, i.e. the slowness or failure of G to innovate, which are likely to be even more significant, certainly in the long run.

2. The context: government and the emergence of a new GPT

There is increasing evidence that we are witnessing the rise of a new "General Purpose Technology" (GPT), which I shall refer to as the "Digital GPT" (*d-GPT* in short).[4] Starting with the steam engine in the late 18th century, electricity a century later, and then semiconductors, computers and the internet, these powerful technological waves impact the economy by fostering transformative innovation in an ever expanding range of adopting sectors. The fundamental role of GPT's in economic growth lies not in the weight of the sector producing the GPT itself, but in the complementary innovations that revolutionize the operations of adopters, old and new.

G as a sector is no exception: over the past two centuries we have seen major changes not just in the scope of G activity (an increase of about tenfold), but also in the way governments operate, as they gradually adopt the leading GPT of each era. However, given that we lack measures of "productivity" of government services,[5] it is hard to gauge the extent to which the GPT drives complementary innovations within G, as it spreads throughout the public sector. Absent such measures, the presumption is that, the adoption of GPTs notwithstanding, G remains highly inefficient in its *modus operandi*, slow in innovating, and not responsive to shifting needs. The widely accepted corollary is thus that attaining efficiency requires G to outsource its activities as much as possible, downplaying the option of G innovating within and by itself.

I shall argue here that such sweeping conclusion is unwarranted, and even dangerous: the great challenges that we face, ranging from unsettling inequality and climate change, to pandemics and a new wave of technology-induced employment disruption, require ***more***, not less G action and leadership. However, this does not imply moving the dial

[4]For the concept of GPT see Bresnahan & Trajtenberg (1996); for the new digital GPT see Brynjolfsson, Rock, & Syverson (2019), Cockburn, Henderson, & Stern (2019), and Goldfarb, Bledi & Teodoridis (2019).

[5] The way the national accounts are constructed does not allow to compute productivity in the public sector, since neither the "outputs" nor the "prices" are well defined in that context.

from “smaller” to “bigger” G along the trite ideological continuum that defined many of the controversies of the past century. Rather, the intention is to move the dial from heavy-handed, slow-moving, and yes, inefficient governments, to smart, *d-GPT* based, and ***innovative*** governments.

As Bruce and Figueiredo explain, beyond *technological* innovation which corresponds to notions that we can easily grasp and measure, there are three additional dimensions of innovation in G: *organizational, regulatory and policy related*. Organizational innovation pertains to the way G functions in itself, whereas the other two refer to the design and implementation of measures that affect others. In each of these realms there is vast room for innovation that can be of tremendous consequence to the economy and society. Furthermore, even if G were not to innovate by itself in these dimensions, its actions or its lack of action can be highly consequential for the ability of the business and civic sectors to innovate. Thus for example, the design and implementation of policies and regulations regarding data privacy issues are already, and will increasingly be, of key importance to the development of the new *d-GPT*, and the complementary innovations that will stem from it. The following sections elaborate on the key role of G in fostering *d-GPT*-based innovation in the provision of public or quasi-public goods, particularly in health care, education and transportation.

3. *d-GPT*-based innovation in the provision of public goods

3.1 Health Care

The health care sector exemplifies as well as any the centrality of G and the need for G-related innovation. The annual budget of the NIH, probably the biggest research agency in the world, stands at about 40 billion $, and R&D expenditures by US-based pharmaceutical companies amount to almost twice as much. Not surprisingly, the US is the undisputed leader in biomedical innovation. Yet, the US health care system, accounting for a staggering 17% of GDP, is one of the most inefficient in the OECD, achieving results well below those of other advanced nations (Table 1).

Table 1: Health Care in the US and the OECD[6]		
	US	**OECD**
Total expenditure on health care, % of GDP	17% *(highest)*	8.8%
Life expectancy	78.6	80.7
Diabetes prevalence % of adults	10.8	6.4
Access to care % eligible for core services	90.8% *(2nd worse)*	98.4%

The point is that innovation in medicine (i.e. in pharma, medical equipment, surgical procedures, etc.) does not necessarily translate into better health outcomes. The intervening factor is obviously the health system itself: the way health care is organized, delivered, and paid for, the extent of access to care, and the like. It is in this context that G plays a key role, in various ways: providing care directly in some countries (as in the UK or Canada); funding and regulating in many others, and in some cases by omission, i.e. abstaining from doing some or any of the above. Managing the health care system so as to attain good health outcomes calls not just for "static efficiency", but for constant improvement and change, i.e. it requires system-wide innovation, above and beyond medical innovation. What good is, say, innovation in diagnostic imaging (e.g. an improved CT-PET scanner) if access to it is very limited, and the diagnostic results do not lead to improved treatment?

The implications are clear: institutional, organizational and regulatory innovations in health care are crucial for obtaining better health outcomes, and G has to play a key role in that respect. Furthermore, the

[6] See OECD (2019).

emerging *d-GPT* offers highly promising opportunities for system-wide innovations, precisely in contexts such as health care. The following concrete examples illuminate this contention:

Managing emergency care units (ER) have become an extremely important aspect of health care, and yet very often demand vastly exceeds capacity, leading to degraded service, long waits, and bad outcomes. Sorting and managing the flow of patients trying to access ER is thus crucial. In fact, there are three types of admissions to ER:

1. Those that should have not resorted to ER in the first place, but should have rather gone to a primary care physician or a local clinic ("false emergencies")
2. Those that could and should have gone earlier for a planned hospital intervention and perhaps hospitalization, before reaching the "emergency" stage
3. True emergencies due to accidents, heart attacks, strokes, etc.

Using big data and machine learning (ML) methods to characterize each category of patients, and coupling such categorization with detailed individual data of patients intending to go to ER, it would be possible to channel them in real time situations to the most appropriate venue. Even if, say, 10% of patients are thus steered away from ER, that can lead to a significant improvement in the functioning of ER units.[7] The development of such organizational innovation based on the intensive use of *d-GPT*, and its system-wide deployment can save precious resources while gaining in efficiency and efficacy in the provision of health care.

Another example is analyzing with ML extensive data from electronic medical records to predict gestational diabetes, and using the predictions to do targeting early testing of women in high risk of developing it.[8] Again, such innovation can save resources and bring about better outcomes.

[7]This is similar to what happens in the context of transportation, whereby even small reductions in the flow of vehicles can greatly reduce traffic congestion – in both cases the processes are highly non-linear.

[8]Artzi *et al* (2020).

These and similar innovations need not be done by G agencies themselves, and yet the role of G in enabling and supporting system-wide innovations of that nature is likely to be very important and even crucial. One of the reasons is that *d-GPT* entails and necessitates the intensive use of vast amounts of widely dispersed and varied data pertaining to individuals, which raises difficult issues of privacy, safety, ownership and intended use, as well as of common protocols. G intervention is required, since market forces or local authorities cannot by themselves successfully cope with these thorny issues. *d-GPT*-based innovation in the provision of health care may well occur outside G, but the pace, scope and reach of it, and the ability to reap system-wide health benefits will strongly depend upon proper G action.

3.2 Education

Revamping the **education system** in order to provide the skills required for the upcoming *d-GPT*, from early childhood to higher education, is crucial so as allow the young generation find suitable employment and ensure future growth. G is a key player in education all over the world, certainly the most powerful, and thus it is bound to play a key role in fostering innovation in education. This is certainly the case for primary and secondary education, which is delivered mostly by public schools, but also for early childhood education, which is increasingly understood to be of paramount importance in the early development of life-long skills.

Furthermore, *d-GPT* coupled with big data on pupils, teachers, and schools, offers the possibility to innovate in the direction of "personalized education", moving away from the "factory model" of education that emerged in the 19th century and is increasingly obsolete. Thus innovating in education entails these interrelated but distinct channels:

- promoting the skills needed for *d-GPT* employment
- taking advantage of *d-GTP* to reorient the system towards "personalized education"

- innovating in the delivery and access to education using the capabilities of distant learning, which is a further manifestation of *d-GPT*.

Regarding the later, the COVID-19 pandemic forced school closures in 191 countries, affecting at least 1.5 billion students and 63 million primary and secondary teachers (UN, 2020). Many of them resorted to studying online (there are no reliable data yet on how many), in what probably will be regarded as the largest educational experiment in history. It is widely assumed that following this dramatic disruption, and the massive exposure to distant learning, some of it will be adopted permanently, but that will require a great deal more of experimentation and innovation.

3.3 Transportation

Traffic congestion has become one of the most challenging issues affecting urban life, and it is widely understood that traditional policies entailing the expansion of infrastructure cannot offer lasting improvement. Rather, what is required is smart traffic management based on *d-GPT*, such as:

- Highly differentiated road pricing using real-time data on location, time and number of passengers in each vehicle.

- The design of efficient shared rides and car-pooling schemes, based on detailed data on the commuting patterns of employees to employment areas.

- The development of last-mile micro-mobility (scooters, bikes, etc.), and its smart management at the interface between individual and public transportation.

4. Further directions to facilitate innovation in Government

When it comes to the inner workings of G and the design of policies, there is vast room for improvement, pertaining to the categories of what Bruce and Figueiredo designate as *organizational and policy related*

innovations. There is increasing awareness of the importance of such innovations, as reflected *inter alia* in the spread "Moneyball for Government"-type of initiatives (Ayotte *et al* 2014): the idea, based on Michael Lewis' bestseller (Lewis, 2004), is that the long-held conceptions of how to carry out activities within organizations, be them in regular businesses, sport clubs or government agencies, may turn out to be vastly inefficient, and that the intensive use of data and rigorous methods of analysis can point out to far better ways. This is bound to be particularly true in the context of G, due to the lack of competition and of adequate measures of performance. The following suggestions exemplify ways by which G can flush out inefficiencies and pave the way to innovative courses of action:

- Expand the use of fast Randomized Controlled Trials (RCT's) to test the prospective effectiveness of new policy programs. One of the stumbling blocks impeding the wide implementation of RCT's so that they become more relevant for policy making, is that they typically take too long (relative to the political clock), and often are too limited in scope. The intensive use of big data to complement that generated by the RCT itself, and of online platforms as well as of ML methods, may significantly enhance the effectiveness of RCT's as a viable tool in policy making (Bouguen *et al*, 2018).

- Revive the application of zero-based budgeting (ZBB) to improve the effectiveness of existing G programs, making use of data-intensive methods. When the yearly G budget is drafted, the discussions typically dwell on the increments or subtractions at the margin, but not on the full budget. Thus, inertia dominates most of public spending, without regard to ex-ante intents or to ex-post results. ZBB is supposed to help tackle two questions: Are the existing activities that appear in the budget efficient and effective? Should current activities be eliminated or reduced to fund higher-priority new programs or reduce the current budget?

The ability to address these questions in a timely fashion has greatly improved with the availability of big data and of advanced methods of data analysis. This is so due to the fact that vast majority of G programs generate over time large amounts of administrative data as they are implemented, which exist in digital form and can be used to examine their ex post effectiveness, particularly when combined with further G-owned data. This was not the case in the past, thus in retrospect the ZBB approach was introduced prematurely leading to its abandonment, but now conditions are ripe for its reintroduction.

- Expand the interaction and engagement of G agencies with a wide range of stakeholders, in order to elicit their preferences, pave the way to acceptance of policy reforms, and cultivate public trust. The availability of online, digital platforms has greatly enhanced the ability to reach wide segments of the public in a timely fashion, and to extract from these interactions useful insights and policy implications. The erosion of public trust in G institutions constitutes a serious threat to democracy, and thus deploying *d-GTP* tools to move in the direction of "participatory (or deliberative) democracy" could be an effective way to restore trust (Fishkin, 2011).

5. Concluding remarks

Fostering organizational and policy innovation in G encounters many difficulties, prominent among them G inertia, lack of incentives, and the proverbial self-preservation tendency of bureaucracies. This is quite certainly the most formidable hurdle, since innovation entails entrepreneurship, which in turn needs to be elicited by powerful incentives. Measurement of outputs is an accompanying factor, as well as flexibility in rewarding effort, novel ideas, and success. Introducing these key ingredients of innovation to G constitutes indeed a great challenge, but one that needs to be tackle in any case: as virtually every aspect of economic activity is being transformed with each new wave of GPT's, the widening divide between G and the rest of the economy will

become untenable, and thus is bound to give rise to new G modes of operation. The point is that reinventing the provision of G services should entail not just moving from one static equilibrium to a temporarily better one, but creating the conditions for constant innovation.

A second set of obstacles refer to data: as we have repeatedly suggested, *d-GPT*-based innovations in G entail the massive use of data. For that to happen it is imperative to link disparate data sources, and to ensure interoperability of different data systems - both are possible but hard to implement. Furthermore, the more G relies on interconnected big data, the more it exposes itself (and thus the public) to cyber threats and privacy hazards. In addition, there is always the lingering concern of abuse, which utmost manifestation (so far) is the Orwellian "social credit system" being implemented in China. These are very real difficulties, but they exist regardless, and thus as with many other side effects of technological progress, we have to learn to confront them, and not refrain from embracing progress because of them.

Lastly, we economists have our share to contribute to advance G innovation: we need to go much further in the way we define and measure innovation and productivity, so as to be able to quantify them also in the context of G. That is, we need to create new context-dependent performance dimensions, which in turn would allow us to come up with new mechanism designs to incentivize them, including competitive schemes for policy design and experimentation.

In terms of the internal functioning of G, we should consider introducing the routine assessment of the innovative impact of new bills and regulations, conducting "quality rounds" as integral part of G work, and incentivizing the mobility of personnel. Likewise, the "grand challenges" that we confront in the 21st century, from climate change to social inclusion, should be constantly presented to all G agencies, prompting them to contribute their share in responding to the challenges.

To conclude, we should foster innovative G action, both in order to revamp the provision of 21st century public goods, and to set the stage for the rapid and effective unfolding of the new GPT throughout the

economy. For that purpose, we need *not "big government"* but more effective and *innovative government,* adopting and tailoring *d-GPT* to policy needs, and in so doing impacting the course of the *d-GPT* itself.

References

Artzi, Shilo, Hadar, Rossman, Barbash-Hazan, Ben-Haroush, Balicer, Feldman, Wiznitzer, & Segal, Prediction of gestational diabetes based on nationwide electronic health records. *Nature Medicine* volume 26, pages 71–76 (2020).

Ayotte, Kely, Mark Warner, Glenn Hubbard, Gene Sperling, Melody Barnes, John Bridgeland, Kevin Madden, Howard Wolfson, Jim Nussle, Peter Orszag. *Disruption Books,* 2014.

Bruce, Joshua R. and John M. de Figueiredo, Innovation in the U.S. Government, *this volume*, 2020.

Bresnahan, T. and M. Trajtenberg. 1995. General Purpose Technologies 'Engines of Growth'? *Journal of Econometrics*. 65. 83-108.

Brynjolfsson, Erik, Daniel Rock, and Chad Syverson. 2019. Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics. In Agrawal, Gans, and Goldfarb Eds. *The Economics of Artificial Intelligence: An Agenda*. University of Chicago Press, p. 23-57.

Bouguen, Adrien, Yue Huang, Michael Kremer, & Edward Miguel, Using RCTs to Estimate Long-Run Impacts in Development Economics. NBER Working Paper No. 25356, December 2018.

Bush, Vaanevar, Science the Endless Frontier - A Report to the President. *United States Government Printing Office*, Washington: 1945. https://www.nsf.gov/about/history/vbush1945.htm

Cockburn, Iain, Rebecca Henderson, and Scott Stern. 2019. The Impact of Artificial Intelligence on Innovation. In Agrawal, Gans, and Goldfarb Eds. *The Economics of Artificial Intelligence: An Agenda*. University of Chicago Press, p. 115-146.

Fishkin, James S. When the People Speak. *Oxford University Press*, 2011.

Goldfarb, Avi and Taska, Bledi and Teodoridis, Florenta, Could Machine Learning be a General-Purpose Technology? Evidence from Online Job Postings in SSRN, October 12, 2019. https://ssrn.com/abstract=3468822

Lewis, Michael, Moneyball: the art of winning an unfair game. *Norton,* 2004.

OECD "Health at a Glance", 2019 https://www.oecd-ilibrary.org/social-issues-migration-health/health-at-a-glance-2019_4dd50c09-en

UN (2020), https://news.un.org/en/story/2020/04/1062232