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Comment Manuel Trajtenberg

Introduction

Ever since Vannevar Bush's groundbreaking report to President Franklin D. Roosevelt, "Science—The Endless Frontier" (Bush 1945), the US government has played an increasingly prominent role in the realm of research and development (R&D) and innovation. This includes funding of research through the National Science Foundation and the National Institutes of Health (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 on innovation goes much further, reflecting the size of government in the economy,¹ procurement policies, the impact of taxation, and the deliberate or unintended effects of regulation. Thus, for example, setting standards for fuel economy or energy conserva-

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1. The average government/GDP ratio for 36 OECD countries stands now at 43 percent, with the US being at the lower end with 38 percent.

tion 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 government” there are plenty of examples of the unintended impact of government action on innovation: from the invention of the tabulating machine to process data for the 1890 US Census (which eventually gave rise to IBM), to the contribution of government 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 government policies, and not always for the better. In fact, government inertia, inaction, political meddling, unions, and plain ineptitude often preclude the adoption of innovative methods and procedures. This is also often the case in the realm of housing, zoning, and building codes, and in the delivery of welfare assistance.² In view of the growing size and importance of these public goods and services in the economy and for our well-being, the fact that government 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 World War II. This has happened in tandem with the expanding role and share of government 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 government impacts innovation, and the way innovation in turn affects the conduct of government activities and the provision of public goods.

The chapter by Bruce and Figueiredo (chapter 9, this volume) 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 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 they are measured. But again, their contribution provides an important piece of

2. 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 government. Here we shall refer mostly to “dynamic inefficiencies” (i.e., the slowness or failure of government to innovate), which are likely to be even more significant, certainly in the long run.

the wider puzzle, allowing us to push further and examine other areas in the innovation government space, which is my intention here.

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).³ 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.

Government as a sector is no exception: over the past two centuries, we have seen major changes not just in the scope of government 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,⁴ it is hard to gauge the extent to which the GPT drives complementary innovations in government, as it spreads throughout the public sector. Absent such measures, the presumption is that the adoption of GPTs notwithstanding, government remains highly inefficient in its modus operandi, slow in innovating, and not responsive to shifting needs. The widely accepted corollary is that attaining efficiency requires government to outsource its activities as much as possible, downplaying the option of government innovating in and by itself.

I shall argue here that such a 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 government action and leadership. However, this does not imply moving the dial from “smaller” to “bigger” government 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 government: organizational, regulatory, and policy related. Organizational innovation pertains

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

4The way the national accounts are constructed does not allow one to compute productivity in the public sector, since neither the “outputs” nor the “prices” are well defined in that context.

to the way government 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 government 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 government in fostering d-GPT-based innovation in the provision of public or quasi-public goods, particularly in health care, education, and transportation.

d-GPT-Based Innovation in the Provision of Public Goods

Health Care

The health care sector exemplifies as well as any the centrality of government and the need for government-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 percent of GDP, is one of the most inefficient in the OECD, achieving results well below those of other advanced nations (table 9.C.1).

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 government plays a key role, in various ways: providing care directly in some countries (as in the United

Table 9.C.1 Health care in the US and the OECD

	US	OECD
Total expenditure on health care (percent of GDP)	17 (highest)	8.8
Life expectancy	78.6	80.7
Diabetes prevalence (percent of adults)	10.8	6.4
Access to care, percent eligible for core services	90.8 (second worse)	98.4

Source: OECD (2019).

Kingdom 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 government has to play a key role in that respect. Furthermore, the emerging d-GPT offers highly promising opportunities for system-wide innovations, precisely in such contexts as health care. The following concrete examples illuminate this contention.

Managing emergency care units (ERs) has 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 ERs is thus crucial. In fact, there are three types of admissions to ERs:

1. Those who should not have resorted to ERs in the first place, but should have rather gone to a primary care physician or a local clinic (“false emergencies”);
2. Those who could and should have gone earlier for a planned hospital intervention and perhaps hospitalization, before reaching the “emergency” stage; and
3. Those who experience emergencies due to accidents, heart attacks, strokes, and the like.

Using big data and machine learning methods to characterize each category of patients and coupling such categorization with detailed individual data of patients intending to go to ERs, it would be possible to channel these patients in real time to the most appropriate venue. Even if, say, 10 percent of patients were thus steered away from ERs, that can lead to a significant improvement in the functioning of ER units.⁵ 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 machine learning extensive data from electronic medical records to predict gestational diabetes, and using the pre-

5. 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 nonlinear.

dictions, to do early testing of women at high risk of developing it.⁶ Again, such innovation can save resources and bring about better outcomes.

These and similar innovations need not be done by government agencies themselves, and yet the role of government in enabling and supporting system-wide innovations of this 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. Government 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 government, but the pace, scope, and reach of it, and the ability to reap system-wide health benefits will strongly depend on proper government action.

Education

Revamping the education system to provide the skills required for the upcoming d-GPT, from early childhood to higher education, is crucial so as allow the young generation to find suitable employment and ensure future growth. Government 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 “personalize~ducation,” 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 toward “personalized education,” and
- innovating in the delivery and access to education using the capabilities of distant learning, which is a further manifestation of d-GPT.

Regarding the last point, 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

6. Artzi et al. (2020).

assumed that following this dramatic disruption, and the massive exposure to distance learning, some of it will be adopted permanently, but that will require a much more experimentation and innovation.

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

Further Directions to Facilitate Innovation in Government

When it comes to the inner workings of government 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 of “Moneyball for Government” types 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 in organizations—be they 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 government, due to the lack of competition and of adequate measures of performance. The following suggestions exemplify ways by which government can flush out inefficiencies and pave the way to innovative courses of action:

- Expand the use of fast randomized controlled trials (RCTs) to test the prospective effectiveness of new policy programs. One of the stumbling blocks impeding the wide implementation of RCTs 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 machine learning methods, may significantly enhance the effectiveness of RCTs 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 government programs, making use of data-intensive methods. When the yearly government 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 because over time, most government programs generate large amounts of administrative data as they are implemented. These data exist in digital form and can be used to examine their *ex-post* effectiveness, particularly when combined with further government-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 government agencies with a wide range of stakeholders 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 government 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).

Concluding Remarks

Fostering organizational and policy innovation in government encounters many difficulties, prominent among them government 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 government indeed constitutes a great challenge, but it is one that needs to be tackled in any case: as virtually every aspect of economic activity is being transformed with each new wave of GPTs, the widening divide between government and the rest of the economy will become untenable, and thus is bound to give rise to new government modes of operation.

The point is that reinventing the provision of government services should entail not just moving from one static equilibrium to a temporarily better one, but also creating the conditions for constant innovation.

A second set of obstacles refer to data: as I have repeatedly suggested, d-GPT-based innovations in government entail the massive use of data. For that to happen, it is imperative to link disparate data sources and to ensure the interoperability of different data systems—both are possible but hard to implement. Furthermore, the more government 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, whose utmost manifestation (so far) is the Orwellian “social credit system” being implemented in China. These are very real difficulties, and as with many other side effects of technological progress, we have to learn to confront them, and we must not refrain from embracing progress because of them.

And finally, we economists have our share to contribute to advance government 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 government. 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 government, we should consider introducing the routine assessment of the innovative impact of new bills and regulations, conducting “quality rounds” as an integral part of government work, and incentivizing the mobility of personnel. Likewise, we should consider presenting the “grand challenges” that we confront in the 21st century—from climate change to social inclusion—to all government agents on a regular basis, prompting them to contribute their share in responding to the challenges.

To conclude, we should foster innovative government action, both 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.

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