

Public Funding of Universities: Why and How? *

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Abstract

Ideas are the source of economic growth and improvements in well-being. A large share of new innovations rest on ideas created by science. As knowledge is non-rival, we face a dilemma in terms of incentivizing the creation of new ideas on the one hand, and allowing the diffusion of created knowledge on the other hand. Two key tools in solving this dilemma are to give academic scientists non-financial incentives, and to use public funds for (basic) research. (Almost) non-conditional base funding is needed because science is long-term and unpredictable, and because without such funding there would be nobody applying for competitive funding. Competitive funding is needed to complement base funding by providing incentives to continue doing research, and to allocate resources to the most promising researchers and research projects. While these arguments apply at the global level, it is less clear why they should apply at the national level. The key reason to use public funds for science even in small nations (regions, locations) is to develop and maintain absorptive capacity as, while new ideas may be freely available, the ability to evaluate and apply them as well as the ability to pass them on requires individuals who (at least attempt to) produce frontier research themselves. To ensure that frontier knowledge and absorptive capacity diffuse throughout the economy speaks for funding universities as research and teaching are natural complements in this process.

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1 Introduction

This chapter travels on well-trodden territory, loved by academics of many stripes – the role of universities in society – but only covers parts of it. To instill some discipline, I proceed by honoring two self-imposed constraints: First, besides some brief remarks about the larger role of universities, I will look at them through the lens of economics, i.e., concentrating on their role in improving living standards and quality of life through well-made resource allocation decisions. Second, I will constrain my analysis on the question of how science, as exercised within universities in particular, should be funded. It turns out that while the territory is generally speaking well covered, there is little in terms of theoretical work on the second issue.

I summarize the well-known economic arguments for why science is the fundamental building block of human progress, whether manifested in improved living standards, well-being or decreases in misuse of planetary resources, in the next Section.¹

In Section 3, I discuss how, i.e., through which mechanisms, public research funding should be allocated. As is the case throughout, I will simplify things and concentrate my remarks on the role of base and competitive funding without paying too much attention to how either is allocated in practice, nor to other important sources of funding, such as private foundations. My main point is that base funding is needed because of the nature of the scientific process - its length and the inherent uncertainties related to it. Also, trivially but importantly, without base funding there would hardly be a need for competitive funding, for there would be no participants in funding competitions. The role of competitive funding is to complement base funding by allowing resource allocation to promising researchers and fields, and by providing further incentives for tenured researchers to remain research active.

While in the first two Sections my approach is to think along the lines of a global (benevolent) social planner, I turn my attention in Section 4 to the fact that it is national (and regional and local) governments that are mostly in charge of allocating resources to science. This observation leads one to ask why any single government would invest in research given that the knowledge produced is (almost) freely available. Why not just free-ride on everybody else's efforts? The first piece of my answer is that free-riding is not a realistic option, as the knowledge created elsewhere may be freely available, but is understood only by those with sufficient expertise. It requires deep knowledge of where the frontier lies - absorptive capacity - to be able to identify the truly valuable new pieces of knowledge, and to be able to pass them on to students. The latter point illuminates the second piece of my answer: A key societal function of locally conducted research is to raise the level of locally produced and locally important higher education.

I change tack in Section 5 to make some remarks on the promises and pitfalls of the emerging empirical science of science - literature before offering final thoughts in Section 6. The main point in Section 5 is that while there is every reason to continue the ongoing efforts to identify the causal effects of

¹One could of course argue that it is economic progress, based on science, that has led to the overuse of planetary resources by enabling us to harness carbohydrates and other nonrenewable raw-materials and for us to start utilizing previously unusable natural resources such as land and forests, as well as being the chief enabler of drastic growth of human population, spurred by decreasing rates of infant mortality. I would not disagree, but would argue that the best way to overcome these challenges lies in scientific progress.

competitive funding schemes, one should be careful to place those results into the larger context of the wider institutional and funding context of research. The main effects of even high-profile funding schemes may be the ex ante incentives they create for the would-be applicants, rather than the ex-post effects on the award-winners. The second point, made by many before me, is that research funding organizations have been embarrassingly slow to adopt best practices which, at low cost, would enable systematic evaluation of competitive funding schemes.

2 Why Use Public Funds for Science?

Modern economic growth rests on productivity growth, i.e., on us making better use of the available inputs. Productivity growth in turn rests on ideas (e.g. Jones (2005)), that is, insights on what better use there would be for a given set of inputs (new products and services) or on how to produce the same output with fewer inputs (process innovations).² Post WWII, the U.S. harnessed science explicitly for these purposes, largely on the basis of the brilliant and hugely influential treatise of Bush (1945) which built on this idea, fortifying the argument with many timely examples of its day.³

The first key question then is: How to efficiently allocate resources to ideas production? A fundamental challenge regarding this question arises from the non-rival nature of knowledge. Though economists' standard references for the public good nature of knowledge (ideas) are Nelson (1959) and Arrow (1962), the insight is much older and is mentioned e.g. by Jefferson (1813): *One's use of an idea does not prevent another person's use of the same idea. The challenge that arises is that once an idea has been generated, the best possible way to use it is to allow everybody (capable of using it; a point to which I will return) use it.*^{4,5} If that is the institutional arrangement and the producer of the idea does not get compensated for their investments, (next to) no ideas will be forthcoming. There is therefore the distinct possibility that humanity is under-investing in science, and not necessarily by a small margin (e.g. Jones and Williams (1998); Jones (2021)). Already Arrow (1962) pointed out that these difficulties are especially pronounced in basic research, i.e., in the production of ideas.

Further challenges are created by the fact that the outcomes of research are, as emphasized by Arrow (1962), uncertain. They are uncertain in two distinct ways: First, it is unclear in advance what results, if any, a scientific project will generate. Second, even once the results have been ascertained, it may take a long time before their usefulness becomes clear. The history of science is full of anecdotes of both serendipity in discovery as well as cases where the importance of a discovery only became obvious

²Mokyr (2005) makes the point that while (pp. 289) *"in the early stages of the Industrial Revolution, many of the important advances owed little to science in a direct way"*, it quickly started to build on science in that (pp. 324) *"The Industrial Enlightenment insisted on asking not just "which techniques work" but also "why techniques work" (that is, what natural regularities explain their success)."*

³Also national security, as our tumultuous time makes clear, is a reason to use public funds for science, a point Bush (1945) also made.

⁴Arrow (1962) provides this nice quote (pp. 617): *"In an ideal socialist [sic!] economy, the reward for invention would be completely separated from any charge to the users of the information."*

⁵As a positive example of the speed of knowledge diffusion that I cannot resist is the discovery of CRISPR-CAS9 by Charpentier and Doudna in 2012, for which the authors were awarded the Nobel Prize in chemistry in 2020. When using the search prompt "crispr cas9 genome editing", the number of scientific publications listed in Google Scholar is about 400 000 at the time of this writing in January 2026.

decades later. It is worth noting that the uncertainty of research outcomes is a motivation to, at the margin, have more rather than less of it, as that is the way to increase the possibility that some researcher succeeds in nudging the knowledge frontier a little further.⁶

The challenge of how to provide incentives for scientific investments obviously has not gone unnoticed, and along its history, humanity has come up with various institutional arrangements to deal with it. Two of them are central to this chapter: Public funding of science and the universities, including the incentive structure for academics. Starting from the latter, as pointed out by e.g. Merton (1957) and Dasgupta and David (1987, 1994), the practice of awarding scientific discoveries based on priority and scientists on achievement respectively, and in terms of peer recognition as much if not more than monetarily,⁷ is our current and best attempt at providing scientists incentives for the discovery of new ideas, that is, besides the utility they derive from being able to conduct research (Stern (2004); Sauermann and Roach (2014); for an early study of the motivations of inventors (of patents), see Rossman (1931)).

Such (mostly) non-monetary incentive systems are obviously not sufficient to keep the scientific endeavor going; money is also needed. Given the non-rival nature of ideas, funding sources that require a financial return are badly suited for the purpose. The natural solution then is to use public funding for science, as the society (humanity) as a whole reaps the benefits of new ideas even if the inventors themselves only receive a fraction of the (monetary) returns. The higher the ratio of societal returns to private (market-based) returns, the stronger the case for public funding. Arguably, basic research is characterized by a high ratio in this respect.

3 How Should Public Funds be Used for Science?

3.1 Type of Funding

Science is funded in myriad ways, and even public funding is allocated using a large variety of tools. There is a relative abundance of knowledge of how universities and research institutes are funded, see e.g. Geuna and Martin (2003); Wang et al. (2018); OECD (2025). Rather than cataloging different ways in which public funds are allocated to science, I will concentrate on the economics of the two most important ways in which public funds are allocated to science. In line with the literature, I call them *base* and *competitive* funding. I categorize as base funding any funding that is directed to a university (or a research institute)⁸ with a large likelihood also in the near future and which is not tied to the quality of research that is going to take place in the near future, no matter what the actual allocation process is. Thus, government block grants and funding allocated through teaching in one way or another (student fees and vouchers, government funding allocated on the basis of student intake of number of degrees produced), to the extent that it overcompensates the costs of education, would count as base funding.⁹

⁶This is just a rephrasing of the argument of Jones (2005).

⁷Mokyr (2005) stresses the open nature of 18th and 19th century science; and that scientists (pp. 310) "*would be rewarded by honor, peer recognition, and fame—not a monetary reward proportional to their contribution*".

⁸For reasons that will become clear, I mainly concentrate on universities.

⁹What I categorize for simplicity as base funding is in many countries based not only on teaching-related metrics, but also on others, such as quantity and quality of research, amounts of competitive funding achieved etc. See e.g. OECD (2025) for more

Competitive funding is, as the name suggests, allocated through a competitive process where (almost always) scientific peer evaluation plays an instrumental role. Competitive funding is also characterized by covering the costs of a well-defined research project or program, for a limited period of time. Almost all (developed) countries have a national science foundation - type organization that typically is the main source of competitive funding.

There is a number of primary economic motivations for competitive funding: First, competitive funding allows the social planner to direct funding to the most promising projects. While it is true that over time the scientific system of peer recognition reveals quality differences among scientists, at any given moment of time it would be unclear who has the best idea for the next project without a process akin to the way competitive funding is allocated. Second, given the institution of tenure, incentives for senior professors (those with tenure) to continue research are strengthened by providing funding on a competitive basis. Competitive funding is an important part of the incentive system to encourage tenured professors to remain research active.¹⁰ Of course, the process of competitive funding is neither free of cost nor unproblematic to execute in practice (e.g. Schweiger et al. (2024)), and such costs should obviously feature when deciding when and to what extent, and through which exact mechanism, to use competitive funding; there is an emerging interesting theoretical literature on how to design the allocation process of competitive funding, recently surveyed in Carnehl et al. (2024). They emphasize the effectiveness of staged mechanisms for awarding grants to facilitate productive use of grants.

With all these benefits to competitive funding, why is base funding needed? A primary motivation for base funding comes from the fact the scientific discovery process is slow and uncertain. A large degree of institutional stability is needed in order to be able to pursue projects of such nature, and base funding is a way to provide a degree of the needed stability. It is worth noting that base funding essentially enables the government to use competitive funding, as without (some) base funding, there would hardly be any competitors. Base funding maintains the institutions that provide the environment in which scientists can pursue competitive funding, and can carry out their research once they are successful in obtaining some.¹¹

3.2 What Type of Institutions to Fund?

An entirely different but equally important way of approaching the question of how to allocate funding has to do with the complementarity between research and teaching, noted e.g. by Arrow (1962) (pp. 623): *"In the latter [universities], the complementarity between teaching and research is, from the point of view of the economy, something of a lucky accident"*, though I would venture to claim that it is by design, not by accident, at least when it comes to modern universities. The Humboldtian view of universities, established in the early 19th century and adopted, over an extended period of time, at most universities, stresses the importance of combining research and teaching (e.g. Östling (2018)). While it is true that the publication of (new) scientific knowledge aims to make it available to the rest of humanity, it is the case that frontier

information.

¹⁰Obviously, there are other incentives, such as peer recognition / pressure, along the lines of the well-known adage "you are only as good as your latest publication". I would argue that competitive funding and peer recognition are complementary incentive devices.

¹¹Stephan (2010) notes that in the U.S., base funding is often quite marginal.

scientific knowledge is often unintelligible without substantial investment in the requisite human capital. Such investments create and maintain *absorptive capacity* (Cohen and Levinthal (1989, 1990)), the ability to (Cohen and Levinthal (1989), pp. 569) "*assimilate and exploit existing [new] information*".¹² I argue that the only way to possess absorptive capacity of frontier scientific research is to attempt to produce such research. Taking that as a starting point implies that the only way to convey to others what is happening at the scientific frontier necessitates that one is engaged in research aimed at being at the frontier oneself. Coupled with the fact that it is mostly not universities, but the private sector that transforms new scientific ideas into innovations and then hopefully diffuses the right ones, this observation is fundamental, as it suggests that public funding for science should, *ceteris paribus*, be allocated to institutions that engage in teaching, i.e., universities. Knowledge production (science, research) is thereby intimately tied to knowledge diffusion (teaching). Notice that this view, in addition to the uncertain nature of science in terms of outcomes, also motivates what might seem "overproduction" of scientific research. Even research that is unlikely to move the frontier may be socially worthwhile if producing such research increases the absorptive capacity of the researchers producing it, and thereby improves their ability to pass on the right (new) knowledge to their students.

The obvious alternative to universities are (government) research institutions. While they clearly are disadvantaged relative to universities in terms of the argument made above, they are also ubiquitous. By revealed preference they are thus serving some useful purpose. Admitting that research institutions deserve a deeper analysis than I can provide here, the following comparative advantages of research institutions come to mind: First, given the academic freedom granted to universities, the social planner may find it easier to influence the direction of research at research institutions than at universities. Second, as research institutions are often administratively under another ministry than universities (university funding), they may provide a way to increase the national research capacity for political economy reasons beyond and thereby closer to the first best than what would be possible if all research funding was directed at universities. These advantages seem to come at a cost however, as they depend heavily on the government's ability to direct research and to allocate research funding across research institutions and within them in an efficient way, in addition to the fact that research institutions by design are not as good at knowledge diffusion as universities.

4 Local versus Global Aspects of Science Funding

4.1 General Arguments

All the arguments presented above apply at the level of analysis most often, implicitly if not explicitly, used regarding science funding, namely at the global level. The reality of course is that national governments are responsible for the vast majority of science funding. Why would a small economy use public funds

¹²While Cohen and Levinthal (1989) discuss absorptive capacity in term of firms, it is seems clear that 1) even within a firm the majority of absorptive capacity lies within the individuals employed by the firm and 2) that the concept applies in other institutional settings besides firms. In Cohen and Levinthal (1990) the authors indeed discuss absorptive capacity at the individual level, too.

for science? Why wouldn't even the large(st) economies rather free-ride on others' investments? After all, the newly created knowledge is made public through the scientific publication process.

The question is at its sharpest with a small economy which, by design, would hardly make a difference to the progress of the scientific frontier no matter which share of its resources were devoted to scientific research. No matter the investments, the vast majority of new scientific ideas would be produced somewhere else. Building on [Cohen and Levinthal \(1989, 1990\)](#), I argue that absorptive capacity is not only an individual or firm-level phenomenon, but also a phenomenon that exists at the national level. Quite simply, a nation that has no researchers at the cutting edge of, say, quantum computing, has no ability to evaluate the usefulness of the latest research on quantum computing and much less an ability to pass on such knowledge to students so that they could make use of it when they transfer to the various sectors of society.

The above argument for why even a small economy should invest in science clearly is very intimately tied to teaching: The local benefits do not in the first place come from the research done in local universities, but from local research enabling local university teachers to convey the latest knowledge and the ability to digest and apply it on their own to their students who then put it to use in whatever job they end up in upon graduation. By this I do not mean to belittle the importance of locally produced (frontier) research, but merely to put it into perspective. Science being an uncertain activity, large inputs (keeping quality constant) dominate small inputs in expected terms. Of course, scientists in small countries do produce break-through ideas,¹³ and there will always exist a number of research questions that are predominantly of local rather than global interest, naturally attended to by local researchers.

The larger the nation (or group of nations, think for example of the EU), the higher the degree to which it internalizes the benefits from ideas produced by its scientists, and the higher should its investments in science be.

4.2 A Sketch of a General Equilibrium Model of Science Funding

The theoretical (economics) literature on science funding, excepting the emerging literature on the design of competitive funding schemes mentioned earlier, is surprisingly scant. [Gersbach et al. \(2013\)](#) study an endogenous growth model where a country can invest in R&D which draws skilled labor from the productive sector (=from applied research into basic research), increases productivity through innovation, and may prevent foreign entry. While very interesting, the model does not capture the possibility that domestic innovations capture a large global market share, nor the dynamic tradeoff of investing in basic research in order to have a better absorptive capacity in the future. [Akcigit et al. \(2020\)](#) also study the trade-off between basic and applied research, but concentrate on the tradeoff between these two (stylized) types of research within firms and ignore the university sector and teaching. [Akcigit et al. \(2024\)](#) on the other hand provide an interesting (calibrated) endogenous growth model that zooms into the relation

¹³To go back to my single example of CRISPR-CAS9, Emmanuelle Charpentier conducted critical parts of her Nobel-prize winning research while at the University of Umeå, in a city of some 100 000 inhabitants, half-way up the Swedish east coast, i.e., at a place that cannot, without taking any stance whatsoever on the quality of the university, be described as a massive agglomeration of science. See e.g. <https://www.nobelprize.org/prizes/chemistry/2020/popular-information/>, accessed January 5, 2026.

between PhD education (and selection into it) and R&D support policies, but without incorporating (university) basic research into the model except as a conduit for producing PhDs. [Fraja \(2016\)](#) studies the question of how a government should allocate funding to basic and applied research when it has incomplete information on the research productivity of the universities in terms of their relative ability to carry out different types of research. In the second-best equilibrium, the government resorts to a combination of base funding ("block grants" in the terminology of [Fraja \(2016\)](#)) and competitive funding. These are important insights; however, the model does not deliver an answer to the question of the extent to which the public sector should provide research funding, and, understandably, models the benefits of both types of research in a reduced form fashion.

While it is not my objective to provide a formal model of science funding, I venture to sketch the outline of a potential such model next. Think of an overlapping generations endogenous growth model of a set of countries that are heterogenous in size and trade (freely) with each other in a fixed number of sectors. Each generation lives for two periods: In the first period, individuals can either work as unskilled labor, or invest in education. In the second period, unskilled individuals continue to provide their labor to production, while skilled labor is either hired to do basic research and to simultaneously educate the new generation, or to work as R&D engineers in the private sector. Scientific knowledge is otherwise freely available, but to access it, an individual has to be educated in the discipline. Only those that participated in producing new knowledge are capable of teaching it to others. You can think of two "subperiods" whereby in the first, research is conducted and in the second, new knowledge is passed on to students. To create a role for competitive funding, assume that at the beginning of the first subperiod, each researcher gets an idea the quality of which is stochastic. Each idea may be developed further if only resources are available. The government is able to imperfectly observe the quality of each idea and can devote further resources to the development of (some) ideas, i.e., provide competitive funding. At the end of the subperiod, the final quality of ideas is established and knowledge is diffused.

Further, and again for simplicity, assume no differences in the quality of research across countries (and individuals), the education or the educated. Education production is characterized by constant returns to scale up to a limit: One researcher can educate some fixed number of individuals. From this it follows that the more individuals a country wants to educate, the more it needs to invest in basic research. What will vary across countries is the capacity to educate, and thereby also the quantity of educated individuals. Scientific advances are stochastic, but the probability and size of advances are a concave function of the global number of researchers doing basic research in a given sector. The marginal returns to private sector innovation are increasing in the level of scientific knowledge.

Governments are benevolent but local social planners and provide both base and competitive funding to their universities, funded by taxes. The role of base funding is to provide a basis for absorptive capacity and for knowledge diffusion, i.e., teaching, and for attracting talent into research, as well as to make sure there is sufficient competition for competitive funding. The role of competitive funding in this simple model is to allow the social planner to direct research to a particular sector.

Based on the above somewhat incomplete description of the model, what would be the equilibrium public investments into science? Two conditions should hold:

1. Marginal local social benefits = opportunity cost of local public funds
2. Marginal local benefit of base funding = marginal local benefit of competitive funding

In a model of this type, all countries would invest at least somewhat in basic research, i.e., universities, as that is the only way to benefit from international knowledge spillovers. Basic funding would determine the number of ideas that can be developed, and competitive funding would allow (some of) them to be developed further. The larger the country, the more it, in relative terms, invests in basic research as it internalizes the benefits from those investments to a greater degree than a smaller country. Without international cooperation, the level of research funding is below the global and local first best.

One could enrich the model in various directions, e.g., by allowing researchers to migrate. With such an extension and without any costs of migration, the wages for researchers (possibly including some non-pecuniary benefits derived from a better research environment) would need to be equalized across countries.

5 Remarks on Facilitating Research on the Impact of Individual Science Funding Instruments

5.1 Placing Results on Causal Effects of Competitive Funding into Perspective

The origins of NBER's investments in science of science is based on the observation shared by many, and expressed e.g. by the (now ex-) chairman of UK Research and Innovation, the UK government's tool to invest in research, John Kingman (July 14, 2021):¹⁴ *"If I look back on many years of involvement in political decision-making and policy-making around science, innovation and R&D, I am struck by how much of it tends to turn on gut feel of the individuals involved, than on hard evidence and analysis. This is of course ironic, since good science is all about testing hypotheses against data, empirical results and facts."*¹⁵

After a slow start, an increasing number of increasingly rigorous empirical studies have appeared, shedding light on the effects of competitive research funding on well-measured outcomes, such as the number and quality of publications. By design, the best of these studies use (quasi-)random allocation of research funding, often comparing the research of those that just received funding to those that were just below the cutoff and were not awarded funding. One can only hope that this literature continues to develop and provide more insights.

However, a risk is built into this literature based on rigorous approaches aimed at estimating the causal impact of competitive funding. The risk is that the results are interpreted without the right context. Should one, as an example, conclude from studies showing that NIH (Lefgren and Lefgren (2011)) and ERC (Ghirelli et al. (2023)) funding have (almost) no causal impact on either the quantity or quality of research, that the mentioned institutions should be closed down as a waste of tax-payers money? The

¹⁴Speech on July 14, 2021.

¹⁵As pointed out by Schweiger et al. (2024), this observation was made already more than 100 years ago (Cattell and Cattell (1910)).

answer is not a straight-forward "yes", as one has to think of the larger impact that funding institutions have on science. Maybe the main effect of these funding schemes is that scientist invest in their research and human capital in order to have a chance of obtaining funding from these organizations? Or maybe the main effect is that the knowledge that funding for talented, industrious, driven (and lucky) researchers is available also in the future to do research on whatever seems the most important question at that given point in time inspires young individuals to embark on a science career in the first place? Before dismissing such effects, think through what the incentives to do research (and the possibilities to carry it out) and therefore also the incentives to choose a research career would be, if it were known for sure that further funding would not be forthcoming no matter how excellent peer evaluation suggests one's research proposal to be? The fact that establishing the existence let the alone the size of effects such as those proposed above is difficult or has not yet taken place does not mean one should deny their existence. The fact that researchers find themselves on somewhat thin ice in arguing that the most important effects of a given competitive funding scheme might be the ones that are impossible or very difficult to measure in practice does not mean they should resign themselves to accept only arguments for which answers are found under the proverbial lamp post.

5.2 How to Improve Possibilities for Research on the Effects of Competitive Funding

While I do think that even a large body of results from well conducted (quasi-)experimental studies on the effects of competitive funding are not alone a sufficient basis for forming policy on the need or size of such funding, one should not give up on efforts to improve our ability to conduct such research. Improvements on that front will likely lead also to improvements in our ability to tackle the indirect effects of science funding. To take on the challenge of Kingman, researchers and funding institutions need to work more closely together than what has been the case in the past. A few suggestions, well implemented, would go a long way:

1. The advice researchers routinely give to policy-making bodies, namely to plan in advance how a future policy can be evaluated and to build the necessary features into the policy already at the planning stage, is fit for purpose also for funding institutions.
2. Evaluations should not be ad hoc, but systematic and take place periodically for funding schemes that are permanent (=exist for an extended period of time).
3. Research institutions should invest in data collection that would facilitate ex-post evaluation. Such data collection would include eliciting permission from **all applicants** to use their:
 - (a) application data in future evaluations;
 - (b) auxiliary data on applicants on and above the application data; and
 - (c) data that enable researchers to track the applicants' research output and career outcomes (e.g. ORCID and/or national IDs)
4. Randomization at the acceptance threshold (extensive margin).

5. Randomization at the intensive margin of the amount of funding.
6. Randomization of committee compositions.

Competitive science funding usually entails that several projects are awarded funding in a given application round. I venture that no evaluation process used in science funding is so precise as to not leave some noise that affects the ranking and thereby the funding decisions. In other words, there is the distinct possibility that a project ranked n^{th} in an application process is actually worse than the project ranked $n + 1st$. If that is the case, then no harm is done if the last m projects that are granted funding are randomized among the m projects initially ranked as the last ones to receive funding, and the m projects ranked to be the first (=best) ones not to receive the funding. This type of randomization would allow identification of the effects of funding at the extensive margin, i.e., which projects are and are not granted funding.

With randomization at the intensive margin I propose to rely on the fact that the expenses of multi-year scientific projects are rarely known in advance very accurately. Any proposed project budget therefore contains room for error. As long as the rules of the funding organization do not directly stipulate that the winning projects all get some pre-specified, constant, amount of funding, there should thus be room to randomize the budget of a given project by $\pm x\%$. Randomization at the margin would thus not randomize which projects get funded, but how much a given project obtains funding.

A social planner would be interested in the causal effects of funding at both the extensive and at the intensive margin. While randomization at the extensive margin is being both discussed (e.g. Philipps (2021); Nature (2022)), argued for on moral grounds (Sandel (2020)) and implemented (e.g. Bendiscioli et al. (2021), chapter 3), I have not seen a systematic discussion or use of randomization at the intensive margin.

Randomization of the committee composition is a part of the institutional setting in some countries such as Italy and Spain (e.g. Bagues et al. (2017)), but could be more widely used. Its uses are different than those of randomization of funding at either the extensive or intensive margin: Randomization of committee composition would allow insights into how the committee composition affects who gets funding and would thereby help the social planner to avoid sources of bias. Obviously, this may have ripple-on effects on the effects of funding on outcomes.

Finally, it is paramount to emphasize that the choice is not between randomized controlled trials and no causal analysis. Economists and social scientists more generally have the ability to utilize other sources of exogenous variation. The papers (Ghirelli et al. (2023); Lefgren and Lefgren (2011)) mentioned earlier in this section are examples of such approaches, making use of the variation caused by the funding organization ranking the applications and only funding them up to a budget-dependent threshold.

6 Discussion

My main point in this chapter is that while the traditional economic arguments (scientific ideas being a central source of growth in income and wellbeing, knowledge being non-rival, research being uncertain

and producing large knowledge spillovers) for using public funds for science apply at the global level, they have less bite at the level of national governments although these are the prime source of public funds for science. This observation does not lead to the conclusion that public funding should not be used, but to the conclusion that the main motivation comes from the (selfish) interest of being able to benefit from the scientific discoveries made somewhere else - "elsewhere" being the often likeliest source of discoveries for even the largest and most research-intensive nations. To have such ability is to have *absorptive capacity*, but neither any individual nor any country can possess and maintain absorptive capacity without investments in scientific skills, i.e., without engaging in research aimed to produce frontier knowledge. To understand frontier science necessitates that one at least attempts to produce frontier science. The main motivation for using national public funds for science is therefore not the ability for local scientists to produce breakthroughs, but their ability to identify when somebody else's research results amount to a breakthrough, and the passing-on of this knowledge to their students.

Base funding that is relatively stable and long-term is a complement to more short-term competitive funding. Base funding is needed because of the slow production process of new knowledge that necessitates stable institutional arrangements; it is a complement not only to competitive funding, but to the other institutional arrangements that lead to the right selection into research and incentives to do research once that career has been chosen. Competitive funding brings the needed flexibility to react to new information regarding both which researchers have the best ideas as well as to new information on the societal needs for new knowledge.

The above arguments in no way nullify the arguments based on the intrinsic value of knowledge made to justify the use of public funds for research, nor do they fall by the argument that, "surely", some research cannot possibly have any direct (economic) benefits to humanity or by the argument that a lot of the material taught at universities is not based on frontier science, but on a well-established body of knowledge. I do agree that knowledge has also intrinsic value; this only strengthens the case for the use of public funding. While it is indeed true that it is hard to imagine how some research would ever convey any economic benefit, it is also true that our ignorance in this respect is still monumental and calls for caution in building policy too much on this argument. For want of a better selection device, we should continue relying on scientific curiosity, peer review and research incentives to guide the choice of research topics, with a dose of government guidance built in. And yes, a lot of the material we teach is "established" knowledge, but it is also true that "established" knowledge every once in a while gets unestablished, and universities that are at the forefront of their fields are the quickest to channel the new knowledge into also undergraduate teaching. But of course this is not to deny the fact that we have excellent examples of higher education institutions that specialize in teaching and do it very well.

While the scientific endeavor likely benefits from having different types of institutions, each with their different roles, the tight link between teaching and research that only universities possess on a large scale makes them an important institution in ensuring that new knowledge and the ability to use it are passed to those (young) people who eventually get employed in a various walks of life.

Any individual contribution on the science of science has its limitations, and certainly a short one like this. Many questions are waiting further analyses. A key observation made while writing this chapter is

that the theoretical literature on science funding still offers plenty of opportunities for economists to make further contributions. Such contributions would naturally provide the basis for empirical analyses. In addition, several other topics are in need of further enquiry: First, incentive effects of base and competitive funding for researchers at different stages of their career.¹⁶ Second, an unfortunately timely topic is the political economy of research funding both within nations and internationally ("resilience"). Third, the interaction between base and competitive funding in general should be better understood, both theoretically and empirically. Fourth, the question of whether and how to allocate scarce resources to particular fields and towards particular applications ("strategic sectors"). Fifth, as is surely clear from this contribution, there is a need for theoretical and empirical work on the role of (government) research institutes in the scientific endeavor. Many important questions in science of science are waiting for somebody to take on the challenge.

¹⁶Checchi et al. (2021) provide an interesting analysis of the role of career concerns in Italian academia.

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