

Amegashie, J. Atsu

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Useless Knowledge: Directed vrs Non-Directed Research

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Useless Knowledge: Directed vrs Non-Directed Research

J. Atsu Amegashie*

University of Guelph**, CDD (Ghana), and CESifo (Germany)

December 1, 2025

Abstract

Much of academic research has been criticized for not being socially useful. Governments sometimes only fund research on particular social issues (e.g., vaccines, renewable energy, electric vehicles). In other cases, they fund research on topics that are independently chosen by scholars. I consider a model in which the value of current research depends on random states in the future. Scientists and a government are uncertain about the future state and thus the future value of current research. The government and scientists get independent and imperfect but informative signals about the *future* value of research. The government can direct the research of scientists or give them the freedom to choose their research projects (i.e., non-directed research). Even if *the government maximizes the social welfare of directed research, scientists do not have better information, and scientists do not maximize the social welfare of their (non-directed) research projects*, I show that *non-directed* research results in a bigger social welfare than *directed* research. If the accuracy of the signal of the social value of research is high or the two future states are sufficiently different, non-directed research gives a higher social welfare than directed research.

Keywords: directed research, non-directed research, scientists, signals, social value.

JEL Classification: H52, I23.

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**Department of Economics, University of Guelph, Guelph, Ontario, Canada N1G 2W1. E-mail: jamegash@uoguelph.ca; phone: 519-824-4120, ext. 58945; fax: 519-763-8497.

"... electrical science, ... is of such recent growth that nobody can pretend to forget how it owes its origin to those who studied it while useless. If Universities do not study useless subjects, who will? Once a subject becomes useful, it may very well be left to schools and technical colleges, to patent-mongers, and the trade." --- Geo. Fras. Fitzgerald, Nature, page 392, 1892.

1. Introduction

Universities need lots of resources to conduct research (basic research). In the USA, the two major research funding agencies of universities are government agencies, the National Institutes of Health (NIH) and the National Science Foundation (NSF). In 2024, the budget for the NIH was \$47.5 billion; it was \$9.06 billion for the NSF.¹ In some cases, agencies that fund research ask researchers to submit ideas in specific areas. For example, the annual EIT awards by the European Institute of Innovation and Technology are for "... innovations that most effectively address societal challenges in climate change, digitalisation, renewable energy, health, raw materials, food, smart manufacturing, and urban mobility."²

How do researchers generate knowledge that has social and scientific impact (D'Este et al, 2018). For more than a hundred years, many people have claimed that most of the research in academia is not socially useful (see Collier, 2016; Dehn, 1932; Fitzgerald, 1892; Flexner, 1939; Modell, 1964; Schwarcz, 2025). To be socially useful, should research have immediate social impact, be useful to policymakers, or have industrial

¹<https://report.nih.gov/nihdatabook/report/5>; <https://www.nsf.gov/about/budget>

²<https://www.eit.europa.eu/activities/eit-awards-our-prime-innovation-competition>

applications? According to Schwarcz (2025), "There are way too many publications these days that should never see the light of day." As the quote above by Fitzgerald (1892) shows, this sentiment is not new. Almost a hundred years ago, Dehn (1932), opined that:

"... only creative chemistry, that is, chemistry that contributes to the betterment of industry and civilization is worthwhile ... As long as money available for research is limited, and it will always be less than is desired, it seems that administrative officers of universities would insist that such money be spent for products which are worthwhile."

There is, of course, a contrary view. In a 1939 article titled "The usefulness of useless knowledge", Abraham Flexner --- the founding director of the Institute for Advanced Study in Princeton --- echoed the quote above by Fitzgerald (1892) by making the case that society can achieve deep knowledge and make practical progress only by valuing and funding the curiosity-driven pursuit of knowledge in both the sciences and the humanities. He criticized governments and universities that force research into narrow practical channels, arguing that the greatest contributions to human progress arise, not from targeted research aimed at immediate utility, but from exploration that is driven purely by curiosity, the pursuit of "useless" knowledge (Flexner, 1939; Flexner, 2017).

In academia, the impact of research is usually determined by the number of citations (Amegashie, 2020; Ellison, 2013). However, citations capture the academic or scientific impact of research (i.e., the impact within the narrow confines of the academic community). Scientific impact does not necessarily imply social impact (D'Etse et al., 2018). There is also the related point that most research is inaccessible because they are

published behind expensive paywalls and therefore are not open access or cannot be read by members of the public who are trained in the subject matter.

Arora et al. (2020) observed that:

“Knowledge produced by universities is not often in a form that can be readily digested and turned into new goods and services ... whereas the division of innovative labor may have raised the volume of science by universities, it has also slowed, at least for a period of time, the transformation of that knowledge into novel products and processes.”

Corporations like Microsoft, Apple, IBM, Toyota, Johnson & Johnson, etc use their own funds to engage in R&D. Angel investors and venture capitalists also help start-ups in the innovative process. Arora et al. (2020) recognized the importance of research by big corporations by noting that small firms and university technology transfer offices cannot fully substitute for corporate research. However, basic research, usually done in universities, and more applied research in big corporations are complements (e.g., Jaffe, 1989; Mansfield, 1991; Nelson, 1986).

This paper is about research funding by public agencies (governments).³ Should governments determine or direct the kind of research that universities should focus on? Through its research funds, should it only support some type of research like research that is intended to address pressing social issues (e.g., vaccines, climate change, renewable energy, and artificial intelligence)? Or should it allow scientists to engage in research that does not have an immediate social value or have the freedom to choose their research projects (i.e., non-directed research)?

³For discussion of a broad range of issues, see, for example, Senior et al. (2025), and Aagaard et al. (2021).

The traditional justification for government funding of academic research is that knowledge spillovers and the inability to appropriate the economic value of *basic* research imply that such research projects will not be undertaken by profit-maximizing private-sector firms or that there will be underinvestment by the private sector in basic research (Arrow, 1962; Nelson, 1959).

Stern (2004) found that wages were substantially lower in jobs that promised scientists some freedom to pursue their own individual research projects, an indication that academics value the freedom of non-directed research.⁴ Consistent with this finding, Aghion et al. (2008) argued that, relative to working in the non-academic sector, academics are willing to accept a lower salary in return for academic freedom. Thus, basic or early-stage research, which tends to be risky and thus has a low expected commercial or social value, should be conducted in universities because it is cheaper to employ academics while granting them some freedom to pursue other academic interests.⁵ Aghion et al. (2008) concluded that, when an idea is farther away from a commercial payoff (i.e., early-stage/basic research), it is optimal for research on it to take place in universities.

I consider a model in which the future value of current research depends on two random states in the future. Both scientists and a government are uncertain about the future state and thus the future value of current research. The government and scientists get independent and imperfect but informative signals about the *future* value of research.

⁴Also, see Agarwal and Ohyama (2012) and Roach and Sauermann (2010).

⁵Even without academic freedom, one can imagine that some academics with a public-service mindset may be willing to work in *public* universities for lower salaries (e.g., Francois, 2000).

The government can choose to direct the research of scientists (i.e., directed research) or give them the freedom to choose their research projects (i.e., non-directed research).

In my model, academic freedom (non-directed research) comes with trade-offs: the *multiplicity* of the scientists' *independent* signals, relative to the government's *limited* signals, as a guide to choice of research projects by scientists reduces the variance of the sum of the social value of research. The disadvantage of non-directed research is that a scientist does *not* choose his time allocation among research projects to maximize the social value of research. This captures the tendency of academics to engage in some apparently useless research.

Even if the government maximizes the expected social welfare of *directed* research, scientists do not have better information, and scientists do not maximize the expected social welfare of their (*non-directed*) research projects, I show that directed research may give a higher social welfare than non-directed research. This is because, by directing the research of scientists, a government --- *relative to the multiplicity of the scientists' independent signals* --- creates a herd-like behavior among scientists which results in a bigger welfare-reducing variance of the social value of *directed* research relative to *non-directed* research, and this variance of directed research is increasing at an increasing rate in the number of scientists. If the accuracy of the signal of the social value of research is high, non-directed research gives a higher social welfare than directed research. Non-directed research gives a higher social welfare if the two future states are sufficiently different.

Thus, my justification for academic freedom is not based on the spillovers of knowledge, the inability to appropriate the economic value of research benefits, or the lower cost of employing academics. However, I note that the spillovers of basic research (or research, in general) is a justification for government funding of basic research, not a justification for academic freedom. The arguments of the low expected commercial value of basic research by Aghion et al., (2008) and the inability to appropriate the economic value of basic research are related but different justifications for academic freedom.

Aghion et al. (2008) conjectured that, given the non-profit nature of academia, academic administrators give their scientists the freedom to pursue their research because, relative to managers of profit-maximizing firms, academic administrators have much lower incentives to invest in resources to monitor and direct scientists. Even if academic administrators (the government in my model) can or have strong incentives to direct the research of scientists, my point is that it may not be socially optimal to do so. Aghion et al. (2008) focused on the allocation of research efforts between academic and non-academic sectors. I focus on the allocation of the power to choose research projects between academic and non-academic sectors (the government).

It is important to note that there are two types of uncertainties about research. In one case, research projects are intended to solve *known or existing* problems. The uncertainty is about whether research methods or strategies will provide a good solution to the *known* problems. This is the uncertainty in Aghion et al. (2008). Another type of uncertainty is whether current research projects or ideas, even if well executed, will be useful in the future, given that the problems of the future cannot be predicted with

certainty. This is the uncertainty I consider in this paper. Of course, both types of uncertainties can be present at the same time. The frustration with apparently useless research stems from a perception that most research projects are not intended to solve any current or future problems. Basic research seems to be the quintessential example.⁶

In the next section, I introduce and solve a model in which a government can choose between directed research and non-directed research. I discuss the results. The results are further discussed in section 3. Section 4 concludes the paper.

2. A model of directed and non-directed research

Consider a model with $N \geq 2$ research scientists who each have 1 unit of time to devote to research. There are *future* states of world, $\omega \in \mathbf{R}$. Suppose there are two equally likely future states of the world, β and θ . Each future state requires an appropriate type of *current* research to make the research valuable. For example, if the future state (e.g., ten years from now) is a virus-induced epidemic, then *current* research in virology and the development of vaccines is appropriate. The future state may be bioterrorism, high levels of water or air pollution, significant depletion of a non-renewable resource, an energy (e.g., oil) crisis, opium crisis, youth drug addiction, high levels of crime, climate change, etc.⁷

⁶Gans (2025) considered the regulation of technological innovation when there is uncertainty about potential harms (e.g., pollution from petrol-powered or gasoline-powered cars; the dangers and disruption of generative artificial intelligence; the harmful effects of nuclear energy, etc). Acemoglu and Lensman (2024) and Jones (2024) also focussed on potentially harmful technologies. These papers are not about academic freedom.

⁷Of course, there could be more than one potential social problem. Thus, the solution to the problems of a given state may require different research projects. I do not consider this scenario. Martin and Pindyck (2015) consider the problem of the optimal allocation resources to avert future catastrophes (e.g., bioterrorism, mega-viruses, climate change).

Aghion et al. (2008) assume that the probability of successfully improving on a research project is increasing in the number of scientists that work on the project.⁸ I assume that the social value of a research project is increasing in the number of scientists that work on the project and the time they devote to it. More time spent on a research project is likely to increase the quality of the final output.

If the state is θ and a scientist uses α of his time on θ -appropriate research and $1 - \alpha$ on β -appropriate research, the social value is $\frac{f(\alpha)}{(|\theta - \theta| + 1)^2} + \frac{f(1-\alpha)}{(|\theta - \beta| + 1)^2}$, where $\alpha \in [0,1]$, $\theta \neq \beta$, $f(\alpha)$ is an increasing function, and $f(0) = 0$. Note that $\frac{f(\alpha)}{(|\theta - \theta| + 1)^2} > \frac{f(\alpha)}{(|\theta - \beta| + 1)^2}$, if $\alpha \in (0,1]$. Note also that the value of β -appropriate research in state θ is not zero.⁹ But it is smaller than the value of θ -appropriate research. This assumption is not crucial. Similarly, if the state is β and a scientist uses α of his time on β -appropriate research and $1 - \alpha$ on θ -appropriate research, the social value is $\frac{f(\alpha)}{(|\beta - \beta| + 1)^2} + \frac{f(1-\alpha)}{(|\theta - \beta| + 1)^2}$.

To capture the uncertainty about the impact of research, suppose the government and *each* scientist receive independent signals, s_j , of the state, where $j \in \{\beta, \theta\}$. With probability, q , the signal is the true state. Otherwise, the signal is wrong. That is, $prob(s_\theta|\theta) = prob(s_\beta|\beta) = q$ and $prob(s_\beta|\theta) = prob(s_\theta|\beta) = 1 - q$. The signals are

⁸This is the case in the version of their model that assumes that scientists working on a project have independent draws from the same success/failure distribution.

⁹This is similar to the assumption in Aghion et al. (2008) that a research strategy that does not advance the *current* line of research may yield insights that may ultimately generate fundamental breakthroughs in new areas. Also, Baccara et al (2025) note that given the uncertainty about the kind of virus that will be the source of the next pandemic, it may be optimal to conduct parallel research agendas on vaccines against multiple potential viruses.

informative but not perfect. In particular, $0.5 < q < 1$. The government and scientists do not observe each other's signals.

The government has enough money to support all research. Therefore, as in Aghion et al. (2008), there is no research contest. Without research support from the government, a scientist cannot conduct research. Thus, I ignore other sources of funding (i.e., from foundations, corporations, alumni, etc).¹⁰ The government can direct a scientist to engage in a particular type of research by making its financial support conditional on that type of research or give the scientist the freedom to engage in whatever research he wants. Thus, the government can direct a scientist to devote all his time to only one j -appropriate research or to devote α to one research project and $(1 - \alpha)$ to the other research project, where $j \in \{\beta, \theta\}$. For example, the government can implement this allocation of time by disbursing research funds according to the relative times that it wants the scientists to spend on each project and then tracking things like the dollars spent on lab materials, graduate students, lab assistants, etc for each project.¹¹

I assume that the social welfare function is given by the following mean-variance preferences:

$$W(\mu, \sigma^2) = \mu - \lambda \sigma^2, \tag{1}$$

¹⁰Governments have historically been the main financiers of basic research. The private sector rarely invests in such research because "... the timescale for returns is too long and the ability of the funder to capture those returns too uncertain." (Marshall, 2025). This is also consistent with the analysis in Aghion et al. (2008). However, this may not be the case in every country. For example, according to Akcigit et al. (2020), almost 15% of total basic research in France is undertaken by the private sector.

¹¹In a public university, the government could make promotions conditional on the research projects of scientists. This is not considered in this paper.

where μ is the expected social value of research, σ^2 is the variance of the social value of research, and λ is a risk-aversion parameter.¹² In appendix A, I argue that using mean-variance type preferences is necessary. In what follows, I provide additional justification.

If $\lambda = 0$ (i.e., risk-neutrality), then social welfare is equal to the expected social value (in a monetary unit) of research. Otherwise, they are different. I focus on $\lambda > 0$, which implies that, all things being equal, a smaller variance of the social value of research is desirable. The *large* macroeconomics literature on business cycles is evidence of the fact that volatilities in variables like output, consumption, investment, and employment are not desirable (e.g., Berger et al., 2020; Bloom, 2009; Busch et al., 2022). Social planners also consider the expected social values of risky socioeconomic outcomes and their associated social risks, which is measured as the variance of expected social values (e.g., Rohde and Rohde, 2015).¹³ Bloom (2009, p. 624) observed that “uncertainty is ... a ubiquitous concern of policymakers”. In energy policy, the risks associated with current and future costs of different energy technologies (e.g., coal, wind, nuclear, solar, hydro, etc) are important in assessing the reliability of the energy mix. Policymakers take account of the expected average costs and variances of the costs of the different energy technologies in the mix (e.g., Costa et al., 2017; Roques et al., 2008). The average person tends to be risk-averse and so dislikes bigger fluctuations in socioeconomic outcomes (e.g., Hintze et al., 2015; Zhang et al., 2014; Epstein and Zin, 1991).

¹²For a discussion and analysis of the connection between mean-variance preferences and expected utility theory, see, for example, Levy and Markowitz (1979), Markowitz (2014), and Meyer (1987).

¹³Rohde and Rohde (2015) refer to this as the *collective expected value* and *collective risk* (social variance) of ex ante allocations.

2.1 Analysis

To simplify the analysis, but without loss of generality, suppose $f(\alpha) = \alpha^{1/2}$ and $|\theta - \beta| = 1$.

2.1.1 Expected value of social research: directed vrs non-directed

Non-directed research: In the case of non-directed research, the government gives each scientist the freedom to choose the research project to work on. This is akin to how most research grants are awarded where scientists independently come up with their own research ideas which are funded by the government.¹⁴

I assume that if the government has a policy of non-directed research, it does not get a signal about the future state because it is pointless to get a signal about the state if it will not use the signal to direct the research of the scientists. Alternatively, we may assume that the government ignores its signal. But the government knows that the probability that each scientist's signal is accurate is q and observes the research projects of scientists.

Expressing a sentiment akin to the notion of “useless knowledge” discussed in section 1, Aghion et al. (2008, p. 618) observed that “The disadvantage of academia ... is that they may end up working on projects that they find interesting, or prestige enhancing, but that have little immediate economic value.” To capture this sentiment that most academics are in ivory towers and engage in research that does not apparently have social value, suppose that a professor's research, regardless of its social value or impact, will be

¹⁴Academic freedom in this paper refers to the freedom to choose research topics to work on. In Aghion et al. (2008), academic freedom refers to the freedom to choose research tools, methods, or techniques (i.e., what they call a *research strategy*). Scientists do not choose research ideas in their model.

highly cited by his peers so long as it is scientifically elegant. Thus, given the freedom, I assume that a scientist does *not* choose α to maximize the social value of his research projects. In particular, he does not consider the likelihood that his signal may be wrong, so he devotes *all his time* to the research project suggested by his signal.¹⁵

Suppose the future state is θ . Suppose r scientists get a signal of θ while $(N - r)$ scientists get a signal of β (i.e., the wrong state). Given that each scientist follows his signal, a scientist who got the θ signal will spend all his time on θ -appropriate research and a scientist who got the β signal will spend all his time on β -appropriate research. The probability of this event is $\frac{N!}{r!(N-r)!} q^r (1 - q)^{N-r}$, and it generates a social value of $r + 0.25(N - r)$ because each scientist follows his signal. So, if the future state is θ , the expected social value of *non-directed* research is $\sum_{r=0}^N \frac{N!}{r!(N-r)!} q^r (1 - q)^{N-r} (r + 0.25(N - r))$. If the future state is β , the same reasoning holds because the problem is symmetric. Therefore, regardless of the future state, the expected social value of non-directed research (*from the standpoint of the government*) is:

$$\mu_n = \sum_{r=0}^N \frac{N!}{r!(N-r)!} q^r (1 - q)^{N-r} (r + 0.25(N - r)). \quad (2)$$

Equation (1) simplifies to:¹⁶

$$\mu_n = (0.75q + 0.25)N. \quad (3)$$

¹⁵If a scientist can work on only one research project, then given $q > 0.5$, it is socially optimal for each scientist to follow his signal.

¹⁶To see this, note that $\sum_{r=0}^N \frac{N!}{r!(N-r)!} q^r (1 - q)^{N-r} (r + 0.25(N - r)) = 0.25N \sum_{r=0}^N \frac{N!}{r!(N-r)!} q^r (1 - q)^{N-r} + 0.75 \sum_{r=0}^N r \frac{N!}{r!(N-r)!} q^r (1 - q)^{N-r}$. Then, using known results of a binomial distribution, we get equation (3).

Directed research: Suppose the government's signal is that the future state is θ . If the government directs each scientist to devote α of his time to θ -appropriate research and $1 - \alpha$ to β -appropriate research, then the expected social value of directed research (*from the standpoint of the government*) is:

$$\mu_d(\alpha, \theta) = \left[q \left(\alpha^{1/2} + \frac{(1-\alpha)^{1/2}}{4} \right) + (1-q) \left(\frac{\alpha^{1/2}}{4} + (1-\alpha)^{1/2} \right) \right] N. \quad (4)$$

Note that $\mu_d(\alpha, \theta)$ is strictly concave in α , has a unique maximizer at $\alpha = \frac{(3q+1)^2}{18^2 - 18 + 17} \equiv \hat{\alpha}$, and given $q > 0.5$, $\hat{\alpha} \in (0.5, 1)$. So, $\mu_d(\alpha, \theta)$ is monotonically decreasing on the domain $\alpha \in [\hat{\alpha}, 1]$, and thus -- on this domain -- attains its *minimum* value, which is $(0.75q + 0.25)N$, at $\alpha = 1$. Therefore, if the government maximizes the expected social value of directed research, then $\mu_d(\alpha, \theta) > \mu_n = (0.75q + 0.25)N$. By symmetry, $\mu_d(\alpha, \theta) = \mu_d(\alpha, \beta) = \mu_d(\alpha)$. No matter the state, the expected social value of directed research is the same.

I summarize the analysis in the following proposition:

Proposition 1: *Suppose the government maximizes the expected social value of directed research. Then the expected social value of directed research is higher than the expected social value of non-directed research.*

Proposition 1 is driven by the assumption that, given its signal, the government, under directed research, chooses α to maximize the expected social value of research while the scientists, under non-directed research, do not maximize the expected social value of their research. However, if scientists are better informed than the government

about the expected social value of research, then proposition 1 may not hold even if the scientists do not maximize the social value of their research. I shall return to this point.

2.1.1 The variance of the value of social research: directed vrs non-directed

Non-directed research: The social value of research by *each* scientist in each state is a random variable whose value is 1 with probability q and 0.25 with probability $1 - q$. These random variables are *independently* distributed across the N scientists. Therefore, the variance of the sum of the social value of *non-directed* research is:¹⁷

$$\sigma_n^2 \equiv Var_n = 0.5625q(1 - q)N. \quad (5)$$

Directed research: Recall that the government instructs each scientist to allocate his research time in the same way (i.e., choose the same α), regardless of each scientist's signal. This has the same effect as the scientists receiving a common (perfectly correlated) signal.

Denote the social value of the directed research of each scientist by x_i , $i = 1, 2, \dots, N$. The variance of the sum of social value of the research of each scientist is $Var(\sum_{i=1}^N x_i) = Var(Nx) = N^2 Var(x)$, where $x_i = x$ for all i because the social values of the scientists' directed research are perfectly correlated, $i = 1, 2, \dots, N$.

Suppose the government's signal of the future state is θ . Then, under directed research, the social value of *each* scientist's research is a random variable whose value is

¹⁷For each scientist, denote the social value of his research by $z = 0.25 + 0.75Y$, where Y is a Bernoulli random variable that is 1 with probability q and 0 with probability $1 - q$. Then $Var(z) = (0.75)^2 Var(Y) = (0.75)^2 q(1 - q)$, where we made use of the known result for the variance of a Bernoulli random variable. Then, for N independent Bernoulli random variables, the variance is the expression in (5).

$\alpha^{1/2} + \frac{(1-\alpha)^{1/2}}{4}$ with probability q , and $\frac{\alpha^{1/2}}{4} + (1-\alpha)^{1/2}$ with probability $1-q$. Then we can write,

$$x = \left(\alpha^{1/2} + \frac{(1-\alpha)^{1/2}}{4} \right) Y + \left(\frac{\alpha^{1/2}}{4} + (1-\alpha)^{1/2} \right) (1-Y), \quad (6)$$

where Y is a Bernoulli random variable that is 1 with probability q and 0 with probability $1-q$. Then,

$$\text{Var}(x) = \left(\alpha^{1/2} + \frac{(1-\alpha)^{1/2}}{4} - \left(\frac{\alpha^{1/2}}{4} + (1-\alpha)^{1/2} \right) \right)^2 \text{Var}(Y) \quad (7)$$

$$= q(1-q)\Phi, \quad (8)$$

where $\Phi \equiv 0.5625(\alpha^{1/2} - (1-\alpha)^{1/2})^2$.

Then, noting that $\text{Var}(\sum_{i=1}^N x_i) = N^2 \text{Var}(x)$, the variance of the sum of the social value of *directed* research is:

$$\sigma_d^2 \equiv \text{Var}_d = q(1-q)\Phi N^2. \quad (9)$$

By symmetry, this is also the variance of the social value of directed research if the government's signal is β .

Given that $q > 0.5$, recall that if the government maximizes the expected social value of directed research, then it chooses $\alpha = \hat{\alpha} > 0.5$. It is easy to show that, on the domain $\alpha \in [0.5, 1]$, Φ is monotonically increasing in α from $\Phi = 0$ at $\alpha = 0.5$ to a maximum value of $\Phi = 0.5625$ at $\alpha = 1$. Then, given $0.5 < \hat{\alpha} < 1$, (9) implies that

$$0 < \text{Var}_d < 0.5625q(1-q)N^2. \quad (10)$$

Then, (5) and (10) imply that $\text{Var}_d > \text{Var}_n$, if N is sufficiently large. For example, if $q = 0.6$, then $\hat{\alpha} = 0.618$, $\text{Var}_d = 0.00383N^2$, and $\text{Var}_n = 0.135N$. Then $\text{Var}_d > \text{Var}_n$, if $N \geq 36$. For $q = 0.8$, we only require $N \geq 5$ for $\text{Var}_d > \text{Var}_n$. This gives the following proposition:

Proposition 2: *Suppose that (a) the number of scientists is large, and (b) the government maximizes the expected social value of directed research. Then, the variance of the social value of directed research is higher than the variance under non-directed research.*

Given that the government chooses $\hat{\alpha} \in (0,1)$, there is some research diversification under directed research. But proposition 2 implies that directed research is less diversified than non-directed research, if the number of scientists is large. The intuition for this proposition as follows: by directing scientists, a government can create a herd-like behavior among scientists where all scientists sub-optimally allocate their time between research projects because the government forces them to ignore their signals and directs each scientist to act in the same way (i.e., choose the same $\alpha = \hat{\alpha}$). Under non-directed research, each scientist chooses his research project based on his independent signal. Although each scientist follows his signal exactly by engaging in only one research project, their aggregate behavior is driven by N independent signals. In contrast, under directed research, the government's decision is based on only one signal.¹⁸ For example, as N gets large, the probability (i.e., q^N) that all the scientists will be in the same research field is close to zero. Thus, as N gets large, the variance of the social value of non-directed research is (relatively) much smaller than the variance of directed research, a result that has the flavor of the “wisdom of crowds” (e.g., Da and Huang, 2019; Hong and Scott, 2004; Palley and Soll, 2019; Surowiecki, 2005).¹⁹

¹⁸In general, what matters is that the government's decision is based on fewer signals than the signals of the scientists. Given that the number of scientists or researchers tends to be big, this is a reasonable assumption.

¹⁹However, the variance is not decreasing in N because there is no averaging of the signals of the scientists.

2.2 The government's choice: directed research vrs non-directed research

The trade-offs related to non-directed research were discussed in section 1.

Propositions 1 and 2 formalized these trade-offs. In this section, the government considers these trade-offs using the mean-variance social welfare function in (1).

Under non-directed research, social welfare is:

$$W(\mu_n, \sigma_n^2) = (0.75q + 0.25)N - 0.5625\lambda q(1 - q)N. \quad (11)$$

Under directed research, the government chooses α to maximize:

$$W(\mu_d, \sigma_d^2) = \left[q \left(\alpha^{1/2} + \frac{(1-\alpha)^{1/2}}{4} \right) + (1 - q) \left(\frac{\alpha^{1/2}}{4} + (1 - \alpha)^{1/2} \right) \right] N - \lambda q(1 - q)\Phi N^2, \quad (12)$$

where $\Phi \equiv 0.5625(\alpha^{1/2} - (1 - \alpha)^{1/2})^2$.

A closed-form solution of the α that maximizes $W(\mu_d, \sigma_d^2)$ is very difficult to find. But it is between 0.5 and $\hat{\alpha}$. To see this, recall that μ_d is strictly concave and is maximized at $\alpha = \frac{(3q+1)^2}{18^2 - 18 + 17} \equiv \hat{\alpha} > 0.5$. Also, σ_d^2 is minimized at $\alpha = 0.5$, where its value is zero. So, given that $W(\mu_d, \sigma_d^2)$ is increasing in μ_d but decreasing in σ_d^2 , the optimal value of $\alpha \in [0.5, \hat{\alpha}]$. I present some simulations in table 1.

Table 1: $N = 100$ and $\lambda = 2$.

q	α^*	$\hat{\alpha}$	$W(\mu_d, \sigma_d^2)$	$W(\mu_n, \sigma_n^2)$
0.55	0.50047	0.55978	88.38960	38.40625
0.60	0.50097	0.61829	88.39351	43.00000
0.70	0.50222	0.72693	88.41193	53.87500
0.80	0.50436	0.81869	88.45781	67.00000
0.90	0.51025	0.890117	88.60582	82.37500
0.94	0.51776	0.912892	88.80298	89.15500
0.95	0.52144	0.918086	88.90008	90.906250

Given that the variance of the social value of directed research -- a quadratic function of N -- is high, the government takes this penalty into account by choosing a value of α (i.e., α^*) that is very close to 0.5 (and thus farther away from $\hat{\alpha}$) to make the variance as close to zero as possible. Table 1 shows that the social welfare of directed research is higher than the social welfare of non-directed if the accuracy of the signal of the social value of research is not too high ($q < 0.94$). Otherwise, social welfare is higher under non-directed research.

When I vary N and λ such that $\lambda N = 200$ (as in Table 1), the cutoff value for q at which $W(\mu_n, \sigma_n^2) > W(\mu_d, \sigma_d^2)$ varies between 0.85 and 0.94. The point is not that there is a range of *specific* cut-off values. The cut-off values will vary depending on the functions and

numbers chosen for $f(\alpha)$, λ , $|\theta - \beta|$, $W(\mu, \sigma^2)$, etc. Therefore, in the following proposition, I state the results qualitatively, *not* quantitatively.

Proposition 3: *Suppose (a) the government maximizes social welfare by striking a balance between the expected social value of research and the variance of the social value of research, and (b) the scientists do not maximize the social welfare of their research. Then if the accuracy of the signal of the social value of research is low, directed research gives a higher social welfare than non-directed research. If the accuracy of the signal of the social value of research is high, then non-directed research gives a higher social welfare than directed research.*

To see the intuition behind proposition 3, note that $\hat{\alpha}$, the value of α that maximizes the expected social value of directed research (i.e., μ_d), is increasing in q . So, when N is large such that α^* -- the α which maximizes $W(\mu_d, \sigma_d^2)$ -- is close to 0.5, then μ_d gets smaller as q increases while μ_n gets bigger because the gap between α^* and $\hat{\alpha}$ gets bigger when q increases. Thus, $W(\mu_n, \sigma_n^2) > W(\mu_d, \sigma_d^2)$ if q is sufficiently large.

Note also that $\hat{\alpha}$, the value of α that maximizes the expected social value of directed research (i.e., μ_d), is increasing in $\Delta \equiv |\theta - \beta|$.²⁰ So, as in the preceding paragraph, if Δ is large, then α^* -- the α which maximizes $W(\mu_d, \sigma_d^2)$ -- will be farther from $\hat{\alpha}$. This results in a smaller value of μ_d . Thus, $W(\mu_n, \sigma_n^2) > W(\mu_d, \sigma_d^2)$ if Δ is sufficiently large. This gives the following proposition:

²⁰ To see this, let $\frac{1}{(|\theta - \beta| + 1)^2} = b$. Then $\hat{\alpha} = \frac{[q + b(1 - q)]^2}{[q + b(1 - q)]^2 + [(1 - q) + bq]^2}$. Then, given $q > 0.5$, $\text{sign } \frac{\partial \hat{\alpha}}{\partial b} = \text{sign } (1 - 2q) < 0$. Note that $|\theta - \beta|$ and b are inversely related.

Proposition 4: *Suppose (a) the government maximizes social welfare by striking a balance between the expected social value of research and the variance of the social value of research, and (b) the scientists do not maximize the social value of their research. Then, non-directed research gives a higher social welfare if the two future states are sufficiently different.*

If the government only maximizes the expected social value of research (i.e., ignores its variance), then it is easy to see that for a very large N , $W(\mu_n, \sigma_n^2) > W(\mu_d, \sigma_d^2)$ because the variance of directed research gets very large. This gives the following proposition.

Proposition 5: *Suppose (a) the number of scientists is large, and (b) the government only maximizes the expected social value of research (i.e., ignores its variance). Then non-directed research gives a higher social welfare than directed research.*

3. Discussion

The assumption that scientists do not allocate their time between the two research projects to maximize the social value of their research projects was intended to stack the odds against academic freedom. Yet, propositions 2, 3, 4, and 5 imply that there is a good case for non-directed research. The key is that, relative to scientists, the government has a narrow view of useful research. In a model in which scientists can *specialize* in one of two research fields, Baccara et al., (2025, p. 23) made the apt observation that:

“... when we think of the society at large, an additional critical aspect of welfare is that of research diversity, or its breadth. Researchers may not necessarily internalize the social value of developing a diverse portfolio of research methodologies, each of which could be

useful to face a future social crisis, such as environmental issues, or a potential viral pandemic. In other words, society might want to hedge optimally through different research fields.”

Thus, Baccara et al., (2025) argued that a smaller variance of the social value of research is desirable. In this paper, I have shown that, relative to government directed research, independent scientists may generate a lower variance of the social value of research. As stated in proposition 4, when the expected social problems are very different in nature, non-directed research gives a higher social welfare than directed research.

As extension of the model, suppose there are $M \geq 2$ unknown and possible future states and a subset of these states will simultaneously occur in the future. We could have a model in which some scientists engage in research that covers some states while other scientists cover other states but at least one scientist covers each of the M states or there is a non-zero probability that the M states are all covered. In contrast, a government will direct the scientists to engage in research that covers only M_g number of *specific* states, where $0 < M_g < M$. The government bans research that it considers to be useless because the future problem that the research is intended to solve is unlikely to occur in the future. Given the intuitive explanations of the propositions in this paper, it should be obvious that the core results generalize because government-directed research concentrates effort on a subset of states, creating correlated payoffs, whereas independent researchers distribute effort more broadly across research projects.

Even if a society is risk neutral (i.e., $\lambda = 0$), the assumption that the government is a benevolent social planner who maximizes the expected social value of the research of the

scientists may not hold. As noted by Senior et al. (2025), governments may be politically motivated to direct research to create an evidence base that justifies their policies rather than to maximize social value. Thus, non-directed research may give a higher expected social value than directed research.

Herein lies the crux of the matter. Bemoaning useless knowledge or useless research implicitly assumes that the person doing so can identify useful research or is committed to useful research. This need not be the case. If each scientist chooses his research time allocation to maximize the expected social value of his research, then non-directed research gives the same expected social value as directed research, but non-directed research has a smaller variance.²¹ Proposition 1 will not hold.

Consistent with Aghion et al. (2008) and Stern (2004), academics may be more motivated to execute a research project if they chose the project relative to the case in which bureaucrats directed their research. This can easily be incorporated into my model by introducing different costs of doing research depending on whether the research is directed or non-directed. This strengthens the case for non-directed research.

The assumption of independent signals among the scientists may not hold. There are leaders and followers in academia. The leaders have control over what is published in the top journals and so determine the kind of research that is professionally valuable.²² They also sit on departmental committees and determine whether junior colleagues

²¹If the government, like the scientists, also sub-optimally chose $\alpha = 1$, then $Var_d = 0.5625q(1 - q)N^2 > Var_n = 0.5625q(1 - q)N$ for all $N \geq 2$.

²²In economics, Heckman and Moktan (2020) argue that the obsession to publish in elite journals encourages careerism at the expense of creativity. They refer to this obsession as the “the tyranny of the top five”.

should be promoted or granted tenure based on their research. Junior scientists and graduate students listen to these leaders and take their advice (follow their signals) on research topics.²³ Thus, many academics may not act on their independent signals or signals about research projects may not be independently distributed among academics.

As in models of informational cascades, pioneered by Banerjee (1992) and Bikhchandani et al. (1992), many scientists discard their signals and follow leading scientists after observing the research choices of these top scientists and what gets published in the leading journals in their fields. This may result in a socially inefficient herd behavior (a cascade) as shown in Banerjee (1992) and Bikhchandani et al. (1992).^{24,25} This weakens the case for non-directed research.

Mindful of how some apparently useless research revolutionized the world more than two hundred years later (e.g., applications of arcane results in number theory and topology to cancer treatment, modern internet security, online commerce, mobile phones, etc), it is important for governments to find a good balance between curiosity-driven or basic research and applied research. A few revolutionary gems have emerged from

²³This also implies that the assumption that all the scientists are identical does not hold. Non-identical scientists can be incorporated in the model by using a different $f(\alpha)$ function for different scientists.

²⁴For a review of this literature, see Bikhchandani et al. (1998). In the context of academia, Baccara et al. (2025) study a model in which scientists, motivated by careerism, choose fields of research specialization. In their model, output in a research field conveys information about a field's viability to scientists who are yet to join that field and information about a research field's viability increases in the total mass of researchers in that field. In one equilibrium, *all* scientists join a *bandwagon* by doing research in the same field. However, in their model, researchers do not have private information (e.g., private signals).

²⁵In this case, $N - 1$ scientists may each get a signal of θ , but follow the research of a top scientist who got a signal of β . This is similar to the case of *correlated draws* in Aghion et al., (2008). However, in my model, the expected social value of research is the same whether each scientist follows his signal or discards his signal and follows the action of a leader. However, recall that if the scientists follow their signals, the variance of the social value of research is $0.5625q(1 - q)N$. If they discard their signals and follow the action (research) of one person, the variance of the social value of research is $0.5625q(1 - q)N^2$, which is N times the variance of the social value if each scientist acts on his signal. This is the undesirable consequence of herd behavior.

apparently useless academic work.²⁶ This is consistent with proposition 3, where non-directed research gives a higher social welfare if the accuracy of the signal of the future value of research is high.

Scientists are likely to be better informed than the government about the expected social value of research. This claim or assumption strengthens the case for non-directed research and weakens proposition 1. It requires some justification.

First, this assumption is consistent with principal-agent models in which an agent is biased (has a different preference from the principal) but the principal may delegate decision-making authority to the agent because the agent has better (exogenous) information or delegation will induce the agent to acquire better (endogenous) information (Aghion and Tirole, 1997; Ball and Gao, 2024; Carmichael, 1998; Dessein, 2002).

Second, academics earn a living by thinking about research. It is their specialization to which they devote considerable time than government bureaucrats do. This increases the likelihood path-breaking ideas will come from academia and other research labs, not government bureaucracies.

Third, governments have historically influenced and shaped the direction of scientific discovery through funding and policy, but the pathbreaking ideas themselves usually originate within the scientific community (e.g., Marshall, 2025).²⁷ The US National Science Foundation was established in 1950 to support *basic* research, which is research driven by *curiosity* and *discovery*, research ideas that are chosen by scientists without any

²⁶Bloom et al. (2020) claim that it is becoming more difficult to find these gems.

²⁷Typically, expert reviewers, who are also academics, spend a lot of time allocating grant money to the researchers with arguably the best ideas.

direction from the government.^{28,29} For example, Fiber optics technology, which is used for almost all *telephony and data communication*, emerged from the *private* labs of Standard Telecommunication Laboratories in England, where the 2009 physics Nobel laureate Charles Kao worked in the 1960s, and Corning Glass Works in the USA in 1970, where scientists operationalized the theoretical insights of Charles Kao (Hecht, 1999). Most Nobel laureates in physics, chemistry, and medicine won the prize for path-breaking research which was not directed by any government.³⁰

Using a panel-data set of 127 countries over the period 1960 – 2015, Berggren and Bjørnskov (2022) found a positive relationship between academic freedom and both labor and total-factor productivity growth in countries where the quality of the legal system is high (see also, Audretsch et al., 2024; Tartari and Stern, 2021).

Even if scientists in academia do not have superior knowledge of research projects, government bureaucrats, who may also be scientists, are unlikely to be better at picking good and bad research ideas. This is because research is an unpredictable process and so micromanaging research is likely to be counterproductive. After all, research is about what is not known.³¹ The fact that apparently useless *basic* research became the foundation of

²⁸<https://www.nsf.gov/about/history>

²⁹ Bush (1945), made a strong case for federal support of the best, curiosity-driven “basic research in the colleges, universities, and research institutes.”

³⁰ However, scientists may not be aware of a number of sensitive issues (e.g., national security threats) which governments know and might wish to explore. In such situations, directed research, perhaps ‘in-house’, would be important. I thank Louis Christofides for this point.

³¹ “... It’s a well-known fact that a vast majority of patents are worthless. Around 97% of all patents never recoup the cost of filing them.” (<https://www.forbes.com/sites/stephenkey/2017/11/13/in-todays-market-do-patents-even-matter/>). Yet, the 3% or less of patents can and have changed the world.

useful applied research several years later suggests that government bureaucrats would not be good at picking winners and losers.

In mathematics, the study of knots, in a field as abstract as topology, has helped scientists to gain a better understanding of DNA and the treatment of cancer (Francis, 2018; Hart, 2005). Number theory, the study of integers and prime numbers, was for so more than a hundred years, considered to be one of the most useless branches of pure mathematics. In his defense of the pursuit of mathematics for its own sake, the British mathematician, Godfrey Hardy, described number theory as “obviously useless” (Hardy, 1940). Yet, results in number theory have now found applications in modern internet security, an example being the RSA encryption algorithm, which makes secure online commerce and communication possible (Blake et al., 1999; Smart, 2016).

According to Smart (2016, p. 59):

*“If you use a mobile phone, have a games console, or use a variety of Internet services then most likely you are utilizing the results of **over 200 years** of research in the mathematics of elliptic curves. Elliptic curve-based cryptography is all around us, yet it is the outcome of hundreds of years of research into basic pure mathematics. **It is a great story of how the impact of mathematics cannot be predicted**; indeed, we shall see that not even mathematicians can predict impact of their work 5-10 years ahead of time.”³² (Bold font mine).*

³²According to Marshall (2025), “Ozempic, MRI machines and flat screen televisions all emerged out of fundamental research decades earlier.” And Carmichael (1988) observed that, “it takes time for any research project to be completed and, in particular, for its value to be ascertained.”

4. Conclusion

Any justification of academic freedom must implicitly or explicitly make the case that such freedom comes with social benefits. A well-known justification is that academic freedom ensures that scholars can write about controversial topics.³³ Aghion et al (2008) justified academic freedom on the ground that it makes it cheaper to employ academics to engage basic research that has a low expected commercial value. This paper made a case for academic freedom (non-directed research) by identifying trade-offs of academic freedom. Non-directed research was justified on the ground that each scientist's signal of the future value of research is more accurate than the government's signal and the *multiplicity of independent* signals, relative to a government's *limited* signals, received by scientists is an advantage. But, on the flip side, non-directed research may result in scientists allocating their time, from a social point of view, inefficiently across research projects. However, there is no compelling evidence, that a government will necessarily maximize the social value of research. On the balance, some academic freedom is socially desirable.

Research intended to solve *known* and pressing social problems is necessary and important. Scientists in a country or region cannot all be engaged in basic or abstract research while research into the solution of urgent social problems is neglected. Both types of research are necessary. Each country and the entire world must find a balance

³³See Carmichael (1988) for a similar but different justification.

between abstract or basic research, which may one day solve *unknown* or unanticipated problems, and research that is focussed on solving *known* social problems.³⁴

In their "Post-16 Education and Skills" white paper -- presented to the British parliament in October 2025 -- the secretaries of state for Education, Work and Pensions, and Science, Innovation and Technology of the United Kingdom acknowledged the need for this balance. They stated that, "We will maintain the right balance across our three research funding priorities: protect and promote **curiosity-driven research**; support research and development for the **delivery of government priorities**, missions and the Industrial Strategy; and **provide targeted innovation, commercialisation and scale-up support to drive growth**."³⁵ (Bold font mine)

Governments call for research ideas in some *specific* areas of research while also funding research in *general* areas based on the research projects chosen by scientists. In the former case, the researchers voluntarily submit research projects or proposals in the areas commissioned by the government. This strikes a balance between *semi*-directed (nudged³⁶) research and non-directed research. Thus, governments can and do incentivize scientists to engage in certain fields of research.³⁷

³⁴One is reminded of a well-known quote by a former US secretary of defense, Donald Rumsfeld. At a press briefing on February 12, 2002, he said, "... there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know."

³⁵https://assets.publishing.service.gov.uk/media/68f518ee06e6515f7914c7ce/Post-16_Education_and_Skills_white_paper_Accessible_Version.pdf

³⁶Nudging academics to certain areas of research is akin to the idea of libertarian paternalism by Sunstein and Thaler (2003, 2009).

³⁷For example, Myers (2020) studies the degree to which scientists are willing to change the direction of their research in exchange for resources.

Appendix A

The necessity of mean-variance type preferences

For the sake of exposition, suppose the society has a von Neumann–Morgenstern utility function, $U(m) = m^{1/2}$. As before, $|\theta - \beta| = 1$.

Then, the expected social welfare of non-directed research, given $\alpha = 1$ for each scientist, is:

$$EU_n = \sum_{r=0}^N \frac{N!}{r!(N-r)!} q^r (1-q)^{N-r} [(r + 0.25(N-r))]^{0.5}. \quad (A1)$$

The expression in (A1) is the expected value of $g(\hat{r}) = (\hat{r})^{0.5}$, where $\hat{r} = (r + 0.25(N-r))$ and r is a binomial random variable. (A1) cannot be simplified to get a closed-form expression. An approximation is necessary. Mean-variance preferences, that can be derived via a second-order Taylor series approximation, is an example and any “reasonable” approximation will be a variant of mean-variance preferences.

Define $\mu = E(\hat{r}) = 0.75Nq + 0.25N$ and $\sigma^2 = Var(\hat{r}) = (0.75)^2 q(1-q)N$. Towards an approximation, we take a second-order Taylor series expansion³⁸ of $g(\hat{r})$ at $\hat{r} = \mu$. This gives:

$$g(\hat{r}) \approx g(\mu) + g'(\mu)(\hat{r} - \mu) + \frac{1}{2} g''(\mu)(\hat{r} - \mu)^2. \quad (A2)$$

Then taking the expectation of $g(\hat{r})$ gives³⁹

$$E[g(\hat{r})] \approx g(\mu) + \frac{1}{2} g''(\mu) \sigma^2. \quad (A3)$$

³⁸This is the delta method in statistics (see, for example, Ver Hoef, 2012; Oehlert, 1992). Oehlert (1992, p. 27) noted that, “The delta method approximates the expectation of $g(X)$ by taking the expectation of a polynomial approximation to $g(X)$. The polynomial is usually a truncated Taylor series centered at the mean of X .”

³⁹If $g(r)$ is a von Neumann–Morgenstern utility function, then (A3) can be written as the mean-variance utility function in the main text (i.e., equation (1)). This is well-known (e.g., Levy and Markowitz (1979), Markowitz (2014), Meyer (1987), and the references therein).

Then, given $\mu = 0.75Nq + 0.25N$, $\sigma^2 = (0.75)^2q(1-q)N$, and $g''(\mu) = -\frac{1}{4(\mu)^{1.5}}$, we get

$$E[g(\hat{r})] \approx (0.75Nq + 0.25N)^{1/2} - \frac{0.56}{8(0.75Nq + 0.25N)^{1.5}} \frac{(1-q)N}{1.5} \quad (\text{A4})$$

Equation (A4) can be rewritten as:

$$EU_n \equiv E[g(\hat{r})] \approx (0.75q + 0.25)^{1/2} N^{1/2} - \frac{9q(1-q)}{128(0.75 + 0.25)^{1.5} N^{0.5}} \quad (\text{A5})$$

Under directed research, if the government gets signal s_j , it directs each scientist to allocate α of his time to j -appropriate research, $j \in \{\theta, \beta\}$. The government chooses α to maximize the expected social welfare function:

$$EU_d = qU\left((\alpha^{1/2} + 0.25(1-\alpha)^{1/2})^{1/2} N^{1/2}\right) + (1-q)U\left((0.25\alpha^{1/2} + (1-\alpha)^{1/2})^{1/2} N^{1/2}\right) \quad (\text{A6})$$

Given $U(m) = m^{1/2}$, we can find a unique value of α that maximizes EU_d . Call it α^{**} and the maximized value, $EU_d(\alpha^{**})$.

The social welfare function, EU_n , in (A5) is an *approximation* while the maximized social welfare function, $EU_d(\alpha^{**})$, is an *exact* expression. Methodologically, comparing an exact social welfare function and an approximated social welfare function, where one function is not an approximation of the other, is problematic. Using the mean-variance preferences in equation (1) in the main text allows a comparison of apples to apples.

References

- Aagaard, K., Mongeon, P., Ramos-Vielba, I., and Thomas, D.A. (2021). Getting to the bottom of research funding: acknowledging the complexity of funding dynamics. *PLoS ONE* 16: e0251488.
- Acemoglu, D., and Lensman, T. (2024). Regulating transformative technologies. *American Economic Review: Insights* 6: 359 – 376.
- Agarwal, R., and Ohyama, A. (2012). Industry or academia, basic or applied? Career choices and earnings trajectories of scientists. *Management Science* 59: 950-970.
- Aghion, P., Dewatripont, M., and Stein, J.C. (2008). Academic freedom, private-sector focus, and the process of innovation. *Rand Journal of Economics* 39: 617 - 635.
- Aghion, P., and Tirole, J. (1997). Formal and real authority in organizations. *Journal of Political Economy* 105: 1 - 29.
- Akcigit, Hanley, D., and Serrano-Velarde, N. (2021). Back to basics: basic research spillovers, innovation policy, and growth. *Review of Economic Studies* 88: 1 – 43.
- Amegashie, J.A. (2020). Citations and incentives in academic contests. *Economic Inquiry* 58: 1233 - 1244.
- Arrow, K. (1962). Economics of welfare and the allocation of resources for invention. In R. Nelson, ed., *The Rate and Direction of Inventive Activity*. Princeton, NJ: Princeton University Press, 1962.
- Arora, A., Belenzon, S., Patacconi, A., and Suh, J. (2020). The changing structure of American innovation: some cautionary remarks for economic growth. *Innovation Policy and the Economy* 20: 39 - 93.
- Audretsch, D.B., Fisch, C., Franzoni C., Momtaz, P.P., and Vismara, S. (2024). Academic freedom and innovation. *PLoS ONE* 19: e0304560.
- Baccara, M., Levy, G., and Razin, R. (2025). Research waves. Cesifo Working Paper 12248, Munich.
- Ball, I., and Gao, X. (2024). Benefiting from bias: delegating to encourage information acquisition. *Journal of Economic Theory* 218, 105816.
- Banerjee, A. (1992). A simple model of herd behavior. *Quarterly Journal of Economics*: 107: 797 – 818.

Berger, D., Dew-Becker, I., and Giglio, S. (2020). Uncertainty shocks as second-moment news shocks. *Review of Economic Studies* 87: 40 - 76.

Berggren, N., and Bjørnskov, C. (2022). Academic freedom, institutions, and productivity. *Southern Economic Journal* 88: 1313 – 1342.

Blake, I.F., Seroussi, G., and Smart, N.P. (1999). *Elliptic curves in cryptography*. Cambridge University Press, UK.

Bloom, N. (2009). The impact of uncertainty shocks. *Econometrica* 77: 623 – 685.

Bloom, N., Jones, C.I., Van Reenen, J., and Webb, M. (2020). Are ideas getting harder to find? *American Economic Review* 110: 1104 – 1144.

Bikhchandani, S., Hirshleifer, D., and Welch, I. (1992). A theory of fads, fashion, custom, and cultural change as informational cascades. *Journal of Political Economy* 100: 992 - 1026.

Bikhchandani, S., Hirshleifer, D., and Welch, I. (1998). Learning from the behavior of others: conformity, fads, and informational cascades. *Journal of Economic Perspectives* 12: 151 – 170.

Busch, C., Domeij, D., Guvenen, F., and Madera, R. (2022). Skewed Idiosyncratic income risk over the business cycle: sources and insurance. *American Economic Journal: Macroeconomics* 14: 207 – 242.

Bush, V. (1945). *Science: the endless frontier*. Washington, DC: U.S. Government Printing Office, 1945.

Carmichael, H. L. (1988). Incentives in academics: why is there tenure? *Journal of Political Economy* 96: 453 – 472.

Collier, R. (2016). Is most clinical research useless? *Canadian Medical Association Journal* 188: 790 – 791.

Costa, O.L., de Oliveira Ribeiro, C., Rego, E.E., Stern, J.M., Parente, V., and Kileber, S. (2017). Robust portfolio optimization for electricity planning: An application based on the Brazilian electricity mix. *Energy Economics* 64: 158 – 169.

Da, Z., and Huang, X. (2019) Harnessing the wisdom of crowds. *Management Science* 66:1847-1867.

Dehn, W.M (1932). Useless chemical knowledge. *Journal of Chemical Education* 9: 1075 - 1077.

Dessein, W. (2002). Authority and communication in organizations. *Review of Economic Studies* 69: 811 – 838.

D’Este P., Ramos-Vielba, I., Woolley R., and Amara, N. (2018). How do researchers generate scientific and societal impacts? Toward an analytical and operational framework. *Science and Public Policy* 45: 752 – 763.

Ellison, G. (2013). How does the market use citation data? The Hirsch Index in economics. *American Economic Journal: Applied Economics* 5: 63 – 90.

Epstein, L. G., and Zin, S.E. (1991). Substitution, risk aversion, and the temporal behavior of consumption and asset returns: an empirical analysis. *Journal of Political Economy* 99: 263 – 286.

Fitzgerald, G.F. (1892). The value of useless studies. *Nature* 45, 392 (letter published, 25 February 1892).

Flexner, A. (1939). The usefulness of useless knowledge. *Harper’s Magazine* 139, June/November 1939.

Flexner, A. (2017). *The usefulness of useless knowledge*. Princeton University Press, NJ.

Francis, M. R. (2018). Untangling DNA with knot theory. *SIAM News* 51, October 2018 (<https://www.siam.org/publications/siam-news/articles/untangling-dna-with-knot-theory/>)

Francois, P. (2000). ‘Public service motivation’ as an argument for government provision. *Journal of Public Economics* 78: 275 - 299.

Gans, J. (2025). The regulation of the direction of technology. *Journal of Public Economics* 246: 105375.

Hart, S. (2005). An interview with Robert Aumann. *Macroeconomics Dynamics* 9: 683 - 740.

Hardy, G. H. (1940). *A mathematician's apology*. Cambridge University Press, UK.

Hecht, J. (1999). *City of light: the story of fiber optics*. Oxford University Press, UK.

Heckman, J. J., and Moktan, S. (2020). Publishing and promotion in economics: the tyranny of the top five. *Journal of Economic Literature* 58: 419 – 470.

Hintze, A., Olson, R.S., Adami, C., and Hertwig, R. (2015). Risk sensitivity as an evolutionary adaptation. *Scientific Reports* 5: 1-7.

Hong, L., and Scott E. (2004). Groups of diverse problem solvers can outperform groups of high-ability problem solvers. *Proceedings of the National Academy of Sciences* 101: 16385 - 16389.

Jaffe, A. B. (1989). Real effects of academic research. *American Economic Review* 79: 957–970

Jones, C. I. (2024). The AI dilemma: growth versus existential risk. *American Economic Review: Insights* 6: 575 – 590.

Levy, H., and Markowitz, H.M. (1979). Approximating expected utility by a function of mean and variance. *American Economic Review* 69: 308 - 317.

Mansfield, E. (1991). Academic research and industrial innovation. *Research Policy* 20: 1 – 12.

Markowitz, H. (2014). Mean–variance approximations to expected utility. *European Journal of Operational Research* 234: 346-355.

Marshall, M. (2025). Seven basic science discoveries that changed the world. *Nature* 646: 1040-1043 (<https://www.nature.com/articles/d41586-025-03474-x>).

Martin, I., and Pindyck, R. (2015). Averting catastrophes: the strange economics of Scylla and Charybdis. *American Economic Review* 105: 2947 - 2985.

Meyer, J. (1987). Two-moment decision models and expected utility maximization. *American Economic Review* 77: 421-430.

Modell, W. (1964). The usefulness of useless knowledge. *Clinical Pharmacology and Therapeutics* 5: 145 - 148.

Myers, K. (2020). The elasticity of science. *American Economic Journal: Applied Economics* 12: 103 – 134.

Nelson, R. (1959). The simple economics of basic scientific research. *Journal of Political Economy* 67: 297 – 306.

Nelson, R. (1986). Institutions supporting technical advance in industry. *American Economic Review* 76: 186 – 189.

Oehlert, G.W. (1992). A note on the delta method. *American Statistician* 46: 27 – 29.

Palley, A., and Soll, J. B., (2019). Extracting the wisdom of crowds when information is shared. *Management Science* 65: 1949 - 2443.

Roach, M., and Sauermann, H. (2010). A taste for science? PhD scientists' academic orientation and self-selection into research careers in industry. *Research Policy* 39: 422 – 434.

Rohde and Rohde (2015). Managing social risks – tradeoffs between risks and inequalities. *Journal of Risk and Uncertainty* 51: 103 – 124.

Roques, F.A., Newbery, D.M, and Nuttall, W.J. (2008). Fuel mix diversification incentives in liberalized electricity markets: a mean variance portfolio theory approach. *Energy Economics* 30: 1831-1849.

Schwarcz, J. (2025). *Not all scientific studies are useful*. Office for Science and Society, McGill University, Canada.
<https://www.mcgill.ca/oss/article/critical-thinking-pseudoscience/not-all-scientific-studies-are-useful>

Senior, H.J., Teimouri, N., Waller, M., Capewell, S., and Cullerton, K. (2025). How governments influence public health research: a scoping review. *Health Promotion International* 40: August 2025, daaf097.

Smart, N.P. (2016). How number theory enables a secure internet. *London Mathematical Society Impact* 150 Stories 1: 59 – 62.

Stern, S. (2004). Do scientists pay to be scientists. *Management Science* 50: 835 – 853.

Sunstein, C. R., and Thaler, R.H. (2003). Libertarian paternalism is not an oxymoron. *University of Chicago Law Review* 70: 1159-1202.

Sunstein, C.R. and Thaler, R.H. (2009). *Nudge: improving decisions about health, wealth and happiness* (2nd ed.), Penguin Books.

Surowiecki, J. (2005). *The wisdom of crowds*. Doubleday (Random House).

Tartari, V., and Stern, S. (2021). More than an ivory tower: the impact of research institutions on the quantity and quality of entrepreneurship. NBER Working Paper 28846.

Ver Hoef, J.M. (2012). Who invented the delta method. *American Statistician* 66: 124 – 127.

Zhang, R., Brennan, T.J., and Lo, A.W. (2014). The origin of risk aversion. *Proceedings of the National Academy of Sciences* 111: 17777 – 17782.