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Perverse incentives

Counterproductive financial incentives divert time and resources from the scientific enterprise. We should spend the money more wisely, says **Paula Stephan**.

Scientists may portray themselves as not being motivated by money, but they and the institutions where they work respond in spades to financial opportunities. Incentives that encourage people to make one decision instead of another for monetary reasons play an important part in science. This is good news if the incentives are right. But if they are not, they can cause considerable damage to the scientific enterprise.

For instance, cash incentives adopted by countries such as China, South Korea and Turkey encourage local scientists to submit papers to high-end journals despite the low probability of success. These payments have achieved little more than overloading reviewers, taking them away from their work, and have increased submissions by the three countries to the journal *Science* by 46% in recent years, with no corresponding increase in the number of publications[1].

Sadly, science is full of incentives gone awry. Look no further than expanding PhD programmes that produce graduates with almost no career prospects, or the growth of lab space with no apparent increase in productivity.

The economic rules behind science were written without much consideration for unintended consequences, but such consequences abound because people and institutions are so responsive to incentives. And in the current economic climate, no one can afford to waste time or resources. In a world of tight budgets, getting the incentives right is more important than ever.

BAD DIRECTIONS

Consider the financial calculations that encourage universities to hire a series of postdocs rather than staff scientists. Postdocs earn around half to two-thirds of a staff scientist's salary. They are young, have fresh perspectives and new ideas and are temporary, so can be let go when budgets decline[2]. But, in reality, postdocs are not cheap: substantial resources — both their own and society's — have been invested in training them.

If a postdoc doesn't get a research job, taxpayers do not get a return on their investment. Neither does the postdoc: someone who did not go to graduate school and entered the labour market in 2001 was earning about US$58,000 in 2008; a first-year postdoc who started graduate school in the United States in 2001 was making around $37,000 in 2008 on graduation[3]. During a three-year postdoc position, a scientist gives up more than $60,000 on average in return for highly uncertain job prospects. And many postdocs will not get a research job. There are few faculty openings, and limited numbers of research positions in government and industry. So even if individual postdocs cost less, from a societal perspective they can be expensive.

Equally harmful are rules that encourage scientists to support graduate students on a research assistantship (RA) rather than on a training grant, despite evidence that the ▶

SUMMARY
- Science is full of incentives that encourage bad financial choices, such as expanding labs and hiring too many temporary scientists.
- These incentives hurt both individual scientists and society as a whole, which gets minimal return on its investment when someone is trained for a field with no career prospects.
- The way forward is to fix incentives that are damaging the system, by considering their true social and personal cost.

latter produces better outcomes. Part of the reason is that RA funding comes with an additional amount to cover the university's overhead, or indirect rate, which may be as high as 50%. For those on training grants from the US National Institutes of Health (NIH) in Bethesda, Maryland, that amount is capped at 8%. This difference easily translates into an institution getting at least $12,000 more for every RA-supported student. Other considerations affect the choice of RAs over training grants, too — RAs are under the direct control of principal investigators, whereas graduate students on training grants are less so.

However, training grants are arguably better for scientists in the long term. Importantly, they give departments the incentive to provide a high-quality training experience, because renewals for training-grant awards are evaluated on the quality of the PhD experience and placement outcomes. By contrast, scientists who support students on research grants are not required on renewal to disclose where graduates end up being placed. Some principal investigators collect this information, but departments typically do not — my informal survey of 45 science departments found only two that were able to report where their students had been placed. Without this knowledge, prospective students will not be able to judge whether a lab is a good place to begin a successful science career.

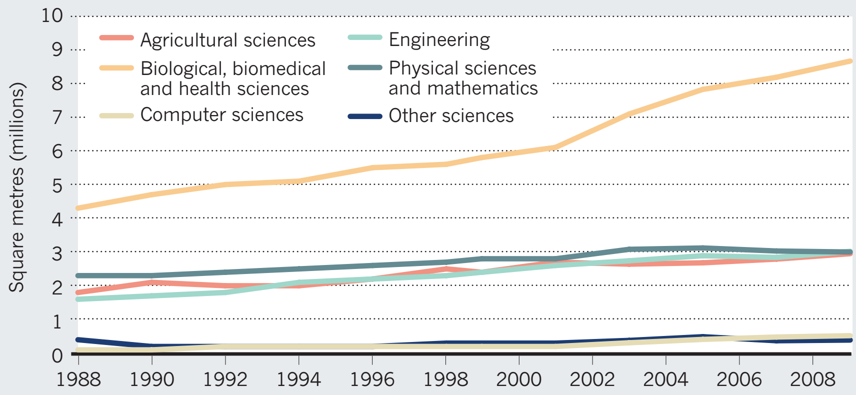
The growth of labs is another result of incentives. Bigger is seen as better: more funding, more papers, more citations and more trainees — regardless of whether the market can sustain their employment. Some institutions pay bonuses to faculty members on the basis of the amount of external funding they receive[4]. But, again, too many trainees creates a glut of people who will not find suitable jobs. It would have been more efficient for both the students and society to steer them in a different direction. And big labs can be wasteful — an analysis by the US National Institute of General Medical Sciences in Bethesda, Maryland, found that an increase in funding is not associated with a substantial increase in output when measured by the number of grant-linked publications[5].

"The building boom is now costing the scientific enterprise by creating space that cannot be paid for."

Other economic incentives indirectly render the scientific process less efficient — such as the tendency of scientists to avoid risk by submitting to funding organizations only those proposals that they consider 'sure bets'. This tendency comes from the need for faculty members to obtain grants to support their salary, the emphasis on preliminary data in grant applications and the difficulty of obtaining funding in today's climate.

BIOLOGY'S RESEARCH FOOTPRINT

There has been huge expansion in laboratory space for the biomedical sciences since the late 1990s in comparison with other fields.



SOURCE: US NATL SCI. FOUND.

If most scientists are risk-averse, there is little chance that transformative research will occur, leading to significant returns from investments in research and development. Funding bodies sometimes give money specifically for field-changing research, but not nearly enough — Pioneer grants from the NIH fund fewer than 1% of applicants.

In the European Union, there are strong incentives for researchers to team up with colleagues in other countries. This is because most funding opportunities under the various research Framework programmes require consortia to be made up of at least three entities in three different European countries. No collaboration, no grant. Is this a good use of resources? Although there is evidence that collaboration leads to better research, I do not know of any that supports the idea that those collaborators should come from different countries. The extra costs of coordination — organizing the work, travel, meetings and so on— can be large relative to the money being invested in research.

Universities are also driven by incentives. By hiring faculty members on 'soft' money, with grants providing the salary, the institutions bear almost none of the risks. Furthermore, universities prefer to put up a new building or invest millions in remodelling existing lab space rather than house scientists in older buildings that they already own. Why? One reason is that debt can be an accounting asset. A US government accounting rule called A21 means that the more debt universities have from construction, the more they can add to grants for overhead costs. If a university borrows $100 million to build a new facility and pays 4% interest, it can increase its indirect rate by including the $4-million interest payment in the calculation. The building binge is further fuelled by competition among universities: recruiting senior faculty members requires space, and lots of it.

What is so bad about institutions putting up new research facilities? The answer lies in what economists call 'incidence' — who eventually pays. Before the global financial crisis, universities had hoped to recoup the money through increased indirect costs and through the 'buy-out' money they receive from funding agencies to cover the salaries of permanent faculty members working on grants. But now that grants are harder to get, that money isn't coming in. Unless states and private institutions default, someone will have to pay the bonds. The money is likely to come from the physical sciences, the humanities and social sciences, as well as cutbacks in hiring across departments. In short, the building boom is now costing the scientific enterprise by creating excess space that cannot be paid for.

FIX WHAT'S BROKEN

The way forward is to alter these damaging incentives. The scientific enterprise should cut back on the demand for graduate research assistants by establishing more research institutes that are not focused on the production of PhDs, such as the Howard Hughes Medical Institute's Janelia Farm campus in Ashburn, Virginia. Research institutes, by producing fewer PhDs, lead to a better balance between supply and the limited number of research jobs. Abstinence, after all, is the most effective form of birth control.

In addition, we should consider ways of making graduate students and postdocs more costly to universities, to discourage their overuse and reflect their social cost. One possibility is to 'tax' the two positions, making them more expensive relative to other staff types, thereby providing an incentive to employ permanent rather than temporary staff. Principal investigators and their departments should also be required to report placement data online as part of all research-grant applications. This would allow society to monitor the return on its investment, and students to assess job outcomes.

Training grants should be made more

economically attractive. And rules should be altered to limit the amount of interest payments universities can include when calculating indirect rates, and the amount of faculty members' salaries that can be charged to grants, thereby dulling the incentive to hire people for soft-money positions. Shifting evaluations from projects to people, and de-emphasizing the importance of metrics in hiring and promotion, could encourage scientists to work on riskier projects[6].

Many of the problems now faced by science accelerated when biomedical funding started to increase steeply. For instance, the doubling of the NIH budget from 1998 to 2003 triggered universities to hire more people and build more buildings, while scientists increased the number of grants they submitted and the size of their labs (see 'Biology's research footprint'). Now, this biomedical machine needs increasing amounts of money to sustain itself — larger labs need more grants, which leads to lower success rates, with calls for more funding.

Biomedical research has done much to contribute to increased life expectancy. But it seems likely that diminishing returns have set in. New drugs are slower in coming to market and there was a less than stellar increase in US publications associated with the NIH doubling[7]. Moreover, many of the breakthroughs that have contributed to better health outcomes have come from other fields of science — such as the laser and magnetic resonance imaging. Funds for the physical sciences in the United States (in terms of the percentage of federal research funding) are close to a 35-year low. Perhaps it is time for deans in the biomedical sciences to rent some of that excess space to their colleagues in chemistry and physics. ■

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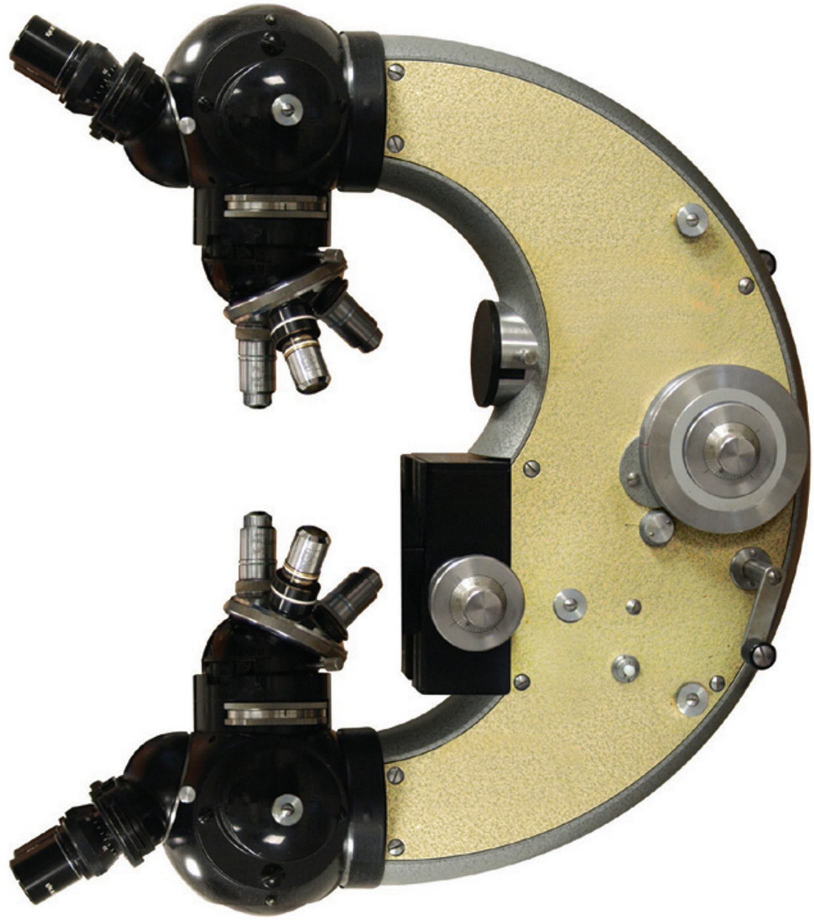

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Turn the scientific method on ourselves

How can we know whether funding models for research work? By relentlessly testing them using randomized controlled trials, says **Pierre Azoulay**.

In times of tight budget constraints, scientists' wranglings about the real and perceived sins of public funding agencies become particularly acute. Complaints usually lead to the creation of a panel of respected, thoughtful and well-meaning scientists who come up with a plan of reform based on their intuition and experience. Funding agencies, who are genuinely concerned about improving the productivity of the scientific enterprise, often adopt these recommendations, at least in part. In one example of this process, the US National Institutes of Health (NIH) in Bethesda, Maryland, has created a large array of funding mechanisms, each one targeted to a particular problem — including the K99/R00 or 'kangaroo' grants, which pair postdoctoral scientists with mentors to help them to prepare for tenure-track faculty positions and funding independence. Not only is this range of mechanisms confusing and costly to administer, but the effectiveness of such reforms is never seriously evaluated.

It is time to turn the scientific method on ourselves. In our attempts to reform the institutions of science, we should adhere to the same empirical standards that we insist on when evaluating research results. We already know how: by subjecting proposed reforms to a prospective, randomized ▶