Skip the Agenda Building

Let the Wisdom of the Crowd Drive a Dynamic Tapestry of Science

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The Netherlands has recently conducted a broad popular survey in which the public were invited to submit online suggestions for the research questions and themes that they deem important. We applaud the idea of letting the public participate in a societal reflection on research priorities. The greater the number of participants and the broader their representation, the smaller the odds of missing relevant and important research areas. It helps science escape the trap of the ivory tower and reduces the risk of scientific tunnel vision. We therefore embrace the notion of stimulating a dialogue between the scientific community and the public. At the same time, we are wary of directing the public's energy towards the subsequent definition of a national science agenda to prioritize research themes. Science agendas that prioritize particular research areas are inevitably susceptible to bias and do not mitigate the widely perceived issues of how we presently prioritize and fund research. In our view this is a missed opportunity to really leverage the 'wisdom of the crowd' and make necessary improvements towards a more efficient, transparent, and equitable science funding system.

Problems of working with research agendas and peer-reviewed proposals

The present science funding system is based on painstakingly reviewing grant proposals, taking into account a variety of prioritized research themes and objectives. Although this system of strategic research agendas and peer-reviewed proposals has served us well, it now suffers from a number of broadly perceived concerns with respect to its ability to cope with the demands and scale of 21st-century science.

1 *Large overhead:* Scientists spend a disproportionally large part of their time writing and reviewing grant proposals, with very low odds of

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actually receiving research funding. In addition, much time is spent on discussions about the prioritization of research themes. A large part of the available resources is thus lost in the process of allocating funding .

2 *Subjectivity:* Ranking and evaluating many excellent proposals easily devolves into an exercise in finding distinctions without a difference. This is demonstrated by the lack of correlation between the rankings produced by the evaluation of research proposals and the impact of the resulting work (Fang et al. 2016). We might do just as well by a random drawing of proposals, a procedure that would be equally fair and certainly more efficient.

3 *Excessive inequality:* A large fraction of available research funding ends up with a small group of scientists. This frustrates the scientific community, but it is also suboptimal with respect to a social cost-benefit analysis. We are not making good use of the available diversity of research talent, possibly amplifying cultural bias towards a select set of overrepresented groups.

4 *Artificiality:* The present system of science funding negates and ignores the important role of serendipity and flexibility that characterizes high-quality, innovative science. Most scientists accept the restrictions of the current project-focused system and its necessity of submitting multi-year plans in advance by deriving proposals from research that they have already conducted, but haven't yet published. This might be a good strategy to obtain research funding, but does not encourage innovation and serendipitous discovery.

Of these four issues, the first is perhaps the most pressing one. An exact determination of the current cost of the system remains difficult. However, recent estimates reveal that in Australia alone researchers spent more than five centuries' worth of research time on the submission of grant proposals (Herbert et al. 2013). These estimates do not include the time spent evaluating proposals, managing projects, writing project reports, defining and stipulating national research priorities, and the many other external costs of our grant peer-review system. Assuming that all these facets of the present proposal-driven funding machinery amount to 10-20% of researchers' time across universities, academic hospitals, and other institutes, we arrive at approximately 0,5-1 billion euros per year in the Netherlands (10-20% of the Ministry of Education, Culture and Science's budget for these institutes). Another rough calculation comes from Canada, where analysis of Natural Sciences and Engineering Research Council Canada (NSERC) statistics revealed that the $40,000 (Canadian) cost of

preparing a grant application and having it rejected exceed that of giving every qualified investigator a direct baseline discovery grant of $30,000 (Gordon and Poulin 2009). We acknowledge that investing time in prioritizing research themes as well as writing and reviewing proposals might have inherent benefits. But do these outweigh the astronomical costs associated with the present system? If the present approach would result in something close to an optimum allocation of the funds that maximizes scientific innovation perhaps it would be worth it. But the strikingly poor correlations between review rankings and the impact of the resulting work (Fang et al. 2016)as well as high inequality in the distribution of funding suggest that this is not the case. The present system most likely does not effectively minimize costs and maximize scientific innovation. In fact, we might perhaps do better by simply skipping the entire procedure and awarding every applicant an equal and unconditional amount of funding (Gordon and Poulin 2009). We clearly need a careful examination of the return on investment of the present science funding system versus that of other possible systems.

Wisdom of the crowd as an alternative

In the remainder of this essay we ponder the possibility of distributing funds in a manner that wastes less money, but still acknowledges the different needs and productivity of individual scientists, avoiding the distortions resulting from the present funding machinery. The basic idea is that instead of evaluating and funding grant proposals, we distribute funding by evaluating the scientists themselves. Of course, this begs the question how this can be done in a reasonable, fair, and efficient manner. One possibility is to leverage the wisdom of the scientific crowd by involving all scientists, collectively, in the distribution of research funding to their peers. All scientists determine whom to best direct research funding to by making individual funding decisions with respect to their peers. The basic procedure to implement such a funding system can be simple and transparent (Bollen et al. 2014):

1 Every qualified scientist receives an equal and unconditional portion of the totality of available research funding.
2 Everybody anonymously donates 50% of the funding they receive to other, non-affiliated scientists, through a well-designed and easy-to-use website possibly managed by the national funding agency.
3 Repeat (1) and (2) so that those who receive a lot of funding must also distribute a lot of funding.

As funding circulates from one scientist to another, it settles into a fair distribution that respects the views and preferences of all scientists combined, without the requirement of submitting proposals, peer-reviewing them, managing projects, writing performance reports, defining research themes and mandates, etc. We should stress that there exists interesting mathematical work that underpins the effectiveness and efficiency of this system, which is why similar approaches are very common in other areas of the economy.

Of course, implementation of a workable and reliable version of this basic scheme requires careful elaboration of a number of aspects. First of all, we would have to decide who can participate in this system. As a first approximation, it could involve everyone with an academic position at an accredited institution. Secondly, it is of vital importance that conflicts of interest are prevented, e.g. by blocking donations to collaborators, co-authors, and individuals in the same institution. The system should be geared to detect the circulation of funding among small groups of colluding scientists. These measures would be similar to the rules that already apply in the present funding system, but one can imagine that a well-designed automated approach using detailed donation data may more effectively eliminate such problems. For instance, co-authorship and shared affiliations can simply be detected, and the same is true for collusion through reciprocal donations. The website where the participants select the names of scientists towards whom they direct the mandatory portion of their funds can show a stop sign upon detection of possible conflicts of interest and ask the participant to choose a different allocation.

Beyond the simplest scheme

This simple scheme can be extended in a number of ways. For instance, the redistribution percentage in the second iteration can be varied to result in either more equal or more 'merit-based' funding distributions. Simulations suggest that a 50% redistribution results in an inequality that roughly resembles the current skewness in the North American system (Bollen et al. 2014), whereas it is easy to see that an obligation to redistribute, say, only 5% in the second iteration round will result in a highly egalitarian distribution as most people receive only their equal minimum share. One can imagine that we could decide on an optimal level of inequality through the wisdom of the crowd as well, by asking participants what they consider

a desirable difference between the richest and poorest in terms of received funding.

Another add-on that might be useful is to provide 'default' distribution options, e.g. 'redistribute my percentage equally to all scientists' or 'redistribute to all female environmental scientists'. Importantly, measurable bias (such as detected gender bias) can be corrected, for instance by raising the funding to each female scientist by a fixed percentage to achieve an unbiased male-female balance. This approach could also be applied to account for intrinsic differences in research costs between domains. For instance, experimental physics tends to be more expensive than theoretical physics. This brings us to another issue that requires some thought. Some lines of research or infrastructural projects need stable funding over multiple years. Sticking with the wisdom of the crowd as a leading principle, one option would be to offer the option of committing one's allocation for multiple years to the same group of researchers who have stated an interest in putting their funds together for such a project. Another possibility is to allow researchers to put up large common projects for funding. Whether such 'super-nodes' would indeed receive funding would remain up to the wisdom of the crowd. This might well make it more difficult to create powerful mega-projects. On the other hand, we have recently seen dramatic failures of seemingly attractive scientific megaprojects that illustrate the risk of making top-down decisions about where to direct public funds (Enserink and Kupferschmidt 2014, Fang et al. 2016, Margottini 2016). The wisdom of the crowd, since it is based on all available information in the system, could perform better at balancing the risks and rewards associated with such efforts.

Keeping the allocation of research funding firmly in the hands of the community reduces the distorting effects of lobbying, while saving a tremendous amount of time and money. Of course, it is possible to expand the definition of 'community' beyond scientists to allow the public, policymakers, and industry to be involved in the distribution weighting. For instance, one could decide to let 10% of the funds be distributed by 'the public vote'. This would stimulate public involvement and interest in the rich tapestry of our national research efforts without heavy-handed, top-down research agendas. Public influence would be accounted for in a transparent and efficient manner. Although it is crucial that the entire procedure remains transparent to the participants as well as the public, the anonymity of donors is paramount to ensure the system's effectiveness.

Unforeseen risks, benefits, and implementation

Self-Organized Fund Allocation (SOFA) addresses all four issues mentioned at the start of this essay, but it may also bring about fundamental changes in scientific communication. For instance, researchers will be incentivized to clearly communicate their plans and their work to the public and their peers, since this will stimulate donations. This reduces the 'ivory tower' effect and makes the scientific enterprise more open, transparent, and collaborative. On the other hand, it may carry the risk that funding will favour those that better promote their work and themselves. Again, the collective wisdom of the crowd may mitigate this issue. If many scientists see this pattern, they might very well decide to fund less visible, silent thinkers that actually need the funding.

Still, it remains impossible to foresee all the consequences, including psychological and social implications. Studies reveal that inordinate inequality leads to displeasure, whereas giving and participating leads to greater levels of satisfaction. SOFA could in this regard bring about positive changes for many researchers. On the other hand, presently well-funded researchers might risk a reduction of their research funding as a result of SOFA. Also, policymakers and administrators involved with the administration, management, and definition of national research priorities might see a sharp reduction in their workload and responsibilities. This raises the important question of whether the introduction of a SOFA-based funding system will be applauded by these constituencies. Obviously, we need to carefully consider these complex social and psychological consequences in designing an implementation process.

Moving to this system of Self-Organized Fund Allocation may seem like a leap of faith. We know the weaknesses of the current system, but how do we know if SOFA would do better? We can only really know it if we try it out. This does not have to happen at full scale immediately. In the Netherlands the allocation of all flexible research money amounts roughly to a yearly base of approximately 30,000 euros per researcher. However, one could run a trial with say 10% of the national research budget. If only active participants in the reallocation trial would receive their share of funding, the average gains of 3,000 euros per researcher should create enough incentive to participate. A multidisciplinary team can then take care of a repeated cycle of careful evaluation followed by adjustments to gradually improve the system over time, before scaling it up.

Between our writing and the moment that this essay went to press, the topic has made it into prime-time news, and the Dutch parliament has requested such an experiment.

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