

# Benefits of steady growth

**W**hen the United States Congress returns from an August recess, it must take up appropriations bills, including those that fund science agencies. These bills will only focus on one fiscal year. Yet, almost all scientific projects require years to yield substantial progress. This timeline may favor longer-term budget allocation and other policy adjustments.

Science-funding agencies typically make multiyear grants, with averages of approximately 3 years for the U.S.

National Science Foundation (NSF) and 4 years for the U.S. National Institutes of Health (NIH). For the NIH and, to a lesser extent, NSF, these grants are paid out over consecutive years. Thus, when an agency makes an award, it often takes on a “mortgage” for funding the grant in future years. This approach allows agencies to monitor research efforts effectively through progress reports. However, multiyear funding means that the likelihood that applications submitted in subsequent years will be funded (often measured by “success rates” or “funding rates”) will depend largely on decisions made in previous years. Transitions from years with relatively generous appropriations (in which many new grants can be awarded) to those with limited appropriations can result in large drops in success rates.

Such fluctuations have important consequences. Outstanding applications that would have been funded one year go unsupported the next year, so that potentially ground-breaking research may be missed for arbitrary reasons of timing. Low success rates result in scientists spending more time writing and reviewing proposals instead of conducting research. Investigators, particularly those at vulnerable career stages, can become demoralized by the apparently capricious nature of funding decisions.

I have constructed a quantitative model that estimates grant success rates based on past appropriation levels, described in *Sciencehound* (<http://blogs.sciencemag.org/sciencehound/2016/08/26/modeling-success-rates>). The first component of the model estimates the number of grants that can be awarded annu-

ally based on the appropriations history. Remarkably, a simple model that captures only the essential features of multiyear funding reproduces year-to-year patterns quite well. The second component estimates the number of grant applications reviewed each year, based on the observation that increases in agency appropriations usually result in increases in subsequent application numbers with a 1- to 2-year lag.

The NIH budget doubled from 1998 through 2003 but has been nearly flat ever since. The model, applied from

1990 to 2015, reproduces the drop in the success rate (from approximately 30 to 20%) that occurred over the 2 years after the doubling. The success of the model supports the hypothesis that basic features of grant-funding processes were responsible for this drop rather than changes in NIH policies.

A benefit of these models is that consequences of potential alternative appropriation scenarios can be examined in quantitative terms. Suppose that Congress had increased the NIH appropriation from 1998 to 2015 at a constant rate instead of the “boom” of the doubling and the “bust” of the flat funding, with the same overall constant dollar investment. The model suggests that this would have resulted in 2.4-fold smaller fluctuations in

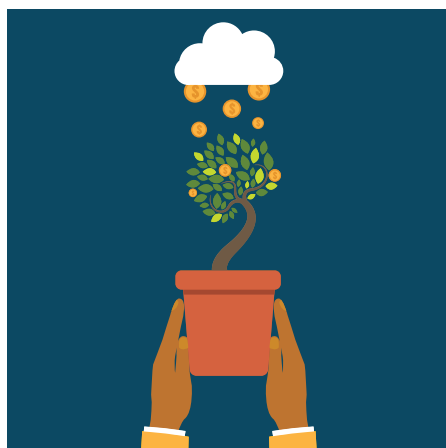
success rates and a decrease of nearly 35,000 unsuccessful grant applications. Thus, with a more stable funding stream, the system would have been more equitable on a year-to-year basis, and an average of 1300 fewer applications would have needed to be written and peer-reviewed per year to support the same amount of research.

Scientists and other advocates often call for steady increases in science budgets, arguing that growth at the rate of inflation is necessary to maintain research activity and that predictable budgets allow longer-term planning. These are important arguments, but they apply to many sectors. The multiyear nature of science funding provides an additional compelling argument for the implementation of longer-term science budget planning by the scientific community and the government.

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