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Comment

Bruce A. Weinberg

Paula Stephan presents a fascinating and compelling story of the evolution of federal support for science in the United States. Her thesis is that in his *Endless Frontier* report, Vannevar Bush emphasized building scientific capacity, while universities were initially standoffish. Today, of course, universities are tremendously dependent on that federal support at a time when federal support is looking increasingly precarious.

How did we get from "there" to "here"? Although Stephan's story is far richer, it has real elements of basic supply and demand. Federal agencies initially sought to build capacity by supplying resources. With supply high, the "generosity" of grants (in terms of support for indirect costs and salaries) increased and the quantity of grants "demanded" naturally increased too. When the supply of funds began to flatten in the 1970s, success rates fell, leading to considerable rent-seeking effort, such as lobbying for support, universities competing for researchers with the ability to bring in large grants, and multiple rounds of revisions. In this environment, an increase in funding, perhaps most notably the doubling of (nominal) funding at the NIH from 1998 to 2002 lead to a large, "speculative" boom in building and hiring.

One of Bush's primary goals was to support the training of graduate students and postdoctoral fellows. As Stephan describes, there has been a striking shift of emphasis from training *per se* to training as part of the production (perhaps even a byproduct) of the production of current research itself. At the National Institutes of Health, as recently as 1980 as many graduate students and postdocs were being supported on training grants and fellowships (combined) as research grants (National Institutes of Health 2012). In the years since, support on training grants and fellowships has held constant or increased somewhat (for graduate students). By contrast, the numbers supported on research grants has tripled (in the case of graduate students) and quadrupled (in the case of postdocs). As a consequence, the number of people being trained (many from abroad) is determined as much by the current research needs of labs as by the long-term market demand for researchers after their training is completed. There is also the perception that the quality of the training on research grants may not be as strong as the training on fellowships, potentially accentuating the extent to which training is deemphasized relative to the production of current research (National Institutes of Health 2012).

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The expansion of the research enterprise that Stephan documents is striking, with the size of awards, the length of awards, the amount of indirect costs covered, and the number of awards all increasing substantially. However, one of the most striking facts that Stephan presents is a decline in the real starting salaries of postdoctoral fellowships, which were (in 2013 dollars) $48,000, compared to under $40,000 in 2012. (Although, she notes that historically a large share of the postdocs were physicians.)

Stephan analogizes the current research university to a high-end shopping mall, which builds buildings speculatively and then competes for researchers to lease the space. There are a number of aspects to this behavior. Although the data are spotty, by all accounts, there has been a shift from supporting researchers on "hard money" to a model where researchers are paid on "soft money," expected to raise their salaries through grants. As Bruce Alberts (2010) has noted, the willingness of federal agencies to cover indirect costs actually compounds the incentive to shift researchers to soft money. Intuitively, an institution that pays people on soft money not only does not have to pay salaries, but also receives the indirect costs paid on the salary. It is striking to see that even at the time when these practices were being put in place, some researchers anticipated the availability of this level of support could be two-edged, with the increased availability of support likely to lead to expectations that researchers would generate more support. The competition for researchers can be seen in the large start-up packages that universities provide to researchers, especially in the natural and biomedical sciences. It can also be seen in the willingness of universities to support newly trained assistant professors on institutional funds for the ever-lengthening time that it takes for researchers (in biomedicine, at least) to obtain independent grant support. Turning to the speculative construction of space, Michael Teitelbaum has vividly pointed out that the calculation of indirect costs favors borrowing to finance construction relative to paying for construction directly, providing a further incentive for Stephan's speculative mallification of academia (National Institutes of Health 2012).

Stephan is to be commended for assembling a tremendous wealth of information and weaving it into a compelling story. Here the evidence from changes over time are complemented by discussions of differences across fields. Although it clearly goes beyond the scope of the current chapter, a formal analysis might compare fields based on the mix of support coming from each of the federal agencies, which differ dramatically in terms of their support parameters— private funding and institutional support.

Stephan rightly notes the tremendous increase in the cost of equipment (as well as the increase in its power). I think that the dissenting voices would focus on this increase in equipment costs as an alternative explanation for some of the trends Stephan highlights. Perhaps the increased reliance on federal support is not driven by its availability but rather by the increased

cost of research. That said, Stephan presents some evidence that the share of R&D budgets spent on equipment have trended down over time.

Whatever one makes of it, the transformation of US science is truly remarkable. Bush wrote in an environment where US science was still very much on the trajectory to scientific leadership, with a small number of universities playing large roles in the scientific enterprise (Weinberg 2013). Today the United States has a leading role in research and far more institutions are actively involved in research. No assessment of science in the United States can overlook the tremendous successes of US science. But, as successful as US science has been, Stephan's piece provides valuable insights into how that success was achieved and how the system could be improved.

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