IV. CAUSAL FACTORS

As already noted, NSF's proposal funding rate represents the number of awards divided by the number of proposal submissions. Anything that causes the numerator (awards) or the denominator (proposal submissions) to change will cause the funding rate to change. Since NSF receives more high quality proposals than can be funded, the chief factors affecting the numbers of awards are financial factors such as the funds available and the size of the awards. The factors that affect the numbers of proposal submissions are more varied. Anything that either attracts a larger pool of applicants or that causes individual PIs to send in more proposals per unit of time will increase proposal submissions. Some of these factors are internal to NSF (e.g., NSF outreach efforts) while others are external (e.g., pressure on PIs to win grants to help support their labs and universities, and/or decreased availability of funds from other granting agencies). In this section, we examine a number of factors thought to be important drivers of increased proposal submissions and declining funding rates.

Financial Factors Affecting Numbers of Awards Made

Over the FY 2000-2006 period, as funding rates dropped from 30% to 21%, the NSF budget, average award sizes and numbers of proposals received were all rising. Below we simulate what would have happened had each of these key factors been held constant over that period. These analyses suggest that the nearly 44% growth in the NSF budget over this period would have been sufficient to sustain a relatively stable funding rate coupled with either increasing award sizes or significant growth in the number of proposal submissions, but not both.[24]

Award Size

Holding NSF's mean award size constant at FY 2000 levels while the NSF budget and number of proposals submitted increase at actual rates, assuming a similar distribution of standard and continuing awards each year, the overall number of awards increases at the rates illustrated in Table 5. Funding rates decline from 30% to 27% rather than from 30% to 21%. However, it should be noted that the effective award size would have decayed due to inflation.

Table 5
Funding Rate if Award Size is Held Constant

Fiscal Year	Mean Award Size in thousands (held constant)	Number of Awards (projected)	Number of Research Proposals (actual)	Funding Rate (projected)
2000	$101.2	6,498	21,442	30%
2001	$101.2	7,110	23,096	31%
2002	$101.2	7,146	25,240	28%
2003	$101.2	8,014	28,678	28%
2004	$101.2	8,484	31,553	27%
2005	$101.2	8,340	31,574	26%
2006	$101.2	8,598	31,518	27%

[24] The simulation Tables 5, 6 and 7 are based on Table 1 in Section 1 of this report, which reports the actual numbers in all the relevant categories.

Proposal Submissions

Table 6 shows that, if the number of proposals received is held constant at FY 2000 levels while the NSF budget and award size increase at their actual rates, funding rate is relatively stable, fluctuating between 28 and 31%. The resulting total number of awards is slightly lower than actually occurred (6,468 rather than 6,712).

Table 6
Funding Rate if Research Proposal Submissions are Held Constant

Fiscal Year	Mean Award Size in thousands (actual)	Number of Awards (projected)	Number of Research Proposals (held constant)	Funding Rate (projected)
2000	$101.2	6,498	21,442	30%
2001	$108.1	6,656	21,442	31%
2002	$108.3	6,678	21,442	31%
2003	$130.9	6,196	21,442	29%
2004	$136.4	6,294	21,442	29%
2005	$142.7	5,914	21,442	28%
2006	$134.5	6,468	21,442	30%

Funding Rate

Table 7 shows the effect on award sizes when the funding rate is held constant at FY 2000 levels while the NSF budget and the number of proposals received increase at the actual rates. Maintaining a 30% funding rate results in a 46% increase in the number of awards (9,455 rather than the actual 6,712) and a 9% decrease in the mean award size ($92,000 rather than the actual $134,500) by FY 2006.

Table 7
Award Size if Funding Rate is Held Constant

Fiscal Year	Mean Award Size in thousands (projected)	Number of Awards (projected)	Number of Research Proposals (actual)	Funding Rate (held constant)
2000	$101.2	6,498	21,442	30%
2001	$103.9	6,929	23,096	30%
2002	$ 95.5	7,572	25,240	30%
2003	$ 94.3	8,603	28,678	30%
2004	$ 90.7	9,466	31,553	30%
2005	$ 89.1	9,472	31,574	30%
2006	$ 92.0	9,455	31,518	30%

Factors Affecting Numbers of Research Proposals Received

If either a given set of PIs sends in more NSF proposals per unit time or a new pool of PIs is attracted to the Foundation (or both), numbers of proposals will increase. Below, we explore the major forces internal and external to NSF that may be leading to larger PI pools and/or to increased numbers of proposals per PI.

Investigators' Expectations

All else equal, if PIs expect that their chances of being funded at NSF have improved, or if they expect to receive larger awards from NSF, they should become more likely to submit proposals. Budgets, funding rates and award sizes are all potentially visible signals to PIs of the probability and potential payoff associated with submitting a proposal.

IPAMM conducted regression analyses using division-level data to see whether these three signals – budgets, funding rates, and award sizes – do, in fact, lead to increases in proposal submissions.[25] The regressions included a control variable ("year") to capture the year-to-year variance in submission rates not accounted for by the other three variables but still isolatable in the model. Specifically, the regression assessed change in numbers of proposals received by a division as a function of the percent change in budget from the prior year, previous year funding rate, previous year average award size, and "year".

The regression results (shown in Appendix C) indicate that none of the signaling variables had a significant effect on submission rates. The only significant effect was the control variable ("year"). Furthermore, the entire model accounted for only about 30% of the change in proposal submission rate. IPAMM concludes that other drivers – either outside forces or other NSF actions (i.e., other than funding rates and award sizes) – are responsible for far more of the change in submissions than are these signaling variables.

However, feedback from the 2007 NSF Proposer Survey suggests that PIs perceive these factors to be important to their decisions to write proposals, even though it could not be detected in the historical data. When asked if any of these factors influenced their decision to submit proposals to particular funding agencies (including NSF), respondents indicated that they considered program budgets (55%), expected funding rates (75%) and award sizes (67%) to a great or moderate extent when making this decision.

Institutional Pressures

Between 1998 and 2003, a greater number of academic institutions became involved in federally-supported research, and more schools expanded their research and development activities than those that reduced them. Overall, academic institutions increased their research space by 21% during this period. This growth in physical research infrastructure was accompanied by a growth in the scientific and engineering workforce. There was greater growth in postdoctoral positions, part-time appointments and other full-time positions than in regular full-time faculty positions.[26]

[25] For this analysis, we used information about unsolicited proposals only. Information about the budgets, award sizes and funding rates for special solicitations was not available. We also excluded the O/D offices, OPP, and EHR as these had so few unsolicited research proposals.

[26] Science and Engineering Indicators 2006, Chapter 5 (Academic Research and Development) Highlights; http://www.nsf.gov/statistics/seind06/c5/c5h.htm

These positions are often "soft money" positions that need to be supported with extramural funds. These trends are all important components of the increasing pressure to compete for research funds.

Over this same period, support for basic research at U.S. universities and colleges increased by almost 60%, and NSF's research budget grew by nearly 59%. A speculative scenario is that increases in Federal research budgets and relatively high funding rates may influence universities to hire personnel and expand research infrastructure, creating increased volumes of researchers and proposals. The impact may not be felt for several years at NSF, by which time the budget scenario and/or proposal funding rates may have changed for any number of reasons.

Anecdotal reports from several sources indicate that PIs have been experiencing more pressure from their institutions to submit proposals and receive awards. IPAMM explored this issue in the 2007 NSF Proposer Survey. Respondents indicated that, beyond their motivation to contribute to their area of research, building and/or maintaining their own research infrastructure (students, lab space, etc.) motivated them to either a great extent (63%) or to a moderate extent (22%) to submit research proposals to any funding source, including NSF. The pressure to build a funding record to support academic tenure and/or promotion was another significant institutional pressure motivating PIs to submit proposals, with 64% indicating that this motivated them to either a great extent (38%) or a moderate extent (26%). Not unexpectedly, PIs who were within seven years of their degree were much more likely to identify this as a significant driver than those that had received their degree more than seven years ago.

Increases in the Applicant Pool

The number of academic researchers grew by 13% between 1999 and 2003.[27] This increase in the size of the scientific and engineering workforce by itself is not enough to explain NSF's increase in proposal submissions. IPAMM investigated the degree to which increasing involvement by underrepresented groups, the effects of special proposal competitions, and/or changes in funding availability from non-NSF sources may have led to increases in the NSF applicant pool.

NSF Outreach

NSF has, over the past decade, been committed to encouraging greater participation by scientists and engineers from groups currently underrepresented in science and engineering and also from scientists and engineers working in nontraditional institutions (i.e., other than Ph.D. granting universities). NSF regularly conducts outreach through a variety of organized efforts, including semiannual Regional Grants Workshops, outreach workshops to minority-serving institutions, and multiple "NSF days" each year. In addition, many of the directorates, divisions and programs conduct outreach workshops, and the NSF Program Officers frequently make outreach visits at conferences and institutions across the country on an *ad hoc* basis. One goal of these outreach efforts is to help underrepresented groups understand NSF's proposal submission and review processes, and to ensure that they recognize that they are welcome and valued members of the NSF community. To the extent NSF has succeeded in these efforts, the pool of applicants has increased.

[27] Science and Engineering Indicators 2006; http://www.nsf.gov/statistics/seind06/

IPAMM examined submission rates for two groups that have been of particular importance in NSF's outreach efforts: groups underrepresented in science and engineering (including women and minorities) and investigators from universities and colleges other than the traditionally research-intensive institutions.

Underrepresented Groups

Nationally, the number of academic science and engineering (S&E) faculty members holding a Ph.D. increased 3.2% biennially between 1997 and 2003. Within this pool, the male population had an average biennial increase of 0.9% while the female population had an average biennial increase of 10.5%.[28] At the same time, the underrepresented minority population of academic S&E full-time faculty members holding a Ph.D. increased, on average, 0.63% biennially.[29] At NSF, the number of proposals from female and minority PIs showed an average annual increase of 8.9% and 0.12%, respectively, between FY 2001 and FY 2004. Although the growth in the female population among NSF proposers is similar to the overall growth of the national female faculty member population, the growth of minority proposal submissions appears to lag behind the growth of the national minority full time faculty member population. However, NSF's demographic data related to minority status are imprecise because a large number of proposers choose not to report their race or ethnicity.

Proposals from Research Intensive and Other Institutions

To determine if the rise in proposal submissions was driven in part by greater participation from a wider range of institutions, IPAMM determined the rate at which proposal submissions increased from various institution types. During the five year period between FY 2000 and FY 2004, the proposals from RI institutions increased by 42% while proposals from all other sources increased by 58%. Nonetheless, in absolute numbers, most of the proposals submitted over that time period were accounted for by RI schools (as shown in Figure 15).

Table 8
Increase in Research Proposal Submissions from Research Intensive and Other Institutions

Fiscal Year	Total increase in proposals	Increase from RI Institutions	Increase from other Institutions	% of increase accounted for by RI Institutions
2000	1,324	1,138	186	86%
2001	1,653	922	731	56%
2002	2,145	1,454	691	68%
2003	3,438	2,198	1,240	64%
2004	2,875	1,545	1,330	54%

Table 8 looks more closely at the increase, to determine the contribution of RI or other institution types. In FY 2000, most of the increase in proposal submissions over the previous year was due to submissions from RI institutions. By FY 2004, nearly half of the increase was due to submissions from other types of institutions. This suggests, in part, that NSF outreach efforts to

[28] Science and Engineering Indicators 2006; http://www.nsf.gov/statistics/seind06/
[29] Science and Engineering Indicators 2006; http://www.nsf.gov/statistics/seind06/

these institutions was successful. It also suggests that pressure on faculty members to submit proposals may be growing at these other institutions.[30]

Special Proposal Competitions

NSF uses a variety of mechanisms to generate proposals, including Dear Colleague letters, Program Descriptions, Program Announcements, and Program Solicitations.[31] Most NSF research proposals are received either as "unsolicited" submissions to programs that invite scientists and engineers to propose whatever they consider to be a promising or important research idea in a general disciplinary area; or they are submitted in response to a "solicitation" wherein, most often, NSF asks the community to address some specific topic, tool or problem.[32] Program solicitations that focused on specific areas of research were used increasingly between FY 2000 and FY 2005 as part of a strategic effort to stimulate interest in, and foster the development of, emerging research areas such as information technology, nanotechnology, and cyberinfrastructure. It is possible that responses to this type of funding mechanism created dynamics that account for some increases in proposals overall since solicitations may attract new researchers into the NSF community and/or may attract extra effort from PIs who are already active within the Foundation.

As shown in Figure 17, the number of solicitations with specific research foci increased by more than 50% in just two years, between FY 2000 and FY 2002. Proposals responding to these specific solicitations increased as a percentage of the overall proposal portfolio in proportion to the number of solicitations, from 14% in FY 2000 to a peak of 29% in FY 2003 (Figure 18). A comparison of the funding rate trends for unsolicited and solicited proposals is shown in Figure 19. For unsolicited proposals, which represent the majority of NSF's research awards, funding rates declined from 31% to 21% between FY 2000 and FY 2005. Funding rates for solicited proposals seesawed between 24% and 18% between FY 2000 and FY 2002, and then declined steadily to 16% in FY 2005. Although the funding rates associated with solicitations were generally lower than for unsolicited proposals, funding rates for both types of proposals declined over the FY 2000-2005 period. Thus the decline in NSF's overall funding rate was not due solely to the lower funding rates for the solicitations.

[30] See Figure 15 in Section 2 of this report for a complete description of proposals by institution type.

[31] Dear Colleague letters are intended to provide general information to the community, and may be used to draw attention to new or existing funding opportunities, but are not used in and of themselves to solicit proposals. Program Announcements (broad, general descriptions of programs and activities in NSF Directorates/Offices and Divisions) and Program Descriptions (formal NSF publications that announce NSF programs) are the primary mechanisms used by NSF to communicate opportunities for research and education support, as well as to generate proposals. Program Announcements and Program Descriptions utilize the generic eligibility and proposal preparation guidelines specified in the Grant Proposal Guide (GPG) section of the Proposal and Award Policies and Procedures Guide (PAPPG) and incorporate the NSB approved merit review criteria. Program Solicitations are formal NSF publications that encourage the submission of proposals in specific program areas of interest to NSF. Program Solicitations are also issued when the funding opportunity includes guidance that deviates from the generic eligibility and proposal preparation guidelines specified in the GPG. Full definitions for these mechanisms are defined in the Part I.A, Chapter I.C of the PAPPG; http://www.nsf.gov/pubs/policydocs/papp/gpg07140.pdf.

[32] For the purpose of this analysis, although the Program Solicitation mechanism can be used for a wide variety of activities, only those solicitations that requested proposals in a targeted research area have been called out.

Figure 17
Trends in the Use of Solicitations with Targeted Research Foci

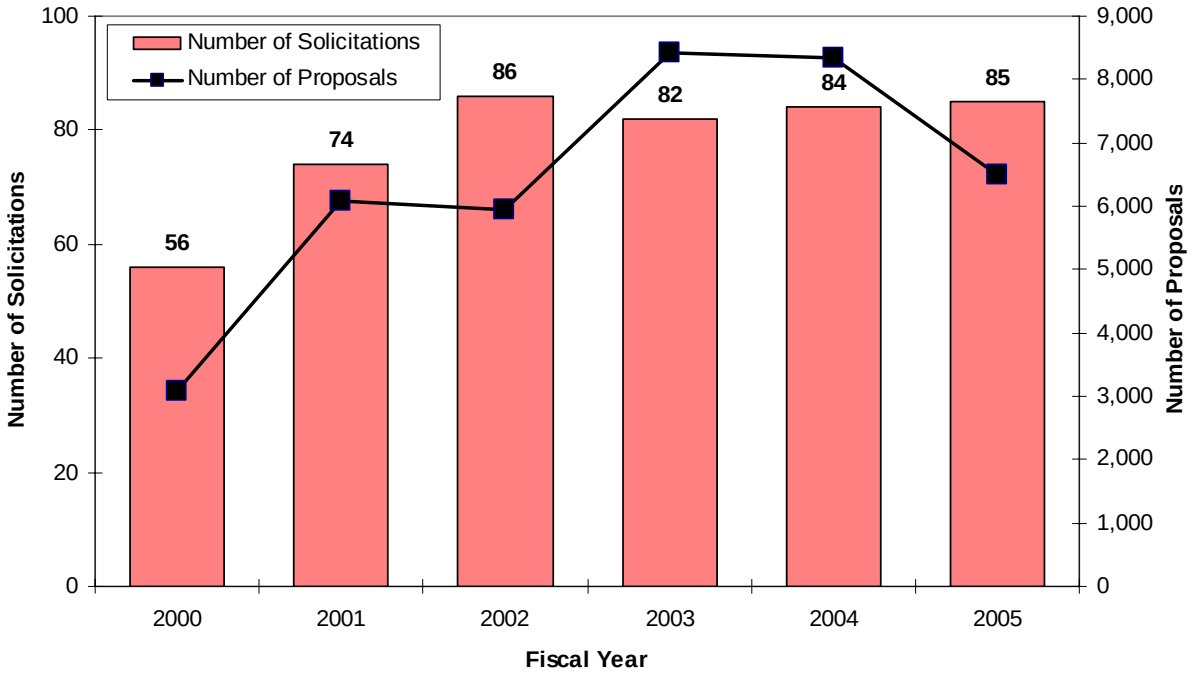

Figure legend: The number of proposals awarded or declined in each fiscal year is shown with the number of solicitations associated with those proposals.

Figure 18
Solicited vs. Unsolicited Proposals within the NSF Research Proposal Portfolio

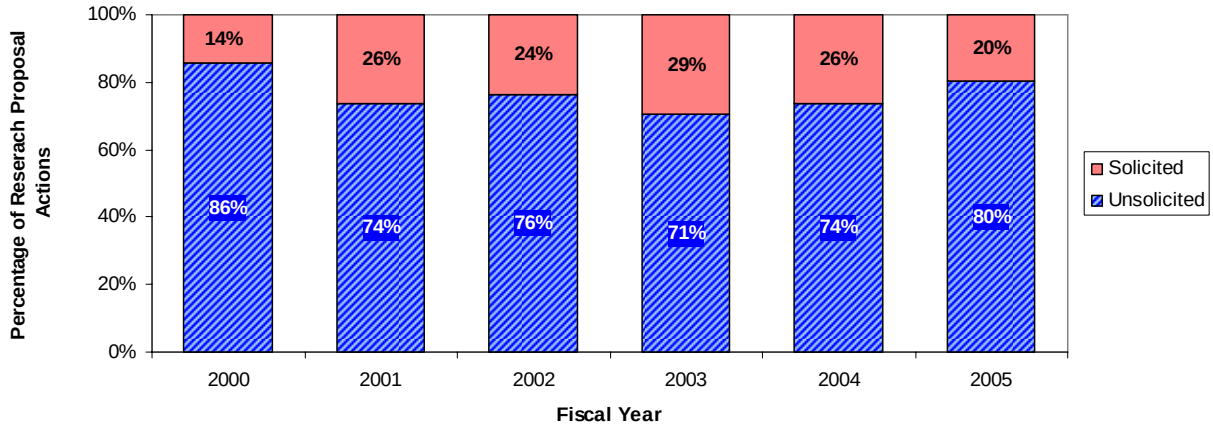

Figure legend: The percentage of all of the proposals processed each fiscal year responding to a solicitation with a targeted research focus compared to the percentage of all proposals processed for unsolicited research areas.

Figure 19
Funding Rates for Solicited and Unsolicited Research Proposals

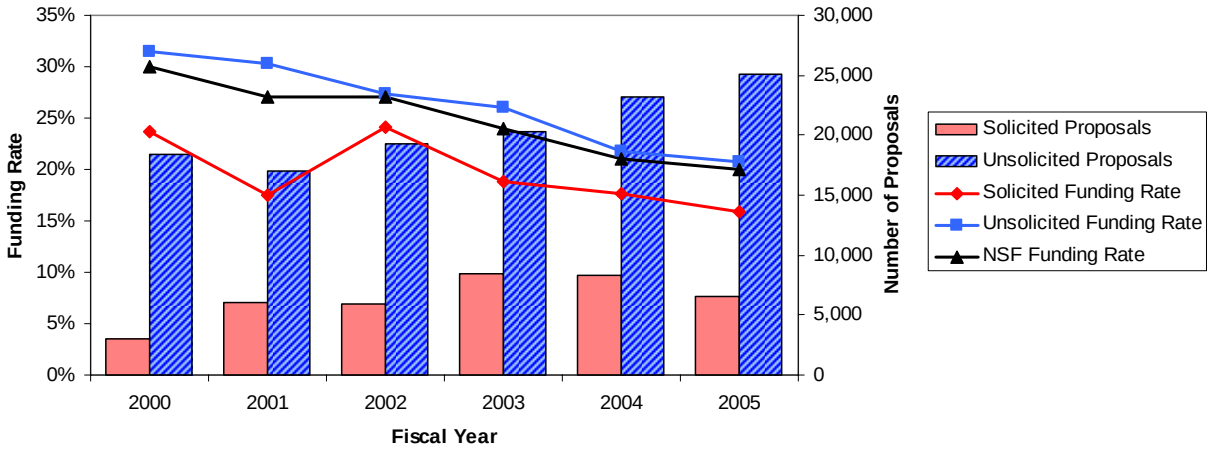

Figure legend: Funding rates for proposals processed in response to a solicitation with a targeted research focus compared to the funding rate for proposals processed for unsolicited research areas. The funding rate for all research proposals is also shown. Also shown are the trends in the number of proposals processed each fiscal year for solicited proposals and unsolicited proposals.

A further analysis of the impact of the solicitations on the increase in total proposals received each year from FY 2000-2005 is shown in Figure 20, which looks at the change each year in proposal submissions to standing or "unsolicited" funding opportunities vs. proposals submitted for special "solicitations". The data in this figure display an interesting seesaw effect, such that in some years the overall increase in proposals was due primarily to an increase in the number of proposals responding to solicitations, while in other years increased numbers of unsolicited proposals drove the overall increase.

IPAMM notes that the Biocomplexity in the Environment and the Information Technology Research Priority Areas were first funded in FY 2000, the Nanotechnology Priority Area was first funded in FY 2001, and the Mathematical Sciences and the Human and Social Dynamics Priority Areas were first funded in FY 2003. The launch of these Priority Areas corresponds closely to the years in which the overall increase in proposals was largely driven by increases in solicited proposals. In the years following the debut of these high-profile solicitations, unsolicited proposals in related areas increased (primarily in CISE, ENG, and SBE), suggesting that PIs who become active with NSF in a special solicitation may remain as members of its submitting pool, and perhaps that declined priority area proposals were revised and submitted to related core programs.

Figure 20
Numeric Changes in Proposals Received (Solicited vs. Unsolicited)

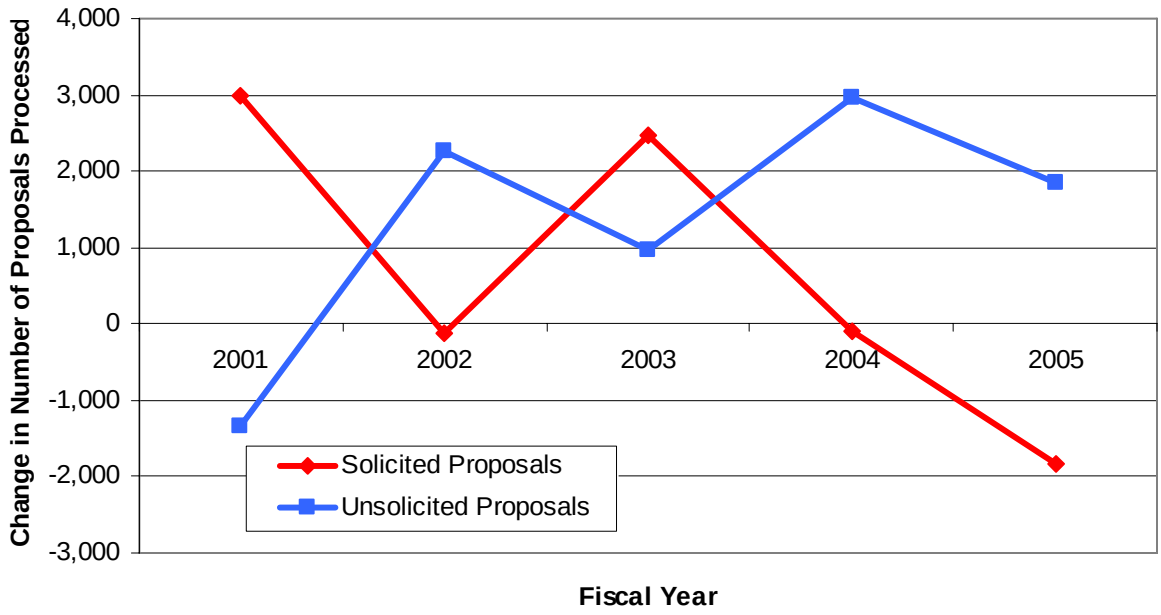

Figure legend. This graph displays the change in the number of solicited and unsolicited proposals processed each fiscal year. It is important to note that the graph shows *increases* in proposals. I.e., in FY 2001, the number of solicited proposals processed increased by ~3000 over the number processed in FY 2000; at the same time the number of unsolicited proposals processed in FY 2001 decreased as compared to FY 2000. After a given increase, that additional volume will reappear in the following year (thus, the baseline volume grows each year). Source: NSF Budget Division

Changes in Funding from non-NSF Sources

Several sources, including some Advisory Committees, suggested that proposal submission to NSF increased because other funding sources, governmental and/or industrial, either reduced their research funding or refocused it in ways that excluded certain existing research communities. IPAMM sought hard data to back up systematically the anecdotal stories shared with us on this topic. In most cases, support from other agencies does not map one-to-one with programs at NSF, making it difficult to compare the consequences of changes. IPAMM looked at three cases that were raised as possible examples:

(1) National Aeronautics and Space Administration (NASA) Funding for Fluid Dynamics: Approximately $35M in annual funding for grants in fluid mechanics, combustion, and transport phenomena was eliminated in NASA's program restructurings between FY 2002 and FY 2005. Between FY 2002 and FY 2006, the number of proposals processed in the Transport and Thermal Fluids Phenomena cluster of programs in ENG (which supports research in the same area as those affected by NASA's cuts) nearly tripled, and funding rates dropped from 35% to 14%.

(2) National Institute of Mental Health (NIMH) Funding for Social Psychology: In FY 2003, NIMH (one of the institutes at the National Institutes of Health; NIH) underwent a

reorganization that included elimination of funding for social psychology. The next year, NSF's Social Psychology program experienced a 116% increase in proposals and a concomitant decrease in funding rates from 21% to 13%. Although these data are suggestive, this same program experienced a similar large influx of proposals in FY 2002, unassociated with any known change in available funding sources.

(3) NIH Funding for Biology: Between FY 1999 and FY 2003, the NIH budget doubled, growing from $13.2B to $27.2B; for the last three years the NIH budget has had only small increases that have not kept pace with inflation. It has been hypothesized that changes in proposal load in the BIO directorate would show an inverse correlation to the changes in the NIH budget. In contrast to this hypothesis, during the five years that the NIH budget was doubling (FY 1999-2003) proposal loads in the BIO directorate grew by 26%; in the past three years, the number of proposals in BIO has continued to grow at approximately the same rate. In comparing proposal numbers in the Division of Environmental Biology (DEB, which is distantly related to most NIH programs) with proposal numbers in the Division of Molecular and Cellular Biosciences (MCB, which is more closely related to NIH programs), we found that both divisions experienced significant growth between FY 1999 and FY 2006, although with different profiles. Proposal submissions to DEB grew substantially in FY 2000 and 2001, and then again in FY 2005 and 2006, for an overall increase of about 61%, while MCB showed a steadier rise in proposal submissions beginning in FY 2001, for an overall increase of approximately 42%.

Based on these analyses, case study #1 seemed to support the perception that decreased funding from other sources was a potential driver for increasing proposal submissions to NSF. However, no clear cause-and-effect relationship could be seen in the NSF data for the other two cases. To gain more insight into community attitudes on this issue, the 2007 NSF Proposer Survey asked PIs to indicate the extent to which decreased funding available from other sources influenced their decision to submit a proposal to NSF in the last three years. 54% of the respondents indicated that they had been influenced to a small (23%), moderate (20%), or great extent (11%) by decreases in funding from other sources. In addition, PIs submitting to either the Social Psychology program or to MCB were more likely than the overall respondent population to indicate that decreased funding elsewhere had moderately or greatly influenced their decision to submit a proposal to NSF (49% and 47%, respectively, as compared to 31%).

Other NSF Internal Activities

Technology: It has been suggested that the use of electronic submission (FastLane) may contribute to increased submission rates. Between FY 1998 and FY 2002, the number of proposals processed by NSF within six months increased by about 30%, due in part to increased efficiencies gained by the shift to electronic proposal processing within NSF. Because NSF was getting proposal decisions to PIs sooner, this may have contributed to increased numbers of resubmissions. NSF does not track the submission of revised proposals, and thus it was not possible to test this hypothesis quantitatively. However, over two-thirds of the respondents to the 2007 NSF Proposer Survey indicated that FastLane made the resubmission process faster, clearer, and easier.

Conclusions

Many factors influence proposal submissions and proposal funding rates. Based on the analyses described in this section, no single factor was identified as the primary contributor.

NSF proposal funding rates declined due to a surge in proposal submissions at the same time NSF was responding to earlier community concerns by making a concerted effort to increase the average award size. Between FY 2000 and FY 2004, NSF's budget increased nearly 44% and the average award size increased by 41%, leaving little room to absorb the nearly 50% increase in proposal submissions.

The increase in proposal submissions resulted from both an increased applicant pool and an increased number of proposals per applicant. There are a number of reasons for the expanded applicant pool, including increased capacity of the research community, increased NSF use of targeted solicitations in new areas, and increases in the NSF budget. The growth in the intellectual capital of the nation is a positive outcome of Federal investments in building the nation's capacity. This is a factor that will need to be incorporated into strategic planning by all funding agencies, including NSF.

The use of special solicitations has contributed to the increase in proposal submission rate, and appears to impact submission rates of unsolicited proposals to the core programs as well. This "halo" effect on increasing proposal submissions to other related programs is an important consequence of using special solicitations, which should be considered as part of the planning during their development. Although the funding rate for solicited proposals was generally lower than that for unsolicited proposals, this was not a major factor in reducing the overall funding rate.

In a few instances the reasons for increased submissions can be traced directly to decreases in funding levels in other Federal agencies. Anecdotal reports suggest that increased submissions may also result from some institutional pressures on faculty members in academic institutions, including valuation of an NSF grant in promotion and tenure, and inclusion of proposal submissions (in addition to receiving awards) in annual performance evaluations. These may be important drivers, but there are not sufficient data to fully assess their role in proposal submissions. Feedback from the 2007 NSF Proposer Survey suggests that some of these increasing institutional pressures, compounded by the declining funding rate, are likely contributors to the growth in the number of proposals per applicant.