2-2014

Which Extramural Scientists were Funded by NIH from its ARRA Funds?

Martin D. Sorin
New York State Department of Health

Randall Hannum
CUNY New York City College of Technology

Recommended Citation
Sorin, M. D., & Hannum, R. J. (2013). Which extramural scientists were funded by the US National Institutes of Health from its ARRA funds?. Science and Public Policy, 41(1), 58-75. https://doi.org/10.1093/scipol/sct035

Which Extramural Scientists were Funded by NIH from its ARRA Funds?

Martin D. Sorin[1*] and Randall J. Hannum[1,2]

Affililations: [1]Wadsworth Center, New York State Department of Health, Albany, New York 12201-0509 USA.

[2] New York City College of Technology, 300 Jay Street, Brooklyn, New York 11201 USA.

*To whom correspondence should be addressed. Fax: (518) 474-3439 Telephone: (518) 486-3882 E-mail: mds01@health.state.ny.us

revised and resubmitted February, 2013

Abstract: NIH distributed $10 billion of ARRA research funds among Principal Investigators (PIs) in 2009-2010. We studied how well the program achieved the goal of creating and retaining jobs. To analyze the distribution of ARRA funding among PIs, they were categorized in two ways: One was based on their history of research funding; the other on the type of funding, ARRA and non-ARRA, each received in 2009 and 2010. These classifications provide insights into who received ARRA funding and how many research PI jobs were created or retained. We found that the majority of ARRA award recipients already had grants and that new and retained PIs received relatively small shares of ARRA funds. Of 13,000 PIs, only 3,000 were created or retained, while the other 10,000 received additional funding. However, ARRA was more efficient in creating PIs than the comparable budget doubling period. But, the PI job effect did not last.

Introduction

The US National Institutes of Health (NIH) is the largest governmental funder of biomedical research in the world. Out of a total budget of $30 billion, it expends approximately $20 billion (Gulledge 2011)[1] annually to fund more than 40,000 extramural research projects[2] and support~~s~~ over 30,000 Principal Investigators (PIs). In 2009-2010, NIH received $10.4 billion[3] (NIH 2012a) or almost one-fifth of additional funds from the American Recovery and Reinvestment Act of 2009 (ARRA)~~.~~ (Stephan 2012).[4] Most of this (or $8.2B) was used to fund over 21,000 extramural research projects. One of the purposes of ARRA was the creation and retention of jobs. The NIH estimated that it created, ~~or~~ saved, or supported[5] 50,000 extramural project staff jobs of all kinds,[6] (NIH 2012b)[7]~~,~~ *(GAO 2011)*[8] with its windfall of federal stimulus funds. According to NIH Director Francis Collins, these "are high-paying, quality jobs that are employing people with considerable skills that we'd hate to see migrating overseas" (Bloomberg News 2009). Now that NIH has largely completed its portion of ARRA, this paper looks at how ARRA funding was distributed among PIs and compares this experience with a prior period of growth in the NIH budget. In what follows, we focus only on research grants and PI jobs (Benderly 2009)[9]*(Kaiser 2009).* [10]

ARRA Implementation Overview

According to NIH, "The recent ARRA legislation provides an unprecedented level of funding ($8.2 billion in extramural funding) to the NIH to help stimulate the US economy through the support and advancement of scientific research. While NIH Institutes and Centers have broad flexibility to invest in many types of grant programs, they will follow the spirit of the ARRA by funding projects that will stimulate the economy, create or retain jobs, and have the potential for making scientific progress in 2 years. We expect to:

1. Select recently peer reviewed highly meritorious research grant applications (R01s and others), that can be accomplished in 2 years or less.
2. Fund new research applications.
3. Accelerate the tempo of ongoing science through targeted supplements to current grants.
4. Support new types of activities such as the NIH Challenge Grant program that meet the goals of the ARRA.
5. Use other funding mechanisms as appropriate" (NIH, 2009c).

In order to expedite review of ARRA grant applications and facilitate the disbursement of funds, a new streamlined set of review criteria placing more emphasis on impact and less on technical details was instituted at NIH (NIH. 2009a). Shortened (12 page research plans instead of 25) and restructured applications were newly required. Virtual reviews were often used in place of in-person meetings. And, more transparent review critiques to help applicants assess whether or not to resubmit amended applications were instituted.

Methods

In order to analyze the distribution of ARRA funding and its impact on the number of funded researchers, this paper uses a database constructed by the authors using data on individual grants obtained from public datasets of the National Institutes of Health. The authors' database consists of all NIH extramural research grant awards for fiscal years 1972 through 2011. The grants for the period 1972 to 1991 in the database were extracted from CDs prepared by the NIH using data from the CRISP (Computer Retrieval of Information on Scientific Projects) system. The grants for the period 1992 to 2011 in the database were extracted from data downloaded from the "NIH Extramural Awards by State and Foreign Country" files of the publicly accessible NIH IMPAC system (Information for Management, Planning, Analysis, and Coordination systems I and II). These websites have recently been replaced by NIH ExPORTER (http://exporter.nih.gov/ExPORTER_Catalog.aspx). The ARRA data were downloaded from their Recovery site (http://report.nih.gov/recovery).

Each PI in the data was assigned a unique identifier (PI ID), which allows for the tracking of individual PIs over time. In order to minimize the two possible errors that can be made in assigning PI IDs, assigning the same number to two different PIs or assigning different numbers to the same PI, various methods were employed. It has been estimated based on a number of samples taken from the data that have been analyzed that the methods used yielded assignment errors of about 1%. The major sources of these errors have been found to be common names, variation in the spelling of names, and name changes due to marriage or divorce.

To analyze the distribution of ARRA funds among PIs and to determine how many NIH research PIs were created or retained as a result, PIs were categorized by their history of NIH research funding. PIs could fall into one of three categories. The first includes PIs with funding in the previous year and are designated as "Previous Year PIs." The second includes PIs with NIH research funding in the past but not in the previous year, designated as "PIs with Gap in Funding." The third includes those with no history of NIH research funding, and are designated as "New PIs." The coding and tracking of PIs over time was made necessary because the US Office of Management and Budget (OMB) ARRA PI reporting instructions and form made no distinction between jobs created and jobs retained (NIH 2009)[11] (OMB 2009).[12] Here, we concentrate on PI jobs, only.

Results

Jobs Created or Retained

PIs were further classified based on whether or not they received NIH ARRA research funding during the fiscal years 2009 and 2010. PIs for each of these two years were classified as having no ARRA funding, "Non-ARRA Only," as having both non-ARRA and ARRA funding, "ARRA+nonARRA," or as having only ARRA funding, "ARRA Only." The number of PIs in each of these categories is summarized in Table 1. (For data on dollars awarded to each category of PIs, see Table S1 in the Supplementary tables.)

Table 1, here

With these PI designations, we identified which PIs received ARRA funds and used this information to determine how many PI jobs were created and retained. In 2009 there were a total of 35,225 PIs supported by NIH research funding, which includes ARRA. Of this total, 10,589 or 30.1% received ARRA funding. The number of new PIs supported only by ARRA funding was 984 (2.8%). The number of PI jobs retained was calculated by summing Previous Year PIs and PIs with Gap in Funding who only received ARRA funding (OMB 2009)[13] and was found to be 1,939 or 5.5% of the total number of PIs. From this it is seen that the majority, 72.4%, of the PIs who received NIH ARRA research grants in 2009 were also getting non-ARRA funding (GAO 2011).[14]

It should be noted that the definitions of the terms 'created' and 'retained' used in this paper in the context of PIs differ from those used to report jobs created or retained as required by ARRA, which as will be discussed later is more accurately described as jobs supported rather than jobs created or retained . Since NIH ARRA funding can be separated from other NIH funding awarded, it is possible to separate those who would have been considered a PI in the absence of ARRA funding from those who were added to the ranks of PIs as a result of ARRA funding. For instance, in 2009 there would have been 32,302 NIH research PIs if ARRA had not existed. With ARRA, the number of PIs increased to 35,225. As a result of ARRA funding, therefore, there were an additional 2,923 PIs. Of this number 984 PIs never had NIH research funding before and are designated by us as created jobs~~.~~, The remaining 1,939 PIs having had NIH research funding in a prior year are designated as retained jobs. Since it is not possible to tell from the data if there were any PIs who accepted an NIH research award on the condition that they also receive an ARRA award, it is not possible to determine if any of the PIs who received both ARRA and non-ARRA funding should also be counted in the 'created' or 'retained' categories. Given the prestige of an NIH research grant and the fierce competition for all sources of research funding, this latter scenario seems unlikely.

Over the two-year period, 2009-2010, there were 41,247 unique PIs supported by NIH research funding including ARRA. Out of this total, 12,958 or 31.5% received ARRA funding. As with just 2009, most of the PIs who received ARRA funding, 76.8%, also received non-ARRA funding during the two year time period. The number of PIs retained over the two year period as a result of ARRA funding decreased slightly from 1,938 in 2009 to 1,830 due to some PIs also receiving non-ARRA funding in 2010. As a consequence, 7.3% of the total number of NIH supported PIs during the two-year period (2009-2010) of ARRA funding received only ARRA funding.

Concentration of Funding

With most of the PIs receiving ARRA grants also receiving non-ARRA grants, we found that ARRA funding increased the concentration of NIH research funding among the well funded PIs (Hand 2012) (Rockey 2011) (Hand 2008). In 2009, the top 20% of PIs in terms of NIH grant money received had 59.3% of the total while the lowest 20% had 3.6% of the total. This contrasts with 58.5% to the top 20% and 4.0% to the lowest 20% in 2008, the year before the initiation of ARRA funding. While this may not seem like that much of a difference, commonly used distribution measures show a significant difference in the years of ARRA funding compared with the period extending from 1980 to 2010 that does not include ARRA funding. In 2011, these measures returned to their pre-ARRA amounts.

Three distribution measures - the Gini coefficient, (World Bank 2002)[15] Top 10% Bottom 10% ratio, and the percentage to the top 10% - all show a significant increase in the concentration in the distribution of NIH research funding among PIs. The Gini coefficient for NIH research funding during the period 1980 to 2010 without ARRA funding has a mean of 0.5158 and standard deviation of 0.0077 (See Figure 1). The Gini coefficient for 2009 for all NIH research funding was 0.5413 or 3.3 standard deviations from the mean and 0.5449 for 2010 or 2.9 standard deviations from the mean. As Figure 1 shows, all of the distribution measures indicate elevated concentrations of funding during the period of ARRA and return to normal levels in 2011 after the program ended. It is interesting to note that the only other years in which the percentage of funding received by the top 10% differed by more than two standard deviations was in 1997 and 1998, the years prior to the doubling of the NIH budget. In these years, though, the percentage was below the mean.

Figure 1, here

Comparison with Doubling Period - 1999 to 2003

In 1998, the Congress and the Clinton administration responded to NIH supporters by approving a significant increase in the NIH budget and indicated its desire to double the NIH budget by 2003 (Frommer 2002). As a result, NIH extramural research grant awards jumped from $9.7 billion in FY 1998 to $18.3 billion in FY 2003. The additional funding ~~grew~~ increased the number of NIH research PIs from 25,085 in FY 1998 to 31,874 in FY 2003, representing a 27% increase.[16] Along with the growth in the number of PIs during this period, the average number of grants per PI also advanced. In FY 1998, the average number of grants per PI was 1.34 and increased to 1.43 in FY 2003, ~~or~~ a 7% increase. (See Figure 2).

Figure 2, here

The doubling period of the NIH budget and the two years of ARRA funding show a number of similarities and differences. By the second year of the doubling period, the NIH research budget had increased by 32.5% compared to 23.4% during ARRA. In terms of the number of NIH research PIs, the first two years of the doubling showed a 9.4% increase. During ARRA, NIH research PIs increased by 7.8%. Hence, in the first two years of each period, a one percentage point increase in the NIH research budget produced a 0.29 percentage point increase in the number of PIs during the doubling and a 0.33 percentage point increase during ARRA. It is interesting to note that the last two years of the doubling showed a 23.4% increase in the NIH research budget and a 10.7% increase in the number of PIs or a 0.46 percentage point increase in PIs for each one percentage point increase in the NIH budget. This suggests that the two years of ARRA produced a more favorable increase in the number of PIs per percentage point increase in the NIH research budget than the first two years of the doubling period, but a less favorable increase compared to the last two years of the doubling.

Both periods show an increase in the concentration of NIH research funding. As Figure 1 shows, starting at a relatively low level in 1998, all of the distribution measures increased during the period of doubling and, for the most part, continued to increase until the ARRA period but stay within two standard deviations of the 1980 to 2011 non-ARRA mean. The addition of ARRA funding causes the three distribution measures presented to increase to values greater than two standard deviations from the mean. This indicates that the concentration of NIH research funding was much higher during the ARRA period than anytime since 1980.

This can be explained in part by the increase in the average number of grants per PI that accompanied both periods. Figure 2 shows that just prior to the doubling period, as the number of research PIs began to increase, the average number of grants per PI also began to increase. The average number of grants per PI peaked in 2004, just after the end of the doubling period and then began to decline. This coincides with the leveling off of the number of PIs and with the flattening of the distribution measures shown in Figure 1. During the ARRA period the average number of grants per PI also increased with the increase in the number of PIs. These two periods show that increases in the NIH research budget bring not only increases in the number of PIs, the average number of grants per PI, but also an increase in the concentration of funding.

Stagnation or decreases in the NIH budget show a different outcome. In the period following the doubling, the NIH research budget essentially stagnated. With that the number of PIs and the distribution measures have remained relatively constant. With the end of ARRA funding the outcome was very different due to an actual decline in funding rather than a stagnation of funding. With the end of ARRA funding all the measures immediately returned to their non-ARRA levels. The number of PIs, the number of grants per PI, the distribution measures all returned to levels that would have been expected had the ARRA program never existed.

Even the mix of PIs engaged in NIH funded research seems to have been relatively unaffected by the ARRA program. Of the 1,198 ARRA-only funded PIs who had a gap in funding 196 (16.4%) were still funded in 2011. Of the 609 PIs with a gap in funding but both ARRA and non-ARRA grants, 480 (78.7%) remained funded in 2011. Of the 1,180 new PIs with only ARRA funding, 153 (13.0%) were still funded in 2011, while of the 377 new PIs with both ARRA and non-ARRA funding, 285 (75.8%) had funding in 2011. This suggests that the ARRA-only funded PIs largely disappeared from the pool of funded PIs when the ARRA funds disappeared.

ARRA Funding Mechanisms

As implemented, the bulk of the NIH ARRA research funding flowed through a relatively small number of grant mechanisms and grant types. NIH utilized both existing and new mechanisms to distribute ARRA funds. The largest percentage of the ARRA funds were distributed using the existing R01 mechanism (see Table 2, Summary by Mechanism and Grant Type; for data on dollar funding amounts, see Table S2 in the Supplementary tables), which generally supports investigator initiated research. The existing R21 mechanism, which is designed to support the early stages of a research concept, was also used extensively. (For data on all mechanisms used during ARRA consult Supplementary Online Materials Table S3).

New or previously underutilized mechanisms in the "RC" family were also used to distribute ARRA funds. The largest of these was the RC2 mechanism, referred to as the "Grand Opportunities" or GO grant. This mechanism was designed to "support high impact ideas that lend themselves to short-term funding". (http://grants.nih.gov/grants/guide/rfa-files/rfa-od-09-004.html) Others included the RC1, called the "Challenge Grant", designed to support comparative effectiveness research, and the RC3, which was designed to commercialize innovative ideas and biomedical technologies. Only businesses were eligible to apply for RC3s. ARRA RC1 or Challenge grants yielded over 20,000 applications and were reviewed by more than 18,000 reviewers (NIHd, 2009).

The three main grant types supported by ARRA were new grants (Type 1), competitive renewals (Type 2) (which were both subjected to competitive peer review), and administrative supplements (Type 3) (administratively reviewed). These had the apparent objectives of speeding up existing awards and ~~to~~ awarding projects that previously fell just below the payline. While new grants represented 50.3% of the 2009 dollars awarded, 40.9% of the dollars went for administrative supplements, (Stephan 2012)[17] which represented additional money for existing grants, and therefore, for the most part, went to PIs with non-ARRA funding. Of the new grants, 63.3% of the 2009 dollars went to PIs who had research grants in 2008.

In 2010, the bulk of the ARRA funds went for continuation (type 5) grants since many of the grants awarded in the first year of the program were funded for two years.

Over the two-year period of ARRA, the largest percentage of ARRA research funds went to ~~the~~ R01 applications with 30.5% of the total.[18] Of the R01 amount, 37.2% went to Type 3 grants or Non-Competing Administrative Supplements (NIH 2012b).[19] In 2009, 75.6% of the ARRA R01 grant dollars went to PIs with non-ARRA grants in that year. In 2010, this percentage was 60.1%. The combined total of four grant mechanisms (RC1, RC2, RC3, and RC4) that saw a very large jump in funding as a result of the ARRA program represented the second largest destination for ARRA research funds with 30.5% of the total. For the ARRA "RC" grants, 65.6% of the grant dollars went to PIs with non-ARRA grants in 2009 and 62.3% in 2010.

Over the two year period of ARRA research awards, 2009 and 2010, 86.3% of the nearly $8 billion awarded was distributed through eleven mechanisms with R01 and RC grants accounting for 62.9% of the total (See Table 2). Of the total amount awarded, 74.0% went to PIs who also had non-ARRA funding during the two-year period.

Of the top eleven mechanisms in terms of amounts awarded, the RC3 mechanism distributed the largest percentage to New PIs with 40.3%, while the P01 mechanism, being more complex and aimed at groups of investigators led by established PIs funded the fewest, with less than 1%. In total, 8.0% of the amount awarded through ARRA went to New PIs (See Supplemental Table S1, Total for 2009 + 2010 New PIs). 1.0% of the ARRA+non-ARRA amount went to New PIs (Supplemental Table S1, item C). And, 12% of the ARRA funding went to New PIs with non-ARRA funding (Supplemental Table S1, item C/Total New PIs).

Table 2, here

Discussion

The American Recovery and Reinvestment Act of 2009 was “a massive program of short-term funding” intended to “jump start” a faltering US economy (Weissert and Weissert, 2012). The program implemented by NIH to distribute ARRA funds must be viewed in the context of the pre-existing NIH funded research enterprise. As highlighted in this paper, most of the NIH ARRA research funds found their way to PIs who already had NIH research grants. While it is relatively easy to determine the impact of ARRA funding on the number of PIs and on the concentration of NIH research funding, much less tangible is the impact on job retention and creation, and on biomedical research outcomes. Neither lend themselves to easy measurement.

This paper deals with the issue of job creation and retention but takes a different approach to the issue than outlined by the official OMB guidelines for reporting job creation and retention (OMB, 2009). In the context of NIH funded research, job creation and retention requirements required those funded to report the number of full-time equivalent jobs supported by the grant money received each quarter of a year. This involved allocating the percentage of time in a full-time schedule devoted to the research project funded. Given the other functions performed by most of those involved in research in an academic setting, it is difficult to determine the extent of job creation and retention. Since the time of those involved in research may be rather fungible, the jobs, if any, actually created or retained may be outside of the research project. One possible scenario is that the funding may have allowed a reduction in the teaching load of a faculty member. As a result, someone else may have been hired to teach the ~~class~~ course, which would create or retain a job, or the ~~class~~ course may have been cancelled, which created no job. In settings where time is allocated in a number of different ways, reporting the number of jobs supported by a grant is not equivalent to the number of jobs created or retained by a grant.

While the concentration of NIH grant resources (the Gini coefficient) rose from its 2008 level with the addition of ARRA funds, it barely rose each year over the five years of budget doubling. The number of research PIs rose each year from 1998 to 2003, and it rose again in 2004. This was a significant difference between the doubling and the ARRA periods. While the additional funds from the 1999-2003 doubling remained in the NIH budget afterwards and the number of PIs continued to increase until the flat funding of the second Bush term, the additional ARRA funds disappeared from the NIH budget after the two years of the program, (with the exception of two I/Cs that chose to stretch out their ARRA funding for three years instead of two). Hence, when ARRA funding ceased being a temporary respite from the years of flat funding, the number of PIs returned to the pre-ARRA level. Thus, it is not surprising that resultant jobs also disappeared when ARRA funds dried up because ARRA funding was not sustained. The 2010 number of research PIs, including those funded by ARRA had been 35,369. But, in 2011 the number fell back to a pre-ARRA level, (32,264).

Further, while the doubling period involved a slight rise in the concentration of funds distribution among PIs, the ARRA period involved substantially more concentration than usual due largely to the distribution of a disproportionate share of the funds to PIs who were already highly funded in the form of "targeted supplements to current grants." In addition, "recently peerreviewed (sic), highly meritorious R01 and similar mechanisms capable of making significant advances with a 2-year grant," and "new R01 applications that have a reasonable chance of making progress within 2 years," were awarded (nih (e) record, 2009). Hence, ARRA funds often went to those who had existing grants and/or whose proposals received high priority scores that were just below the 2008 funding line.

NIH research funding should be judged by the contribution that it makes to science and ultimately its impact on human health. ARRA funding, though, brought an additional objective and that was job creation and retention. From the base years (1998 and 2008) the first two years of the doubling added 9.4% PIs for a budget increase of 32.5% while ARRA added 7.8% PIs for a budgetary increase of 23.4%. During that period, PIs increased 0.29% for each 1 percentage point increase in the research budget, while during ARRA PIs increased by 0.33%. In this limited sense, ARRA was more efficient than the first two years of the doubling.

Among the jobs created by ARRA, were undoubtedly those of co-PIs/research scientists/other faculty, IT/data information specialists, consultants, lab technicians, pre-/post-doctoral fellows/students, graduate students, summer students, science educators, temporary/part-time employees, administrators/management/executives, medical specialists, and sub-contractors

(NIH 2012b).[20] Before creating these jobs, NIH used an estimate of $50,000 per Master's degree-holding staff member to forecast the number of jobs that could be funded by ARRA (GAO Report 2011).[21] These non-PI FTE lab personnel jobs were funded by Type 3 supplements to existing projects and Type 1, Type 2, and Type 5 awards to PIs who had existing NIH projects.

Supplements were a convenient vehicle that could be used to expand existing projects to incorporate additional specific aims and hire additional staff. However, when we removed supplements from the data and redid the calculations, the effect was less than we expected; that is, the concentration of awards among existing PIs was still greater than usual. Eliminating supplements from the ARRA analysis only reduced the ARRA elevation in the usual Gini coefficient at NIH by about half (from about .54 to .53). In fact, when the share of ARRA funds that went to the top 10%/bottom 10% was computed, 64% of 2009 and 50% of 2010 ARRA funds still favored those in the top 10%, without supplements.

Our data shows that the top quintile of PIs – those who received about 60% (61.4%) of all NIH research funding in 2009 and 2010 - received two-thirds of ARRA funding. This aspect of the NIH distributional stratification is at the heart of the recent debate in *Nature* and in Sally Rockey's "Nexus" blog concerning what some see as the excessive concentration of NIH funds among a relatively small stratum of very well funded PIs (Hand, 2008) (Rockey, 2011) (Cole & Cole, 1973).

As outlined earlier, ARRA reporting requirements did not distinguish between jobs created and retained. In addition, they did not distinguish between PIs that already had funding and those that did not, relying instead on whether a job was supported by the ARRA project budget or not. [9, 10, 2220] Our approach lends greater clarity to the term "jobs created and retained," at least for PIs, by separating those who already were funded, those with a gap in funding (retained), and those who were newly funded (created).

As our analysis has shown, most of the additional money for PIs went to PIs who already had non-ARRA NIH grants. This caused the average number of grants per PI to grow and the concentration of research funding among PIs to reach historic highs.

Future Research

The paradox is that when a sudden influx of funds with a known end date came to NIH, it went to scientists who already had funding. Perhaps this is the only way the program could have been quickly implemented.

One wonders whether a similar pattern of funds distribution occurred with ARRA funding at the other scientific funding agencies. On the other hand, when a sudden increase in NIH funding that was sustained on a permanent basis took place, only a slight increase in funding concentration occurred. Was this also true of recent, sustained increases in the extramural budgets of other agencies like NSF, NIST, etc.? Would the effects on the jobs created/retained and the science have been better had the annual NIH stimulus funding been smaller and stretched out over a longer period of time? Or, was the missing element sustaining the budget increase permanently in an agency that largely survives on the basis of its extramural grants?

Aside from its impact on creating and retaining jobs, did either the doubling or ARRA result in important scientific advances or the acceleration of breakthroughs? Or, did it only temporarily accelerate short-term progress at the expense of future progress? It is easy to associate outcomes with specific NIH ARRA grants; it is much more difficult to determine the overall difference that ARRA funding made given that all of the positive scientific outcomes may have occurred in the absence of ARRA funding.

These are questions that will require detailed studies of published papers and possibly, patents, to answer. And, without the existence of a control group – a counterfactual - how is one to know?

Looking at how ARRA funding changed measurable research outputs such as publications and patents may provide insights into its impact. Analyzing the future funding of researchers supported by just ARRA, may provide clues as to the value of the research supported by ARRA funding. Further research along these lines is definitely warranted.

Certainly, in the area of military operations, recent evidence from the Iraq conflict indicates that a so-called troop surge helped to make advances where progress was stalled. Is this also true with scientific research where the goals are more illusory? Are analysts like Michael Teitelbaum (Teitelbaum, 2007) correct in maintaining that funding surges in science only lead to increased numbers of applications, lower success rates, and more unemployed scientists? Are the effects of sudden, unsustained increases of funding to grantmaking agencies in science transitory? Do they lead to permanent overloads of administrative structures via continuing increases in the number of applications for funding?

How much of the economic recovery is traceable to ARRA at NIH? How many lost their ARRA jobs afterward? How long were they without jobs before ARRA and after? And, what about the major purpose of NIH – health research? Was it improved? What would NIH funded research have been like without ARRA funding? How many pending studies would have been funded without ARRA?

Experience with the Stimulus also presents researchers with a possible partial, solution to some of NIH's persistent problems in solving its difficulties with its social mission – decreasing the average age of new PIs and increasing the proportion of female and minority PIs - while maintaining the quality of its awards. Can this possible solution be modeled? Would reserving a significant portion of the funds for new awards for 2 year R01s, new PIs or "Early Independence Awards" using the ARRA-tested, streamlined review process, (for which previous and current PIs would be ineligible), bring a higher proportion of new and young PIs in, as well as new ideas? Could postdoctoral fellows be sponsored by their more established mentors? Would this result in spreading the new funds to more young, female, and minority scientists while reducing the concentration of NIH funds?

Lastly, how well did the disparate components of ARRA work when based at NIH – improving the economy, creating and retaining jobs, and fostering scientific advancement? Did the burdens of adding the troubled economy to the already great burden of science, slow the science? Or, did ARRA only change the emphases among the existing impacts of grant funding at NIH, where extramural grants which account for 70% of the budget, already mostly go to pay the salaries of project staff?

These are all topics that deserve additional research.

[1] For federal plans to cut research budgets see Gulledge, J. (2011).
[2] NIH usually defines research as excluding fellowship, training, and construction grants, and contracts. For purposes of ARRA research training and extramural construction were included. We exclude them for purposes of consistency in making comparisons to other years.
[3] In FY2010 NIH non-ARRA funding totaled $31.2 billion of which $21.4 billion was awarded to extramural researchers.
[4] For the story of how former Sen. Arlen Spector increased NIH stimulus funding from $3.9 billion to $10.4 billion see Stephan, P. (2012).
[5] OMB, 2009
[6] Direct, indirect, and induced quarterly, fulltime equivalent jobs.
[7] NIH ARRA Funding report. (2012b). ARRA-created jobs included 5,000 summer jobs for students and science educators. (p. 1 of ARRA Funding report.
[8] See Figure 3, p. 12 *GAO Report to Congressional Requesters. (*2011) for the approximate distribution of ARRA-supported jobs.
[9] See Benderly, B. L. (2009) for details of one I/C's ARRA-funded faculty hiring program.
[10] On hiring students and postdocs with ARRA funds, see Kaiser, J. (2009) We have no data on jobs created and retained for non-PI positions. Obviously, job creation/retention were byproducts of the main goal of NIH funding – the conduct of biomedical research. In addition, Star Metrics will have data in the future on the FTE jobs of all staff supported by ARRA and non-ARRA federal grants at participating research institutions. (see https://www.starmetrics.nih.gov/)
[11] NIH ARRA Frequently Asked Questions – American Recovery & Reinvestment Act of 2009 (ARRA). Section D, p. 18, Job Creation Estimates. "What is the difference between a job created and a job retained?" "For the purposes of ARRA reporting there is no difference…" "Are 'Jobs Created' and 'Jobs Retained' reported separately?" "No…" http://grants.nih.gov/recovery/faqs_recovery.html
[12] Also see OMB December 18, 2009 Updated Guidance on the American Recovery and Reinvestment Act – Data Quality, Non-Reporting Recipients, and Reporting of Job Estimates (OMB M-10-08).
[13] An alternative method for calculating the number of Created and Retained PIs is ~~to follow~~ the method outlined in Section 5.5 of OMB's December 18, 2009, Updated Guidance on the American Recovery and Reinvestment Act – Data Quality, Non-Reporting Recipients, and Reporting of Job Estimates. There, a method for calculating jobs created and retained that we are unable to implement with our annual data is used in PIs' quarterly self reports. It is really a method for calculating the number supported. The guidance document says "A second important change is in the definition of a job created or retained. Previous guidance required recipients to make a subjective judgment on whether a given job would have existed were it not for the Recovery Act. The updated guidance eliminates this subjective assessment and defines jobs created and retained as those funded in the quarter by the Recovery Act. Jobs funded by non-Recovery Act funds will not be counted unless they will be reimbursed (See Section 5.9). Jobs funded partially with Recovery Act funds will only be counted based on the proportion funded by the Recovery Act (See Section 5.5)" (OMB M-10-08, Section 5.1, p. 11).
"2. Definitions of jobs considered to be created or retained:
a. A job created is a new position created and filled, or an existing unfilled position that is filled, that is funded by the Recovery Act;
b. A job retained is an existing position that is now funded by the Recovery Act.
Using the definitions above, recipients must estimate the total number of jobs that were funded in the quarter by the Recovery Act. A funded job is defined as one in which the wages or salaries are either paid for or will be reimbursed with Recovery Act funding.
3. A job must be counted as either a job created or a job retained; it cannot be counted as both." (OMB M-10-08, Section 5.2, p. 11)."

[14] See also Table 3: Percent of NIH Recovery Act-Supported Jobs That Did Not Exist Prior To Receiving NIH Recovery Act Funding, as Reported by Selected Principal Investigators, through March 2011,
Appendix II, p.22 of GAO Report to Congressional Requesters. National Institutes of Health: Employment and Other Impacts Reported by NIH Recovery Act Grantees, GAO—12-32, November 2011 in which it is reported

that two-thirds of the 42 responding PIs (50 non-representative recipients of new, non-supplement, $500,000+ ARRA grants at the 5 largest grantee institutions were sampled of whom 8 PIs did not respond) indicated that their ARRA projects "(s)upported jobs that existed prior to receiving NIH funding." The other one-third reported creating new ARRA-funded jobs. Most jobs were part-time. GAO Report, pp. 12 and 20.

[15] Also known as the index of dissimilarity.

[16] Authors' calculation of number of 2003 research PIs divided by number of 1998 (base year) research PIs.

[17] Undoubtedly, many such supplements were awarded to permit the hiring of additional staff by so-called "shovel ready" projects. See Stephan, P. (2012) p. 144 for additional details about how ARRA funds were allocated among mechanisms and grant types.

[18] In 2009, 59.68% of the ARRA PIs had ARRA supplements (6,319/10,589). In 2010, there were 30.78% (2,325/7,553).

[19] See NIH 2012b p. 1. See also Table 6 Appendix 2, p. 24 of aforementioned GAO Report.

[20] NIH 2012b, p. 1. See also Table 6 Appendix 2, p. 24 of aforementioned GAO Report.

[21] Also see p. 9 and its footnote 21 of the aforementioned GAO Report for similar NIH statements prepared for that report and the aforementioned NIH Funding Report for mention of the 50,000 jobs.

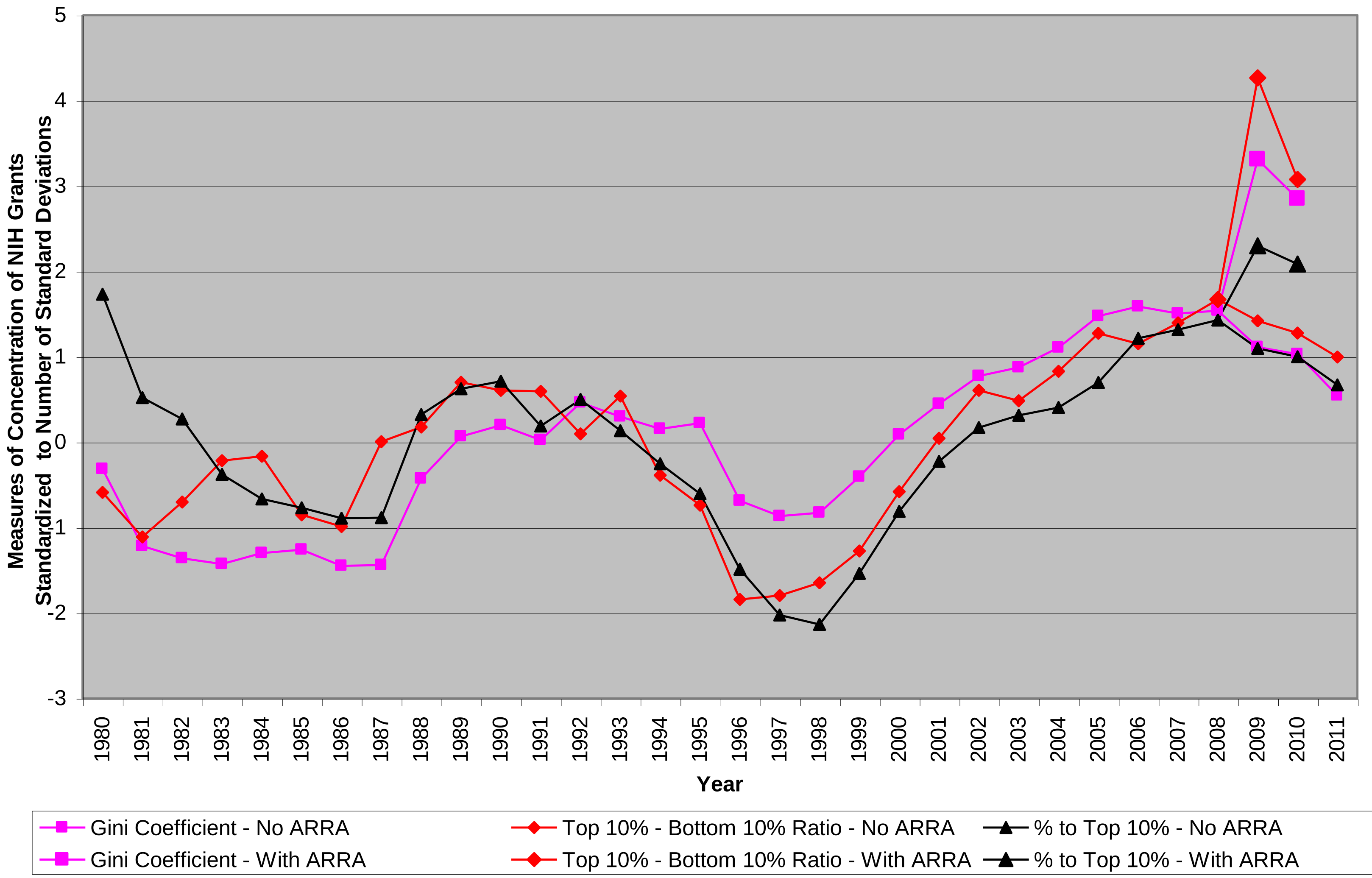
[22] ARRA reporting requirements also do not distinguish among different positions created and retained.

References

Benderly, B. L. (2009) ‘Support for Tenure-Track Jobs in Biomedical Sciences,’ Science, 324/27.
Bloomberg News, (December 31, 2009).
Cole, Jonathan R. and Stephen (1973) Social Stratification in Science, University of Chicago Press, Chicago.
Frommer, R. (January 14, 2002) ‘POV: Point of View. Research Advocacy: Making A Difference New from Columbia Health Sciences,’ 1/1.
GAO Report to Congressional Requesters. National Institutes of Health: Employment and Other Impacts Reported by NIH Recovery Act Grantees, GAO—12-32, November 2011.
Gulledge, J., (2011) ‘Debt Crisis: Crunch Time for US Science. Nature 477, 155-156.
Hand, E. (19 March 2008), ‘222 NIH grants: 22 researchers,’ Nature, pp. 258-259.
Hand, E. (2102) ‘Extra scrutiny for ‘grandee grantees.’ Nature 482, 450-451.
Kaiser, J. (2009) ‘NIH Stimulus Plan Triggers Flood of Applications—and Anxiety,’ Science, 324, p. 318.
NIH. (2009a) Updates American Recovery Act (ARRA) & Enhancing Peer Review Project, Peer Review Advisory Committee, June 8th, 2009, Lawrence A. Tabak, DDS, PhD.
NIH (2009b) ARRA Frequently Asked Questions – American Recovery & Reinvestment Act of 2009 (ARRA). Section D, p. 18, Job Creation Estimates.
NIH. (2009c). http://grants.nih.gov/recovery/
NIH (2009d) News, June 8, 2009.
nih (2009e) record. March 20, 2009.
NIH Office of Budget. 2012a http://OfficeofBudget.od.nih.gov/spending_hist.htm downloaded April 18, 2012 (tables Appropriations History by Institute/Center (1938 To Present) and Spending History By Institute/Center, Mechanism, etc. (1938 To Present).
NIH ARRA Funding report. 2012b http://report.nih.gov/recovery/NIH_ARRA_Funding.pdf downloaded April 18, 2012
OMB December 18, 2009 Updated Guidance on the American Recovery and Reinvestment Act – Data Quality, Non-Reporting Recipients, and Reporting of Job Estimates (OMB M-10-08).
Rockey, S. April 6, 2011, updated May 13, 2011. ‘Myth Busting: Number of Grants per Investigator’ *Nexus*.
Stephan, P. (2012) *How Economics Shapes Science* pp. 128-129 Harvard University Press, Cambridge
Teitelbaum, Michael S. (November 6, 2007) Testimony of Michael S. Teitelbaum, Vice President, Alfred P. Sloan Foundation before the Subcommittee on Technology and Innovation, Committee on Science and Technology , U. S. House of Representatives.
The World Bank “Measuring Inequality”, (2002) http//web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTPOVERTY/EXTPA/0,,contentMDK;20238991`menuPK:492138`pagePK:148956`piPK:216618`theSitePK:430367,00.html
Weissert, William G. and Carol S., (2012) Governing Health, The Politics of Health Policy, 4th edition, Baltimore, The Johns Hopkins University Press), 241.

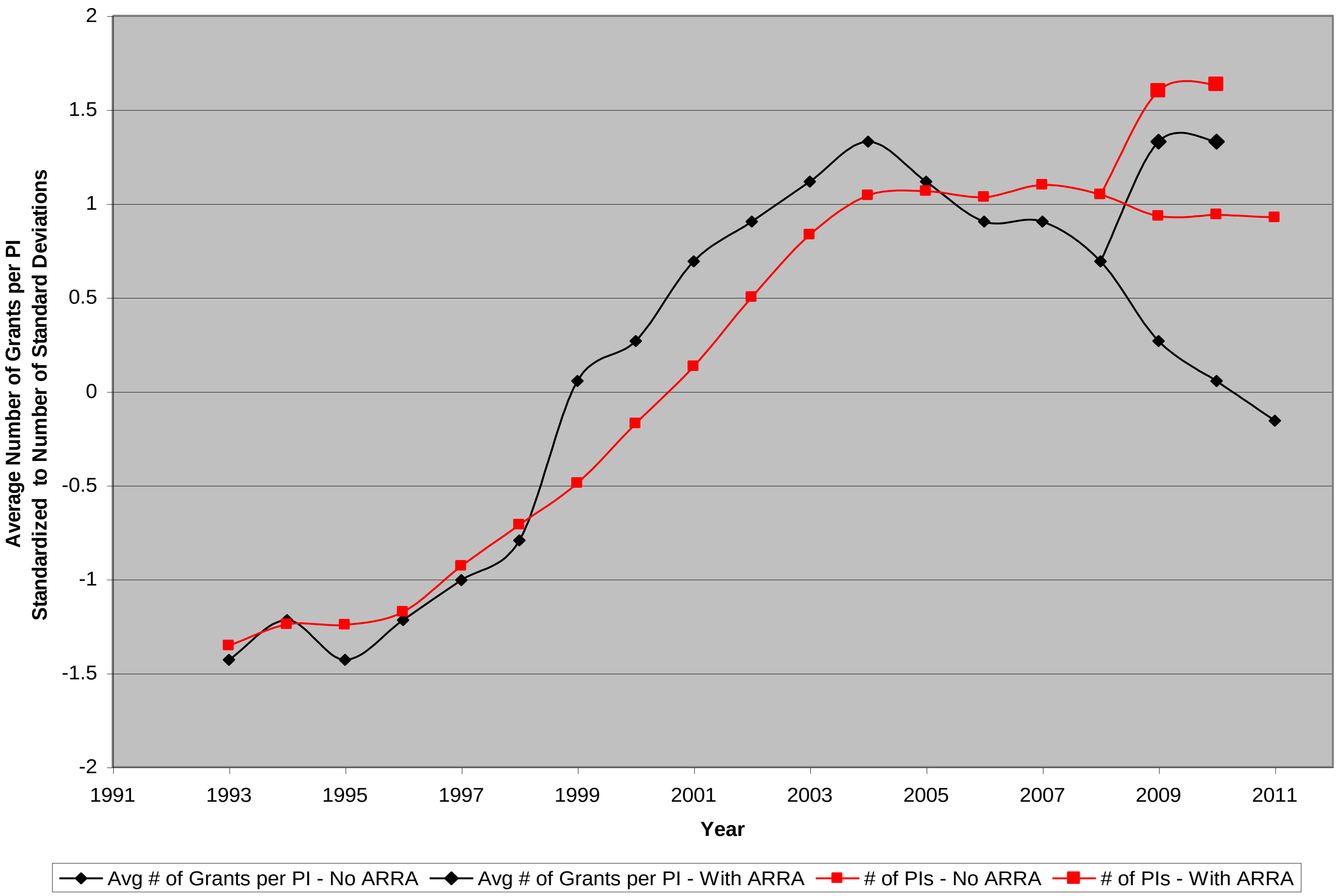
Acknowledgements. We thank the reviewers of this article, Kei Koizumi, Assistant Director for Federal Research and Development at the White House Office of Science and Technology Policy (OSTP), Julia Lane, Senior Managing Economist at the American Institutes for Research and former Director of the Science of Science and Innovation Policy program (SciSIP) at NSF and developer of Star Metrics, and Carmen Mannella, Associate Director for Research and Technology at the Wadsworth Center work, as well as the anonymous reviewers for Science and Public Policy for their valuable contributions to this article.
All remaining errors are, of course, ours.

ARRA 2009 and 2010 data are available on the NIH web page under Recovery Act.


Measures of Concentration of NIH Grants Standardized to Number of Standard Deviations
5
4
3
2
1
0
-1
-2
-3
1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Year
Gini Coefficient - No ARRA
Gini Coefficient - With ARRA
Top 10% - Bottom 10% Ratio - No ARRA
Top 10% - Bottom 10% Ratio - With ARRA
% to Top 10% - No ARRA
% to Top 10% - With ARRA

.

Fig. 1. Measures of concentration of NIH grants among PIs. During 2009 and 2010 measures of PI funding distribution are far more concentrated with ARRA (top 3 lines) than without it (bottom 3 lines). 2009 recorded the highest concentrations.



Notes:
Avg # Grants per PI - Mean: 1.38, Standard Deviation: 0.047
# of PIs - Mean: 28,200, Standard Deviation: 4,387
(Supplements are not counted as separate grants. In 2009 without ARRA 7.45% of PIs had a supplement, with ARRA 22.82% had a supplement. In 2010 without ARRA 6.54% had a supplement, with ARRA, 12.00% had a supplement.)

Fig 2. Average number of grants per PI by year. The average number of awards per PI peaked shortly after (2004) the period of NIH budget doubling (1999-2003) and during ARRA (2009 and 2010) at 1.44. The number of PIs remained stable (+/- 1,000) after the end of the doubling until 2011 without ARRA and rose during ARRA by only 3,000 due to the large proportion of awards to PIs with non-ARRA funding.

	FY 2009						
	nonARRA only	ARRA+nonARRA		ARRA only		Total
Previous Year PIs	19,682 (55.9%)	7,149 (20.3%)	A	859 (2.4%)	D	27,690 (78.6%)
PIs with Gap in Funding	2,064 (5.9%)	309 (0.9%)	B	1,080 (3.1%)	E	3,453 (9.8%)
New PIs	2,890 (8.2%)	208 (0.6%)	C	984 (2.8%)	F	4,082 (11.6%)
Total	24,636 (69.9%)	7,666 (21.8%)	G	2,923 (8.3%)	H	35,225 (100.0%)

	FY 2010					
	nonARRA only	ARRA+nonARRA		ARRA only		Total
Previous Year PIs	22,420 (63.4%)	4,417 (12.5%)	A	2,518 (7.1%)	D	29,355 (83.0%)
PIs with Gap in Funding	2,166 (6.1%)	63 (0.2%)	B	257 (0.7%)	E	2,486 (7.0%)
New PIs	3,238 (9.1%)	29 (0.1%)	C	269 (0.8%)	F	3,536 (10.0%)
Total	27,824 (78.6%)	4,509 (12.7%)	G	3,044 (8.6%)	H	35,377 (100.0%)

	FY 2009 and 2010					
	nonARRA only	ARRA+nonARRA		ARRA only		Total
Previous Year PIs	18,096 (43.9%)	8,961 (21.7%)	A	633 (1.5%)	D	27,690 (67.1%)
PIs with Gap in Funding	4,132 (10.0%)	609 (1.5%)	B	1,198 (2.9%)	E	5,939 (14.4%)
New PIs	6,061 (14.7%)	377 (0.9%)	C	1,180 (2.9%)	F	7,618 (18.5%)
Total	28,289 (68.6%)	9,947 (24.1%)	G	3,011 (7.3%)	H	41,247 (100.0%)

	2009	2010	2009 - 2010
PIs with ARRA Funding (G + H)	10,589	7,553	12,958
New PI Jobs Created (F)	984	269	1,180
PI Jobs Retained (D + E)	1,939	2,775	1,831
Additional Funding to Funded PIs (G)	7,666	4,509	9,947

Table 1. Impact of ARRA funding on NIH research PIs. Most of the approximately 13,000 PIs with ARRA funding also had existing non-ARRA awards (9,959, 77%). Almost 1,200 (9%) New PIs were created by ARRA. Another 1,800 (14%) were retained. Seven-tenths of ARRA funds went to Previous Year PIs. One-eighth of ARRA funding went to New PIs. One-sixth of funding went to PIs with a funding gap.

Amounts - 2009

Mechanism	Grant Type: 1	2	3	5	Other	Total
R01	526,197,634	277,989,824	782,823,789		542,467	1,587,553,714
RC2	625,231,375					625,231,375
RC1	389,581,204		4,279,590			393,860,794
R21	247,132,485		29,947,211			277,079,696
Other	354,606,503	96,899,149	923,262,575		76,750	1,374,844,977
Total	2,142,749,201	374,888,973	1,740,313,165	0	619,217	4,258,570,556

Percentage of Total - 2009

Mechanism	Grant Type: 1	2	3	5	Other	Total
R01	12.4%	6.5%	18.4%		0.0%	37.3%
RC2	14.7%	0.0%	0.0%		0.0%	14.7%
RC1	9.1%	0.0%	0.1%		0.0%	9.2%
R21	5.8%	0.0%	0.7%		0.0%	6.5%
Other	8.3%	2.3%	21.7%		0.0%	32.3%
Total	50.3%	8.8%	40.9%	0.0%	0.0%	100.0%

Amounts - 2010

Mechanism	Grant Type: 1	2	3	5	Other	Total
R01	4,927,995	9,798,394	175,686,048	783,590,034	12,808,999	986,811,470
RC2	7,977,480		8,801,781	531,462,489	3,213,638	551,455,388
RC1	44,994,939		1,025,588	377,306,145	5,321,926	428,648,598
RC4	321,630,524		320,490		1,743,324	323,694,338
RC3	102,848,696				-	102,848,696
R21	9,151,368		7,907,799	227,266,940	4,103,434	248,429,541
S10	246,422,392				842,429	247,264,821
Other	175,033,046	28,639,849	240,009,372	346,709,611	4,927,275	795,319,153
Total	912,986,440	38,438,243	433,751,078	2,266,335,219	32,961,025	3,684,472,005

Percentage of Total - 2010

Mechanism	Grant Type: 1	2	3	5	Other	Total
R01	0.1%	0.3%	4.8%	21.3%	0.3%	26.8%
RC2	0.2%	0.0%	0.2%	14.4%	0.1%	15.0%
RC1	1.2%	0.0%	0.0%	10.2%	0.1%	11.6%
RC4	8.7%	0.0%	0.0%	0.0%	0.0%	8.8%
RC3	2.8%	0.0%	0.0%	0.0%	0.0%	2.8%
R21	0.2%	0.0%	0.2%	6.2%	0.1%	6.7%
S10	6.7%	0.0%	0.0%	0.0%	0.0%	6.7%
Other	4.8%	0.8%	6.5%	9.4%	0.1%	21.6%
Total	24.8%	1.0%	11.8%	61.5%	0.9%	100.0%

Table 2. Amounts by Grant Mechanism and Type. R01 awards dominated ARRA funding, followed by RC2s or Grand Opportunity (GO) awards. ARRA Supplements (Type 3) were the predominant method of funding R01s in 2009. In 2010. Noncompeting continuations predominated followed by supplements in funding R01s.