Frozen Money: The Economics Antarctica

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Author Note

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Executive Summary

Antarctica is the world's southernmost continent, and is a the last remaining unexplored and uncolonized frontier. It's a haven for advanced scientific research, exploration, and international geopolitical cooperations. A massive amount of funding is necesary to support these various objectives in Antarctica - this includes funding of core logistics, facilities, as well as the essential research and development projects. The National Science Foundation is the Federal Government's agency which is tasked with managing funds and overall management of all operations in Antarctica. Out of the NSF's total FY2015 budget of $7.463 billion dollars, $67.52 million goes into direct funding in Antarctica. This paper breaks down analysis of operations in funding in Antarctica into these key categories:

- Funding sources and distribution to Antarctica initiatives
- Scientific and Geopolitical goals of America's presence in Antarctica
- Historical trends and future outlook for operations in Antarctica

Introduction

Antarctica is the frozen frontier of humanity. It's the world's southernmost continent, is almost completely frozen, and remains one of the last pristine locations for conducting scientific research. Because of its unique location and circumstances, almost all of the research that happens in Antarctica can't be done anyplace else.

This is a cold, hostile environment, and in order for scientists to work in the harsh conditions of the frozen continent, they require a large amount of support, supplies, and logistics. The management and support of science in antarctica is overseen by the National Science Foundation, who through the use of taxpayer dollars, funds almost all aspects of operations on Antarctica. In this paper, I'll focus on defining and assessing the economic, governmental, scientific, and social implications of the US maintaining a consistent presence and producing useful research in the highest, coldest, windiest, driest, and highest desert on earth.

In researching this topic, I used the resources of the University of Denver Library, including various online publications, governmental databases, books, and journals. Additionally, I drew heavily on my own personal experience working in Antarctica, as well as interviews with a small subset of my peer group.

My personal experience in Antarctica covers two seasons on the ice. During my first season spanning the Austral Summer of 2012-2013, I worked for Gana a'Yoo Service Corporation, under contract from the Lockheed Martin Antarctic Support

Contract. I was deployed to the Amundsen-Scott South Pole Station, located at the geographic south pole of the earth. My primary job was as the station's breakfast cook. However, during almost all of my available free time, I volunteered to work at an Emergency Medical Technician at the medical clinic, as the South Pole Press Correspondent for the National Science Foundation, and as a field science assistant for the Askaryan Radio Array, Ice Cube Neutrino Observatory, KECK Array Microwave Telescope, South Pole Telescope, and BICEP2 Microwave Telescope. I got the absolute most I could out of my season at the south pole.

My second deployment was during the Austral Summer of 2014-2015, to the West Antarctic Ice Sheet Field Camp. During this deployment, I worked as a field science manager for the University of Wisconsin Space Science and Engineering Center's Ice Drill Design and Operations Division, under a science grant from the National Science Foundation. I spent the first month of my deployment at McMurdo station taking care of core expedition logistics and preparations, and the rest of my time on the ice at WAIS Divide Field Camp, working on servicing, disassembling, packing, and shipping the Deep Ice Sheet Coring Drill.

Throughout both of my seasons in Antarctica, I wrote an extensive account of my experience, which is available online at *http://JeffreyDonenfeld.com/Antarctica* .

This research paper aims to assess how the National Science Foundation accounts for and supports research and operations in Antarctica. This study is limited by the amount of accurate and timely information available at the time of writing.

Antarctica has been a controversial topic for many years, managed piecemeal by a wide variety of governmental and nongovernmental organizations, and broadly overseen by the United States Antarctic Program, overseen by the Office of Polar Programs. As such, there's somewhat little specific information readily available about the business and economic aspects.

The answers and issues that this paper aims to address are:

1. How does funding flow from American taxpayers, through the National Science Foundation, into both science grants as well as Antarctic support contracts?
2. How is a budget for Antarctic science and support spending developed, and how has the budget fluctuated in recent years? Is the current scope of operations appropriate, or should more/less funds be allocated? What are the top negative issues surrounding the historic allocation of funding for science in Antarctica?
3. Why does it make sense for the United States to support operations in Antarctica? Is "Basic" research economically important? Are there other reasons, including geopolitical reasons, to maintain a presence in Antarctica?
4. Do other government organizations who use Antarctic resources, such as the National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA), and Department of Defense (DOD) contribute significantly to the overall project?
5. Does money come from sources other than tax payers?

This paper is organized into 5 main sections addressing each of the five main questions, as well as summaries and a bibliography.

Literature Review

The studies of this topic that were most relevant seemed to be the US Government's "Blue Ribbon" Studies, as well as the NSF's Congressional Budget Request documents. These studies contained a good amount of hard data, as well as worthwhile analysis of the issues they covered. Additionally, I made use of a number of excellent journal articles. Most of these sources tended to focus on budget issues and geopolitical issues of the presence of the United States in Antarctica, with a few also covering the value of science. Additionally, the most abundant and insightful research for this study came from my own expeditions to to the ice, where I learned firsthand what it takes to make the United States Antarctic Program run. The pieces of data that were the most useful for this study were the quantitative analyses of actual budgetary constraints.

Results and Analysis

General Funding Flow from US Government to Antarctic Projects

Signed into law December 18, 2015, the United States Consolidated Appropriations act of FY 2016 appropriated the National Science Foundation $7.463 billion dollars in funding. That amount was $119 Million (1.6 percent) above the

previous years appropriation level, and $119 more than the Senate Appropriations Committee version of the act. It was $69 million more than the version passed by the house, as well. See Fig1 for the FY16 Omnibus breakdown. [1]

That $7.463 billion dollars that the NSF receives is subsequently distributed through a number of subcategories. These include Research and Related Activities ($6.033B), and Major Research Equipment ($200.31M). These funds are then broken down even further, and eventually flow to activities directly related to both Antarctic science and Antarctic operations support. [2] Fig 2 & 3 highlights the portions of the NSF Omnibus that goes to sectors supporting Antarctic activities. [3]

Further breaking down the flow, within the Research and Related Activities account, funding flows to Directorate for Geosciences (GEO), among other accounts. It's within the GEO account that the Polar Programs division is housed (PLR), and within PLR, i sthe US Antarctic Logistical Support (USALS). GEO is the office that supports the fields of basic research into the earth's global environment, including Water cycle, geologic interactions, and ice sheets. The USALS requested $67.52 million in funding for 2016. [4]

[1] (2016). Jan. 4th Congressional Highlight - NSF. Retrieved April 15, 2016, from https://www.nsf.gov/about/congress/114/highlights/cu16_0104.jsp.

[2] (2016). Jan. 4th Congressional Highlight - NSF. Retrieved April 15, 2016, from https://www.nsf.gov/about/congress/114/highlights/cu16_0104.jsp.

[3] (2016). Jan. 4th Congressional Highlight - NSF. Retrieved April 15, 2016, from https://www.nsf.gov/about/congress/114/highlights/cu16_0104.jsp.

[4] (2015). FY 2016 - NSF Budget Request to Congress | NSF - National. Retrieved April 15, 2016, from http://www.nsf.gov/about/budget/fy2016/.

Within the Division of Polar Programs, there's an additional breakdown of funds. The primary benefactors include The Ice Cube Neutrino Observatory (Which I've visited personally), US Antarctic Facilities and Logistics, US ANtarctic Logistical Support, and the Antarctic Infrastructure Modernization for Science initiative, which includes the "Master Plan" McMurdo redevelopment plan. [5] See fig4 for a complete breakdown of this section.

The McMurdo "Master Plan" is a phased plan to redevelop the entire McMurdo station area, including science, housing, logistics, and support facilities. It's the subject of an ongoing Blue Ribbon Panel review chartered in 2011[6], and is expected to cost a total of $300 million in all. [7]

Historical Budget Fluctuations

According to a presidential request to congress in 2014, and the subsequent House Appropriations Committee voice vote on the FY 2015 Commerce, Justice, Science, and Related Agencies appropriations bill, the NSF, and related R&D projects were one of the only categories to receive an increase in funding. This follows the historical trend of Science receiving more funding year over year since 2000. More specifically, the GEO office, which manages funding of Antarctic operations has seen a

[5] (2015). FY 2016 - NSF Budget Request to Congress | NSF - National. Retrieved April 15, 2016, from http://www.nsf.gov/about/budget/fy2016/.

[6] (2012). US NSF - OPP - U.S. Antarctic Program BLue Ribbon Panel ... Retrieved April 15, 2016, from http://www.nsf.gov/od/opp/usap_special_review/usap_brp/.

[7] (2013). The Antarctic Sun: News about Antarctica - Master Plan. Retrieved April 15, 2016, from http://antarcticsun.usap.gov/features/contenthandler.cfm?id=2947.

steady rise in its funding. In 2000 GEO was appropriated roughly $650 million, which has now increased to roughly $850 million in 2015. [8] Fig6 highlights this increase in funding.

Maintaining National Presence and Geopolitical Influence in Antarctica

In addition to supporting science and research in Antarctica, there's a strong drive to maintain a powerful geopolitical influence in Antarctica. As of FY16, the Directorate of Geosciences is directly tasked via Presidential Memorandum 6646 with funding and supporting the US Department of State. [9] The Department of State acts as the primary steward of the Antarctic Treaty, which covers all territory of the continent of Antarctica, as well as the Southern Ocean. [10]

Despite America's overwhelming geopolitical influence and power in Antarctica, there are still large, unrecognized territorial claims by various nations. The nations formally claiming (sometimes overlapping) sections of Antarctica are Argentina, Australia, Chile, France, New Zealand, Norway, and the United Kingdom. Notably absent from this list is the United States and Russia, who make no formal claims, yet reserve the right to do so if and when that time comes. [11]

[8] (2014). NASA, NSF Continue R&D Budget Recovery in House, But ... Retrieved April 15, 2016, from http://www.aaas.org/news/nasa-nsf-continue-rd-budget-recovery-house-climate-research-cut.

[9] (2015). FY 2016 - NSF Budget Request to Congress | NSF - National. Retrieved April 15, 2016, from http://www.nsf.gov/about/budget/fy2016/.

[10] (2012). Antarctic Treaty - US Department of State. Retrieved April 15, 2016, from http://www.state.gov/t/avc/trty/193967.htm.

[11] (2007). The World Factbook - CIA. Retrieved April 15, 2016, from https://www.cia.gov/library/publications/the-world-factbook/geos/ay.html.

Other Governmental Organizations Using Antarctic Resources

In addition to primary scientific grantee groups performing research and activities in Antarctica, there are a number of other intergovernmental agencies with interests there. These include the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), the US Geological Survey (USGS), the Smithsonian Institution, and the Department of Energy (DOE). These organizations are supported directly under the Directorate for Geosciences, as per Presidential Memorandum 6646, and receive a portion of the $67.52 million in funding for GEO in Antarctica.

In my personal experience working in Antarctica, I've interacted with representatives from NOAA, USGS, DOE, and NASA. For example, I was privileged to be given a tour of the NASA Satellite Downlink control room and witnessed the repositioning of the major downlink satellite dish. I've been given a personal tour of the National Oceanic and Atmospheric Administration's Atmospheric Research Observatory at the Amundsen Scott South Pole Station. I've stood in the former location of the first and only nuclear power plant in Antarctica. I've used Antarctic maps created and maintained in part by the US Geological Survey. These supported organizations play a critical and necessary role in both completing their own missions, as well as supporting the missions of the various other scientific and logitical groups involved.

Sources of Funding for Antarctic Operations

Funding for operations in Antarctica comes primarily from the federal government. According to a 2009 NSF report , while overall R&D expenditures has been increasing from 2000 onward, the actual proportion of federal funding of academic R&D effort has been steadily dropping - from 64% in 2000 to 60% in 2008. See Fig7. Other sources of funding, besides the federal government include state and local governments, industry, institutional funds, and a small portion from other sources, which may include private funding. [12]

Conclusion

Out of the 7+ billion initial budget, a surprisingly small amount of money flows down to support for the complex logistics or operating in Antarctica - a mere $67.52 million. Since 2000, the budget for science and operations in Antarctica has been steadily increasing, from $650 Million in 2000 to over $650 Million in 2015. The US supports and maintains operations in Antarctica not only for science and research, but also for geopolitical reasons, such as acting as the primary and most powerful steward of the Antarctic Treaty. The South Pole Station is a major symbol of America's key role in Antarctic Geopolitics. A presidential memorandum directs the usage of Antarctica for other governmental organizations, and appropriates a portion of the overall Antarctic

[12] (2009). nsf.gov - NCSES Federal Government is Largest Source of ... Retrieved April 15, 2016, from http://www.nsf.gov/statistics/infbrief/nsf09318/.

funding to them. These organizations include both scientific, logistical, and geopolitical players. In addition to federal funding, roughly 40% of the overall funding comes from other sources, which include both local governmental resources, academic institutions, and private organizations.

In this paper, I've aimed to explore the organizational and appropriation structure of broad R&D funding for operations in Antarctica. I've explored high level budgeting, geopolitical objectives, science breakdowns, as well as funding sources.

I found that the flow of funds from the US Taxpayer to projects in Antarctica is long and complex, and that in recent years the amount of overall funding has been steadily increasing. I'm a huge supporter of scientific researching and development, and am glad to see that the US is putting increasing dollars into supporting this R&D.

Further lines of research include a closer look at budgeting for the upcoming "Master Plan" McMurdo redevelopment and reconstruction plan, a deeper analysis of how funding translates to a tangible economic ROI, and further implications of geopolitical friction and economic interests on the ice.

Although this study take a good look at a few of the topline issues surrounding operations in Antarctica, there are a few caveats. Oftentimes details surrounding operations on the ice can be murky. It's also notoriously difficult to trace the exact path of dollars, and harder still to track those dollars back around to the other side of economic ROI. Going forward I'm looking forward to being able to parse these aspects further.

The most important broad implications of this study are the scientific discoveries that come from research done in Antarctica. For example, recent work by Cornell University and the BICEP2 Microwave telescope could one day shed light on what happened at the very beginning of the universe. [13]

[13] (2015). Joint Analysis of BICEP2/$Keck Array$ and ... - inSPIRE. Retrieved April 15, 2016, from http://inspirehep.net/record/1342425.

Figures

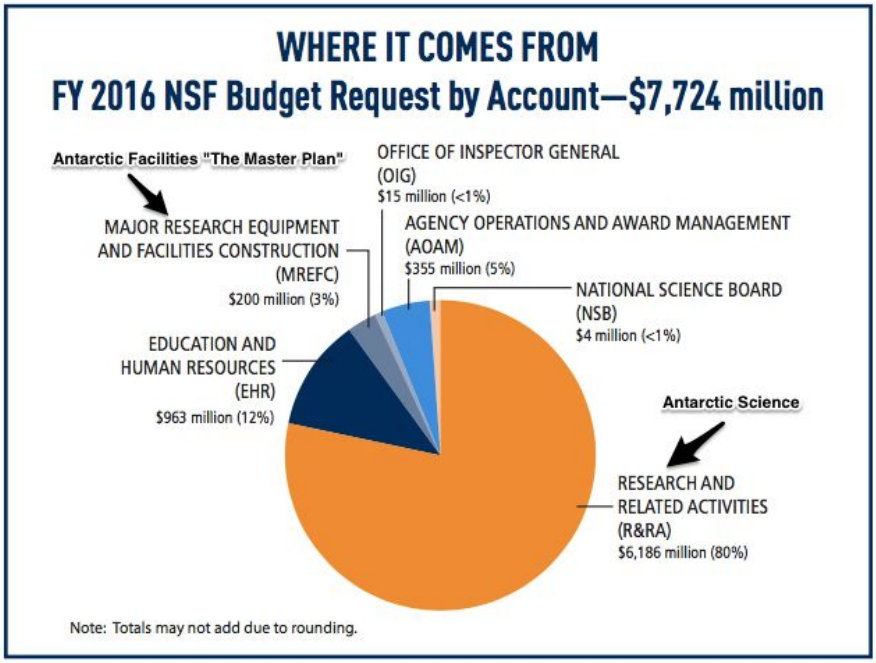
Fig 1[14]

FY 16 Omnibus

(in millions of dollars)

	FY 15 est	FY 16 request	Omnibus	Delta / FY 15 $	Delta / FY 15 %
R&RA	5,933.65	6,186.30	6,033.65	100.00	1.7%
EHR	866.00	962.57	880.00	14.00	1.6%
MREFC	200.76	200.31	200.31	-0.45	-0.2%
AOAM	325.00	354.84	330.00	5.00	1.5%
NSB	4.37	4.37	4.37	0.00	0.0%
OIG	14.43	15.16	15.16	0.73	5.1%

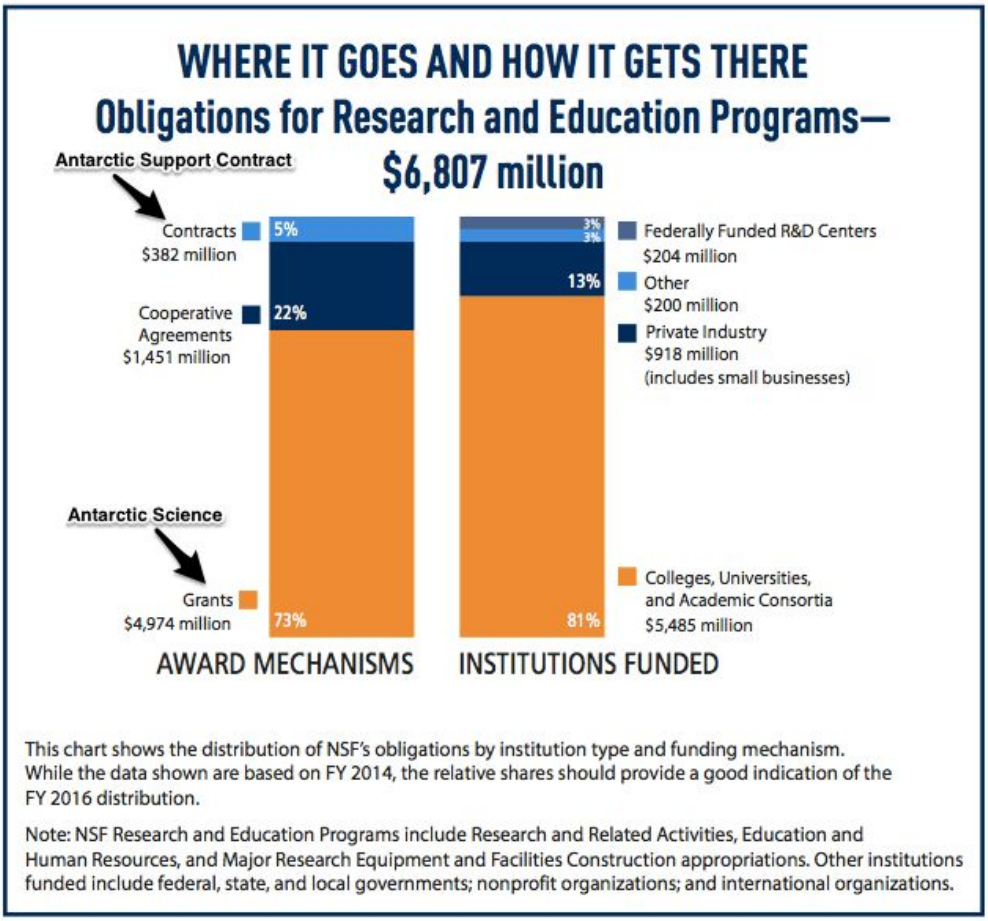
Fig 2 [15]



[14] (2015). FY 2016 - NSF Budget Request to Congress | NSF - National. Retrieved April 15, 2016, from http://www.nsf.gov/about/budget/fy2016/.

[15] (2015). FY 2016 - NSF Budget Request to Congress | NSF - National. Retrieved April 15, 2016, from http://www.nsf.gov/about/budget/fy2016/.

Fig 3 [16]



[16] (2015). FY 2016 - NSF Budget Request to Congress | NSF - National. Retrieved April 15, 2016, from http://www.nsf.gov/about/budget/fy2016/.

Fig4 [17]

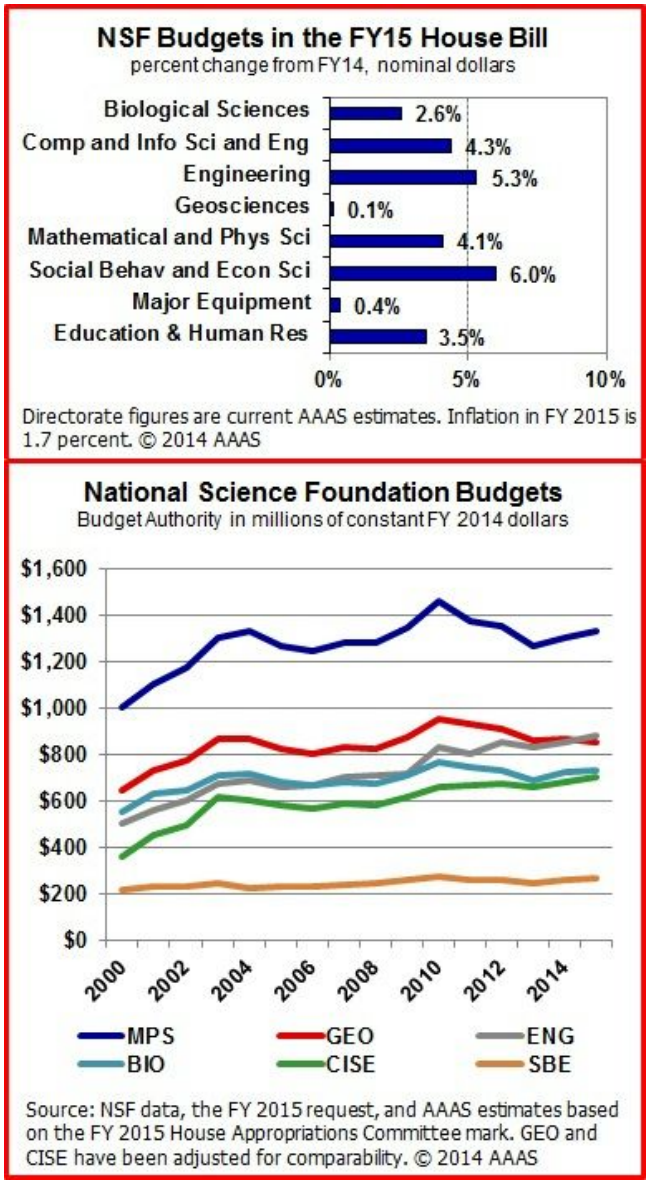
PLR Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, PLR	**$452.86**	**$436.35**	**$449.51**	**$13.16**	**3.0%**
Research	**129.57**	**125.39**	**130.95**	**5.56**	**4.4%**
CAREER	1.01	1.57	1.65	0.08	5.1%
Centers Funding (total)	2.68	-	-	-	N/A
STC: Center for Remote Sensing of Ice Sheets	2.68	-	-	-	N/A
Education	**2.77**	**3.80**	**2.71**	**-1.09**	**-28.7%**
Infrastructure	**320.52**	**307.16**	**315.85**	**8.69**	**2.8%**
Arctic Research Support and Logistics	44.08	38.64	40.27	1.63	4.2%
IceCube Neutrino Observatory (IceCube)	3.45	3.45	3.45	-	-
U.S. Antarctic Facilities and Logistics	196.99	189.31	195.11	5.80	3.1%
U.S. Antarctic Logistical Support (USALS)	68.94	67.52	67.52	-	-
Polar Environment, Health and Safety (PEHS)	7.07	6.24	6.50	0.26	4.2%
Facilities Pre-Construction Planning (total)	-	2.00	3.00	1.00	50.0%
Antarctic Infrastructure Modernization for Science (AIMS)	-	2.00	3.00	1.00	50.0%

Totals may not add due to rounding.

[17] (2015). FY 2016 - NSF Budget Request to Congress | NSF - National. Retrieved April 15, 2016, from http://www.nsf.gov/about/budget/fy2016/.

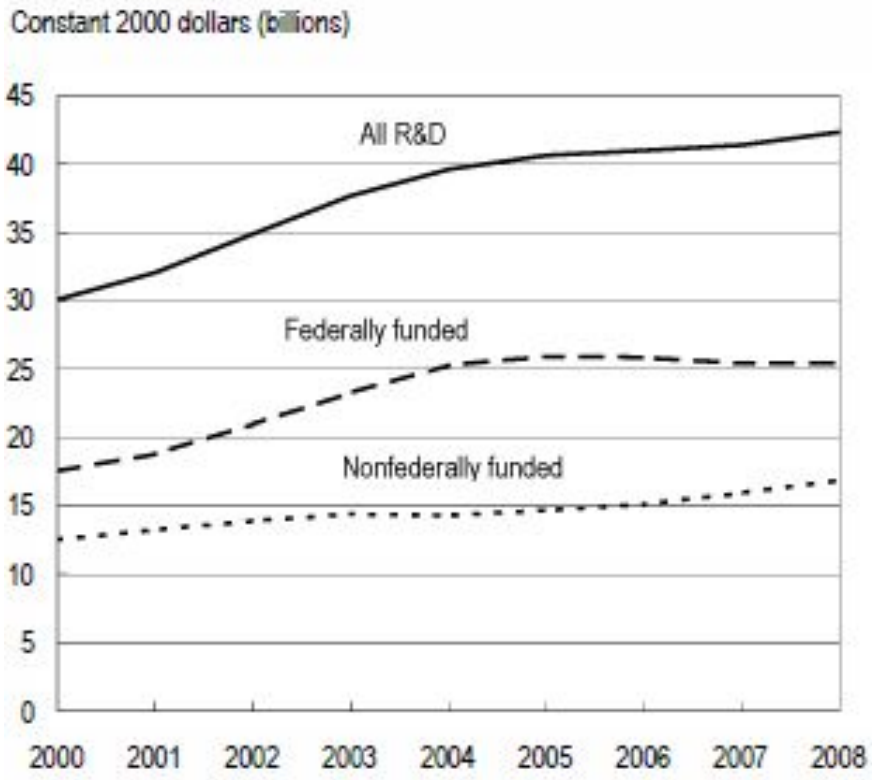
Fig6 [18]



[18] (2014). NASA, NSF Continue R&D Budget Recovery in House, But ... Retrieved April 15, 2016, from http://www.aaas.org/news/nasa-nsf-continue-rd-budget-recovery-house-climate-research-cut.

Fig7 [19]

FIGURE 1. Science and engineering R&D expenditures at universities and colleges, by source of funds: FY 2000–08



SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Research and Development Expenditures at Universities and Colleges: FY 2008.

[19] (2009). Federal Government is Largest Source of University R&D ... Retrieved April 15, 2016, from http://www.nsf.gov/statistics/infbrief/nsf09318/.

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The author standing at the Geographic South Pole, Antarctica, with the Amundsen-Scott South Pole Station in the background. 2012.