



## Department of Astronomy

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## Abstract

*This paper will explore the implications of growing economy in GDP per capita and public opinion about NASA on the budget granted to the agency each year. These trends are interesting and relevant to the Astronomy and Astrophysics community through the funding aspect and the public association of NASA with Astronomy and space. Using data from the General Social Survey, U.S. Gross Domestic Product, Office of Management and Budget, this paper explores relationships between public opinion, economic trends and NASA's budget. Implications of this research show that if high economic trends result in more spending or if public interest and other factors have an influence on how much money the national government spends on outer space. Due to the drawbacks of GSS survey data, this paper also examines other relationships of public interest using Google Trends, most notably the solar eclipse of 2017. Findings confirm previous studies that NASA spending is infra marginally responsive to public opinion, is significantly correlated with the previous year's GDP, and the 2017 eclipse did have an impact on searches for NASA. Implications for Space Policy include that though public opinion does not impact the NASA budget directly, important events in Astronomy can generate interest in NASA in areas that do not generally show interest. NASA can increase the transparency of the organization through education and outreach.*

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Sincerely,

Layla A. Bryant

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## Introduction

The National Aeronautics and Space Administration (NASA) is dependent on the federal government budget for funding every year. The implications of this are that publicly funded space research is subject to Congress. Governmental panels can make decisions about how many federal agencies should fund astronomy. The Federal Communications Commission (FCC) manages spectrum use and can have both helpful and harmful impacts on astronomy. At the local level, lighting policies can have both harmful and helpful outcomes for astronomy. In education, school boards can pass regulations preventing certain scientific ideas from being taught in local schools or printed in textbooks. The possibilities for both good and bad actions by the government at all levels are tremendous. NASA spending is a one of many ways to attempt to quantify overall interest in Astronomy and funding for Astronomy. In the past, major projects such as the James Webb Space telescope and Space Launch System have been postponed due to lack of funding. Multiple studies have explored the implications of public view and NASA funding, this paper seeks to elaborate on how federal funding shifts and the importance of public support for NASA.

Public opinion can be influential in determining federal budgets, cuts for NASA can be devastating to existing programs and prevent new developments. A lot of NASA funding is tied up in expenditures such as the International Space Station. While, NASA's budget is not the most contentious impact of the Trump Administration, it does carry huge ramifications for the future of U.S. Space Policy. Government spending on basic research has fallen by roughly a quarter to \$30 billion last year, one of the sharpest declines ever (Howell). For astronomy the impact resulted in decreased government funding which they had come to rely on after WWII. The gap created by these spending cuts has resulted in the collapse of many projects.

When the US reached the moon, spending for NASA was at its highest percent of the federal budget (Lanius, 2003). If we want to return, or go to Mars, people are going to have to be okay with increasing the budget! The question is, how does public opinion impact the spending of NASA's budget? A costly return to the moon, prompted by the President's, newly reinstated National Space Council, could have huge ramifications for the rest of NASA programing. We can explore ways to interest the public if it is correlated with major celestial events. NASA currently makes up around .5% of the U.S. Budget (Amadeo, 2018). Using the budget as an indicator of government support for space, we can extrapolate how space funding alters depending on varying factors.

# Background

## History

It was during the second World War that a rise in government funded research became the standard. For astronomy the implication became the donation of sensitive, groundbreaking equipment. Government funded astronomy gave rise to many developments within the Infrared Spectrum under the Strategic Defense Infrastructure developed during the Cold War (Gugliucci). The Space Race prompted increased funding for astronomical resources but many astronomers didn't realize the restrictions that came with government funds. International Traffic in Arms Regulations (ITAR) of the U.S. Department of State strictly limited the export of military equipment and knowledge. Astronomy fell under this because sensitive technical information or devices could not be shared readily with international partners, prohibiting what appeared to be innocent, mutually beneficial scientific collaborations. Military support resulted in an inability to collaborate internationally for astronomy research. More recently the Freedom of Information Act has forced astronomers to share/publish data within 3-6 months of collections when public government funds are used, preventing part of the competitive nature of research (Harwit, 2013).

The Mansfield agreement to the military procurement authorization act for Fiscal Year 1970 forbade the defense department the use of appropriating funds "to carry out any research project or study unless a direct and apparent relationship to a specific military function" (NSF). With the implementation of the Mansfield agreement the ability of the military to fund science was restricted but the civil research community became dependent on military support, though the amendment eliminated easy communication between military and civilian research. Through government grants, the National Science Foundation (NSF) and Space Studies Board (SSB) became the organizations in charge of funding. With the NSF overseeing most science funding through grants, the standard of judging the quality of research fell too easily quantifiable methods such as citation counts rather than merit and contribution to the field. In the current climate with 1 in 7 proposals being accepted, it is the hardest it has ever been to secure funding for astronomical research (Daniels).

Without NSF funding after 2017, at the National Radio Astronomy Observatory (NRAO) in Green Bank and Kitt Peak are in danger of closing down. Not only will the important telescopes be lost but also jobs for scientists, engineers, software developers, education professionals, shop mechanics and more. The astronomy community, especially those at large and small universities that do not own their own telescopes, will lose access to the sky. Other facilities can try and chip in, but they do not compare in sensitivity, resolution, and capability. Their associated education centers will be in danger and the projects with high school and college students will disappear. The reliance on government for astronomy

funding is deep-rooted in the past 50 years, the public mostly associates this funding with NASA.

The decline in government spending leads to a heavy reliance on the private sector. In astronomy, there is some motivation for companies to develop and research for space exploration and engineering such as SpaceX but the private sector is not invested in the expansion rate of the Milky Way and other astronomical phenomena. Philanthropists have returned to center stage in the research fields. In the near future, it is possible they offer more support than the government. For example, Yuri Milner's funding of Breakthrough Listen, a SETI program, has kept the Green Bank Telescope from shutting down with the exodus of the NSF. Science philanthropy is prominent, as many of the richest Americans seek to reinvent themselves as patrons of social progress through science research. There is some worry about a reliance on philanthropy as “the practice of science in the 21st century is becoming shaped less by national priorities or by peer-review groups and more by the particular preferences of individuals with huge amounts of money”(Jogalekar, 2014). Another concern for the future is that philanthropist only enriches elite universities while undermining political support for federally sponsored research and its efforts to foster a greater diversity of opportunity including geographic, economic and racial opportunities (Broad, 2014). Funding from philanthropists works for projects that draw widespread interest, but basic research is lost when the only funding is through people invested in the outcome and only for “attention-drawing” projects.

## Previous Research

The shift in funding and lack of enough private funding to support research and development in astronomy has led the field to rely on NASA more than ever for funding. As NSF funding declines, NASA's budget has also shrunk, including cuts to the education and planetary sciences offices. The budget has been relatively stable over the past 10 years, but the distribution of NASA funding within the agency has shifted towards an emphasis on exploration, which leads to cuts in grants and education programming that stimulate interest in space. Roger Lanius argues that "The American public is notorious for its willingness to support programs in principle but oppose their funding at levels appropriate to sustain them" (2003).

Lanius explores opinion polls and the perceptions of human spaceflight in 2003 he examined how trends have changed since the Apollo moon missions and the peak period of NASA funding. He finds that the percentage of people who think the government should fund human trips to the moon has been relatively stable from 1961 to 1995 and that on average more people oppose than support funding trips to the moon. Opinion polls have been criticized for survey method as well as for a common misconception among the general budget about NASA's percentage of the federal budget.

NASA's budget and GSS public opinion data have been used in other studies most notably Steinberg. From Steinberg's analysis, one can draw the conclusions "space policy funding is responsive to public opinion at some times and less at others. Second, when looking at two different metrics of spending, it seems that policy funding is both responsive and non-responsive at the same time" (2011). Steinberg approximates that the next step in this project would be to run the same analysis using elite level opinions to see if this holds true quantitatively as well. However, there exists a void of research on the influence of elites on space policy.

Nadeau uses multiple regression to determine the type of people who tended to be more interested in funding space exploration. Nadeau used GSS and expanded on Steinberg's findings "in particular, the odds of wanting to increase funding for space exploration are significantly higher for white, male Baby Boomers with a higher socioeconomic status, a fondness for organized science, and a post-secondary science education" (2014). This establishes the dimension of the public that would like to see an increase in space exploration spending, this would be seen mostly through the NASA budget.

Wittman and Cobb examine space exploration in terms of surveys as well as using big data tactics to discern public opinion for space exploration (2015). They provide a basis for using google trends and Twitter to evaluate public interest in US space policy. The shortcomings of their analysis is that Google Trends data is all relative to the most searched date. The combination of polling data and trends can give important insights into how the public feels about space policy. However, it is important to note that interest does not imply support for funding projects.

Building off of this work, in an attempt to determine factors that are indicators of NASA's budget. These factors include public opinion, and the events that might impact public opinion; notably the presidency, the status of the economy, and others. Limitations of survey data can seep into the results and as discussed later there is a popular misconception with how much money NASA receives. Additionally, previous research focuses on the term "space exploration" which is a subsection of NASA's budget, therefore less indicative of total regard for NASA and astronomy funding. The General Social Survey questions are composed to focus on space exploration, thus it is limited to individuals thoughts on space exploration and not NASA funding as a whole. Other methods should allow expansion on the idea of favorable public opinion for NASA funding as an indicator of favorable funding for astronomy. This paper expands on the ideas in Steinburg to compare public opinion and the state of the economy. Despite evidence that initially the President has guided space policy, as in other issues of foreign policy, no studies seem to exist that measure the degree of elite influence.



## Research and Methods

The NASA budget is used as an indicator of government support for space. Being utilized to look at how much money the US government is willing to spend, OMB provides trends on the general state of the U.S. Economy. To measure the economic trends, I will compare the NASA spending by year with GDP per Capita from NASA and OMB respectively, both of these datasets are normalized to 2009 dollars. Each year, beginning in 1973, the GSS survey from has asked respondents ‘is the government spending too much’, too little or about the right amount on space exploration. Here we explore those who responded too little (the assumption that they would like to see spending increase) as a percentage of total respondents by the year the survey occurred. There are other methods to analyze the survey data, but for the purpose of this analysis, only too little spending will be used.<sup>1</sup> I additionally compiled information on major astronomical events, including Haley’s Comet, major space missions, the Cherberdky Meteor, and Solar eclipses, to indicate if public opinion is related to awareness. Most of this information is from NASA historical information and astronomy almanacs. The analysis excludes the NASA startup period as well as the first moon landing because this period is skewed with extremely high amounts of spending due to external competition and political viability of spending.

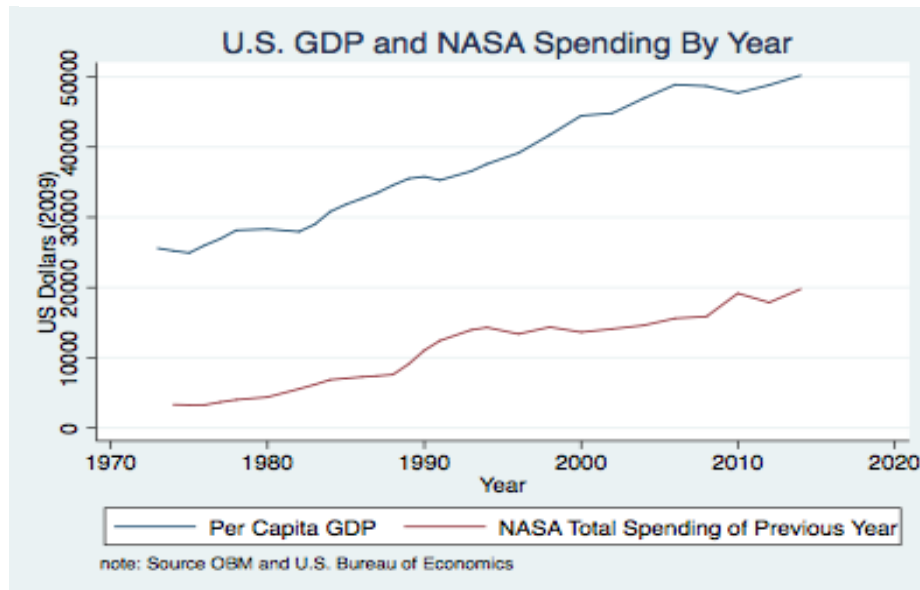
## Economic Overview

Using a lag of the amount of NASA spending every year and various indicators such as a percent of people from GSS who want to increase spending on Space Exploration, GDP Per Capita, presidential political party, major celestial events and other variables to determine if there is a relationship to spending increases or decreases. I used a lag because the budget would change in response to many of these factors. In regards to public opinion and events, lagging by a year may not have been long enough. Another limiting factor is the years of observation of NASA only go back to 1958, and the GSS started surveying public opinion on space exploration in 1973.

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<sup>1</sup> See Steinberg's “Space policy responsiveness: The relationship between public opinion and NASA funding” tolerance for NASA spending GSS setup

Figure 1



While figure 1 shows a noticeable trend between spending on NASA and GDP per capita, it is not the most representative of the proportion of the federal budget granted to NASA each year. GDP per capita and NASA spending appear to trend together, and the lag indicates that the budget changed in response to different GDPs. Unsurprisingly, there is a small correlation between an increase in GDP and the percent of people who want to see more spending on NASA. GDP was only a significant measure of total spending and was inframarginal on the percent of total spending.

Furthermore, some of the largest drops in funding come in 1988 and 1992 and happen during times when the levels of funding are more tolerated by the public than at other times. Previously, there were high levels of spending due to the Apollo program which completed in 1987 (NASA). From 1992 to 1996, tolerance for funding is going up, and from 1996 to 2000 remains relatively stable; meanwhile, NASA's budget is going down. It is only from 2000 to 2008 that we see trends of increased support for more spending and the NASA budget increasing simultaneously.

Columbia and Challenger disasters occurred, 2003, and 1986 respectively. There are not enough data points to determine if this is causal, but it is of interest in regard to spending on future missions and the implications of budget cuts for space launches. It is important to understand that the framing of NASA's budget can make it appear as if spending increases or decreases, which may be politically exploited to make whichever point an individual would like to make. This paper draws no conclusions on the increasing NASA budget or decrease of total federal spending on NASA.

Figure 2

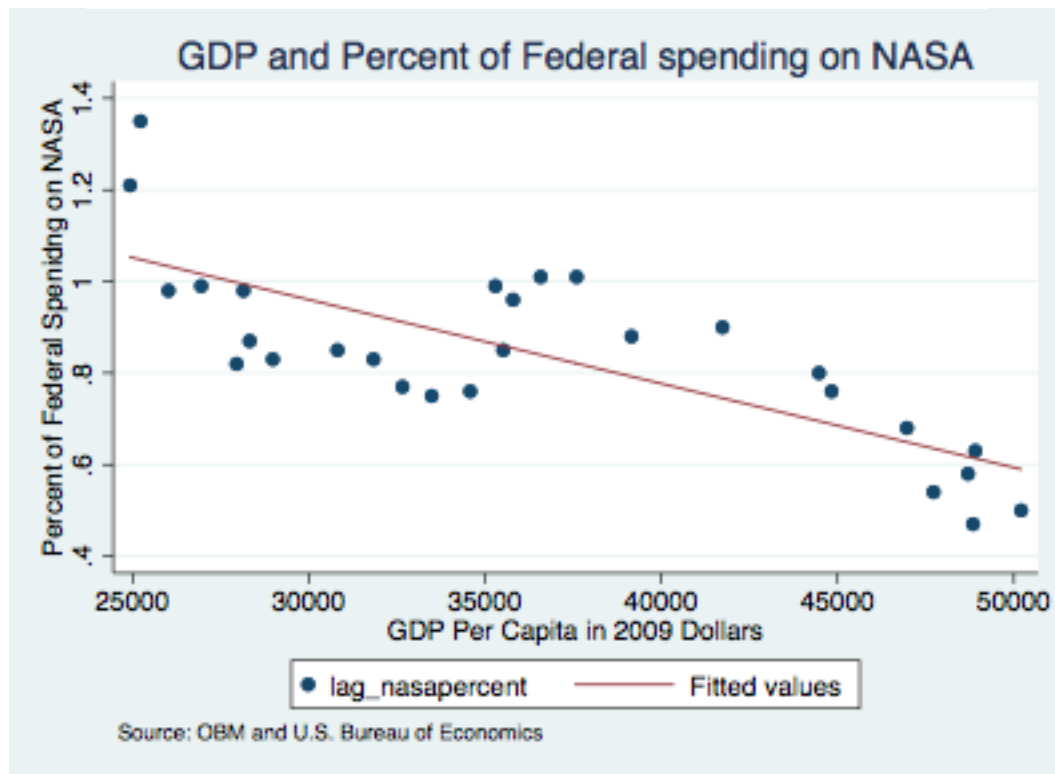


Figure 2 better depicts the relationship between GDP and the decline in NASA funding, because though the price tag on NASA is more, the percentage of the federal budget spent on NASA has been declining, even though the economy is doing well. Other studies such as 2001 Gallup survey have found that there is high public regard for NASA, though it appears, less high of a regard for increasing spending on NASA (Carson).

The presidency is an indicator of the political climate in the U.S. Additionally the President has had tremendous power in setting the Agenda for Space and NASA. The President appoints the NASA Administrator, while there have been congressional attempts to change control of NASA for consistency purposes, this has not happened yet. Every time a new president enters the office, NASA has to adjust its programs to suit the goals of the new administration. This sometimes involves canceling ongoing projects altogether, as demonstrated by programs like Constellation, which President Bush Jr. implemented but was canceled by the Obama Administration in 2010 (Finarelli, P., & Pryke I. 2009). Administrations have the ability to change the direction of NASA, therefore every 8 years projects can be derailed. Many projects end up delayed and costing more money than they originally planned, causing Congress to become less likely to keep providing funds to keep the programs running.

Figure 3

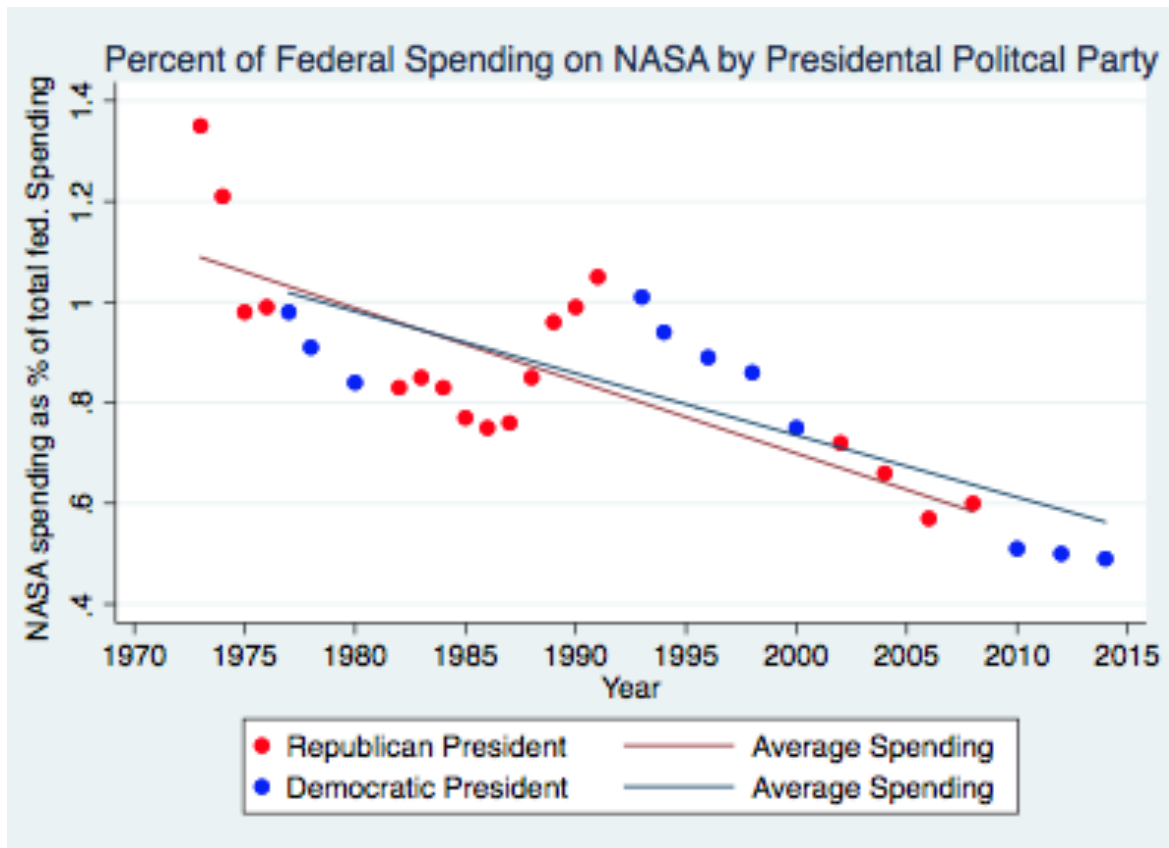


Figure 3 shows a plot of NASA's budget as a percent of total US Spending by year. It highlights the difference in the percentage of spending which we can see declined for 20 years and slowly increased under President Clinton (Smith et al., 2016). Though each president has changed the agenda of NASA, it appears that the political party does not have an overall significant effect on the budget. Lines of best fit for both sets of points are almost the same, showing that NASA as a percent of federal spending is declining over time, regardless of the president's political party. This is interesting because of the movement in Congress to separate NASA from the presidency through the NASA Transition Authorization Act which is meant to prevent agenda switches on large investments in NASA as presidential administration change (Cruz, 2016). If this passes, we can expect Congress to play a larger role in planning NASA missions. There has also been a discussion on making NASA's Director a permanent congressionally appointed position rather than presidential appointment, this would give further continuity but could lead to funding issues when Presidents don't agree with a NASA Administrator.

## Public Opinion Overview

*If public opinion on space exploration funding was driving actual funding, as we would expect to see in a dynamically responsive relationship of domestic policy, as tolerance for spending is reduced, there should be a subsequent reduction in NASA's budget*

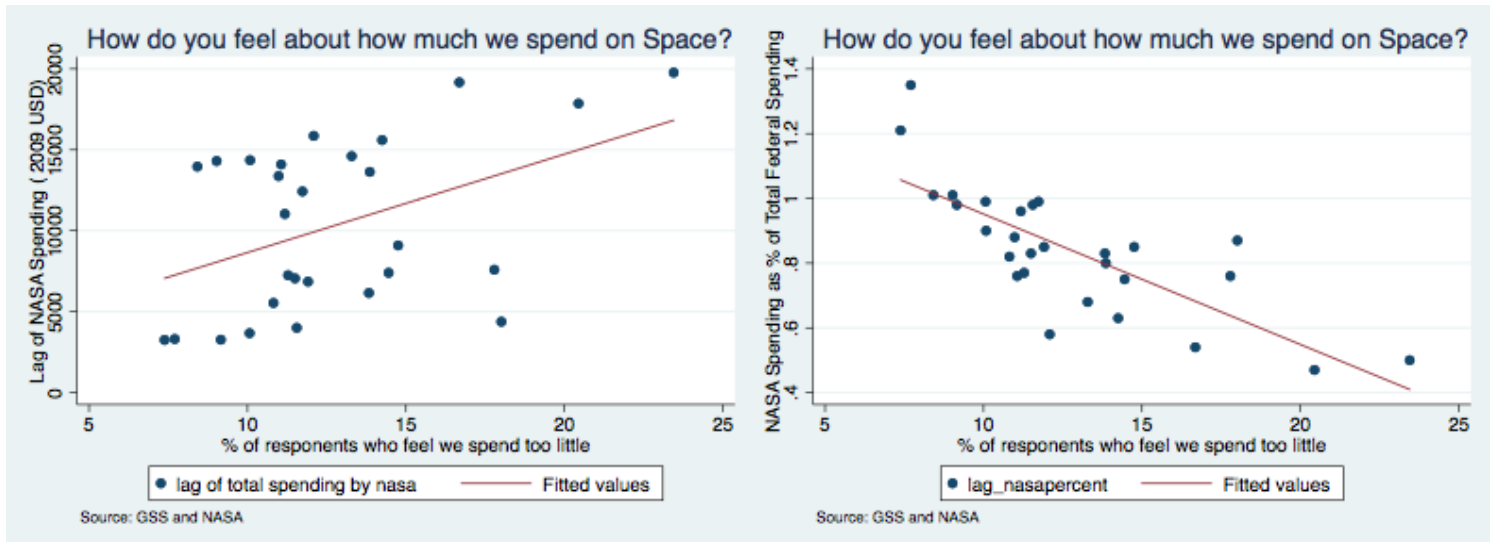
Lanius found that “space policy funding is responsive to public opinion at some times and less at other.”(2003.) I continue this by looking at two different metrics of spending, concluding that that policy funding is both responsive and non-responsive at the same time. I look at both GSS survey response on a lag of total NASA spending and as a lag of percent of total federal spending. A lag is used because the budget for the fiscal year would be impacted by the previous year's public opinion when the budget was decided upon and not the year the budget impacts. The GSS limitations are the same mention in the background section and will be expanded upon in the following discussion.

The *Astronomy events* dataset will be compared to public opinion to discover if major events have an impact. This dataset was constructed through determining years of major events from several sources including NASA's Goddard Space Flight Center Milestones in Space Exploration, The Pew Research Center, and others.<sup>2</sup> I choose to exclude lunar eclipses due to frequency. The dataset includes solar eclipses in the U.S., major missions ( including the loss of Challenger and Columbia, comets, and other events (such as meteor impacts). I also explored movies about space but found no evidence of effects on GSS survey results.

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<sup>2</sup> See Appendix 1 for astronomy events dataset. (limitations include how major events are defined)

Figure 4



Public opinion is much harder to discern but from regression, it appears that an increase by 1 percent in people who want to spend more on space is associated with a 607-dollar increase in NASA spending the next year (Smith et al., 2016). This is insignificant due to few observations in the dataset and when combined with a negative correlation when using NASA's percent of federal spending as the dependent variable.

These are contradictory graphs using the same information, which is why many NASA budget debates can be misleading. How public opinion affects NASA spending is inconclusive due to NASA's total spending increasing, while the percentage of total GDP decreases. The right figure demonstrates that as popular opinion increases for spending the government spends more total on NASA. While the left figure shows that as more people feel spending should increase, NASA spending as a proportion of total federal spending decreases. Steinberg found the same results in his 2013 analysis, that NASA spending is both responsive and non-responsive depending on the metric.

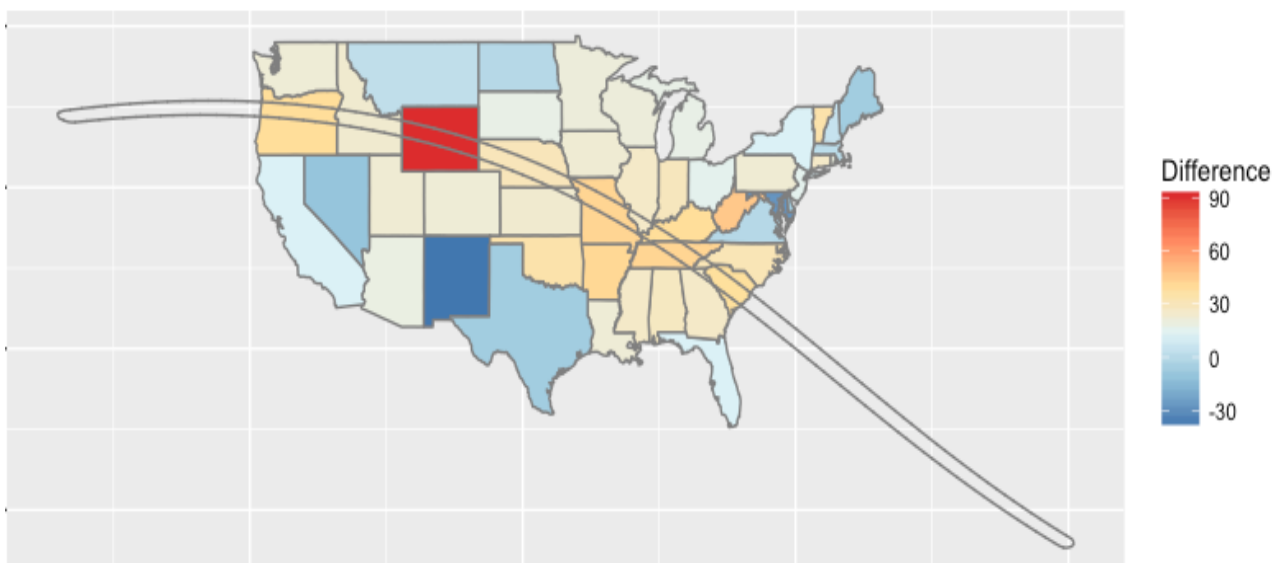
A limitation of survey data, specifically for funding is that it is difficult for individuals to understand government spending. Ditmar found "the average estimate of those polled of NASA's share of the federal budget was 20%, as compared to the actual budget of less than 1%" (Ditmar, 2006). This indicates that people who believe we spend too much on space exploration in GSS survey, might not accurately understand the amount of funding that is actually received. Ditmar also found that the public perception of NASA's budget is significantly inflated from what is actually received. Along with the distortion of public ideas of NASA spending, survey data has drawbacks on the reliability of the data and how it applies to the overall public. The GSS is useful but only to the extent of survey respondents understand current spending and represent the overall population.

Comparing a database of major space events to public opinion should show that people are more interested in space during certain years, this was not found to be the case with a small and statistically zero effect. Though the GSS survey data does not indicate a correlation between astronomical events and an increase in public desire to increase spending, this does not mean that the events do not generate interest and potential support for NASA. Google Trends helps circumvent the problems of survey data, and public distortion of the budget. Instead, Google Trends can tell us what people are searching and the frequency of the search terms. The caveat of Google Trends is that data only dates back to 2004 and is normalized in relative percentage of total searches to the most popular day. Due to the limited range of time, and change in scaling, this paper explores the August 21, 2017 eclipse and searches for NASA in the month of August 2017 compared to searches for NASA during August 2016.

The month of August 2016 is used as the control month, and it is compared to the month of August 2017 when the eclipse occurred. In order to apply this analysis, I argue, that in the absence of the eclipse searches for NASA in 2017, it would have been the same as in August 2016. This is proven by looking at overall searches for NASA by state and selecting random times and comparing it to August 2016. Parallel trends do exist in the case of searches for NASA during the August 2017 eclipse. This assumption can be furthered by looking at searches for NASA during August 2018 as well to confirm that the reason for increased searches is, in fact, the eclipse.

*Figure 5*

Google Trends from Aug. 2016 compared to Aug. 2017 for NASA



The results indicate that large-scale public events do have an increase in the general population's interest because the states that were searching NASA in August 2016 are not the same as the states that searched for NASA during the eclipse. One drawback is that many interested individuals traveled to view the eclipse and might have skewed the data based on their location being along the path of totality. Wyoming is an outlier because the low population resulted in the increase in searches as a percent is extremely high during the eclipse.

Google Trends indicates that On August 21st the Day of the “Great American Eclipse”, *NASA* had the largest increase in searches followed by eclipse live stream and *Eclipse* was the top search term of the day. Much of the searches for NASA were due to the live stream event, which is run by the Office of Education. In many citizen’s minds, NASA is associated with Space, Astronomy and the sky. Astronomy funding is tied into public perceptions of NASA, thus the risk of losing NASA funding, especially for outreach and education puts at risk not only the development of future astronomical tools (such as the launches of telescopes) but also the interest of children who will build the future of Space studies and exploration.

The issue with science having to be high profile to earn public regard to receive funding is that most science is not interesting to the public. Basic research makes up the majority of government-funded research and development. If NASA and other agencies have to spend money in order to have a budget, is it really worth it? The General Social Survey (GSS) indicates an inframarginal effect of public opinion on NASA spending. If space spending is to be increased, it appears the main focus should be stimulating the economy through increasing GDP, which is not feasible for NASA though the Administration does have a large return on investment. Public opinion may rely on NASA in unquantifiable ways to inform and work with the public, which may have marginal returns to the NASA budget. It may be interesting to further explore Google Trends in relation to other astronomical events or even movies about space and see if searches change for NASA and Astronomy around the release of major films.

Interestingly as GDP per capita increases, there is an associated increase in NASA spending the next year, however not an associated increase in the percent of total federal spending. The political party of the President does not have a significant impact on NASA spending, indicating that NASA funding is still a bipartisan issue, though Figure 3 shows a small divergence in recent spending trends. NASA's budget is both responsive and nonresponsive to sentiment to the number of people who would like to see the budget increase. Public opinion, may have a larger effect on NASA than is quantifiable, but the 2017 Eclipse in the United States is an indicator that NASA plays a large role in awareness of space and sky



activities, whether or not those alter the budget, it is important to note that NASA spends increased resources on celestial events and advocacy.

## Conclusion

How much money would NASA need to spend on Public Opinion and outreach for it to have a substantial impact on their budget? Would allocating money for more outreach and awareness take money from projects that fall under NASA's actual mission directives? Ultimately, NASA was not founded for the Public but to put the United States at the forefront of innovation and discovery. The science has gotten so involved that many people do not understand the Space Policy Agenda of the United States. The President and Congress have the power for setting the Space Policy Agenda, with a limited effect from public opinion, which may be affected by how much we spend anyway. For example, we may spend more money during the Apollo missions, which people paid more attention to than something like the launch of Hubble. The current administration has reduced NASA's emphasis on Earth science, which will free up more money for the agency to use in other scientific endeavors, such as launching probes to Jupiter's icy ocean-bearing moon Europa, or building new space telescopes to study Earth-like planets around other stars as well as the origins of the universe. NASA's existing crop of planetary-science and astrophysics missions such as the orbiters and rovers on Mars, or the soon-to-launch James Webb Space Telescope, presently enjoy broad bipartisan congressional support, and thus appear less likely to suffer from cuts in a Trump budget.

Undoubtedly there will be an increase in reliance on privatized space industry due to the growing interest and increased competition of companies and availability of government contracts. The current privatized space industry will most likely double, with new competitors entering and large government contracts. This is especially true for existing private companies like ULA and SpaceX who are working on private long-term human transit capsules that will be more economically beneficial than SLS. Earlier this month, the Senate unanimously passed legislation that amends current law by adding human exploration of Mars to one of NASA's objectives (Quinn). The bill—which is not expected to become law this year but could come up again in the next Congress—is intended to make it politically difficult for future administrations to drastically alter NASA's plans to send astronauts to Mars by the 2030s. The legislation is sponsored by Republican Senator Ted Cruz, a supporter of deep-space exploration.

Figure 6

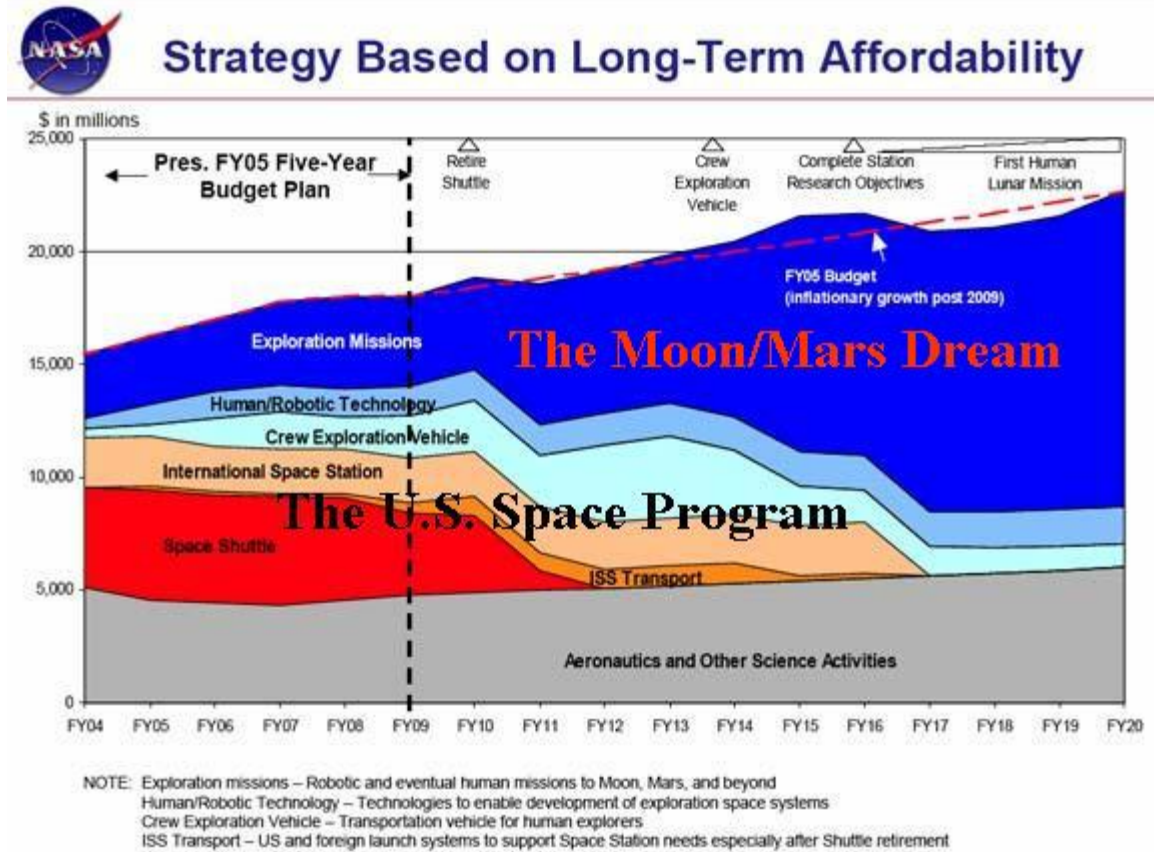


Figure 5 demonstrates projections of the future of NASA's budget show that a return to the moon or mars will absorb the majority of the NASA budget. Most experts agree that a mission to Mars would require large-scale national coordination and political support that hasn't been seen for a Space Program since the Apollo missions. There would be a large impact on NASA's ability to launch new astronomical tools. In conclusion, "any mission to Mars is at an order of magnitude greater in complexity risk and cost." (Lanius, 2003)

The Trump administration is considering a bold and controversial vision for the U.S. space program that calls for a "rapid and affordable" return to the moon by 2020, the construction of privately operated space stations and the redirection of NASA's mission to "the large-scale economic development of space," according to internal documents obtained by Politico (Bender). Another thrust of the new space effort would be to privatize Low-Earth orbit, where most satellites and the International Space Station operate — or a "seamless low-risk transition from government-owned and operated stations to privately-owned and operated stations" (Cowing). Obstacles to the privatization of space include convincing skeptical lawmakers that are worried about the loss of NASA contractor jobs in their districts could be difficult — “not to mention finding the additional federal money that might be needed to

partner with private space companies” (Billings). Lori Garver, who served as the deputy NASA administrator in the Obama administration, predicts major pushback from Congress despite the potentially significant economic benefits of an aggressive government role in the privatization of space (Cowing).

Without an increase in funding for NASA, it appears that most of its budget will be spent on returning to the moon. Even if there is a bump in popular opinion from the recent solar eclipse, it is undoubtedly not enough to save NASA programs, that is up to the state of the economy and the whims of current administration, it appears. As the space industry privatizes, it will be interesting to see how NASA's budgeting process changes, as well as implications for human spaceflight. This analysis does not conclude that any of these relationships cause the NASA budget to change, but that there are factors that align with the budget. Over the years, NASA has increased their spending on public awareness and media campaigns to garner public support to maintain their budget, but the data reveals that this spending is in vain, short of another Space Race, NASA's best option to increase their budget is to stimulate the economy.

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# Appendix

## 1. Open Source Data

This Google Folder contains all data files used in this paper as well as the do-files for replication.

[https://drive.google.com/open?id=1AR25EE2B1uCwL1fit\\_67Jzt\\_Gxsi8y07](https://drive.google.com/open?id=1AR25EE2B1uCwL1fit_67Jzt_Gxsi8y07)