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Space Funding and Geopolitical Competition: How Information Shapes Public Support

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Space Funding and Geopolitical Competition: How Information Shapes Public Support

Abstract

The space sector has remained central to geopolitics since the end of the Cold War, leading to an increase in national space spending worldwide. This study investigates how public support for space funding is influenced by information about (i) national space spending, (ii) the spending of geopolitical rivals, and (iii) the roles of private companies. We collected data from 2,135 citizens from the nine most important spacefaring nations. When informing them about their national space budgets, we find an increased willingness to increase their national space budget. However, information about high spending from rivals significantly reduces support for space budgets. When it comes to solving geopolitically relevant tasks, citizens show no preference for traditional space agencies over private companies, except in the US, where NASA receives stronger support than private firms. The findings serve as a caution to policymakers against using comparative rhetoric, as it may inadvertently reduce public support for space funding.

JEL-Codes: C990, D830, F500, F510, H500, H560.

Keywords: geopolitics, space race, contest theory, policy preferences, limited information, public economics.

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“This spaceship [...] came down so gently and then it wrapped those arms around it. And it held it. [...] I said, ‘Who else can do that? Can Russia do it?’ ‘No.’ ‘Can China do it?’ ‘No.’ ‘Can the United States do it? Other than you [Elon]?’ ‘No, nobody can do that.’”

Donald Trump on the successful catch of a Starship rocket, in his re-election victory speech (November 6, 2024)

1. Introduction

Public support is crucial for space funding. However, misconceptions have been found to significantly influence citizens’ opinions on public policy issues (Lergetporer et al., 2018; Norton and Ariely, 2011). Providing citizens with factual information about topics such as migration (Dylong and Uebelmesser, 2024; Grigorieff et al., 2020), public debt (Roth et al., 2022), inequality (Cruces et al., 2013; Pellicer et al., 2019), and education budgets (Lergetporer et al., 2018) can rectify misconceptions and shift public opinion. As geopolitical tensions rise around the world, real or perceived facts about citizens’ own country and real or perceived adversaries can lead to shifts in political opinions. The present study examines the influence of factual information on opinions regarding a strategically sensitive area: public support for space funding. We also examine how citizens view the role of presumably efficient private companies possessing capabilities that were once the exclusive providence of states.

Since the Cold War, the space industry has remained one of the most geopolitically sensitive industries. As the number of international conflicts increases, politicians are once again recognizing the value of space technologies for reconnaissance, communication, and navigation. Public support for space spending is critical for nations seeking to project geopolitical power through space capabilities. However, when budgets have to be trimmed, citizens often list space programs as among the first public programs to be cut (along with foreign aid, military spending, and social welfare), partially because citizens overestimate their national space budget by a wide margin (Launius, 2003). Providing citizens with factual information can influence their political demands (Haaland and Roth, 2020), particularly in democratic nations (Hines, 2022; Weeks, 2008). This in turn can influence political decisions such as the focus of foreign policy (Weeks, 2008). Across different public policy issues, correcting overestimation is the primary mechanism for increasing public support after factual information is provided, suggesting a similar effect on support for space budget increases (Dylong and Uebelmesser, 2024; Grigorieff et al., 2020). Evidence of a positive

information effect on space budgets could thus provide important guidance to policymakers seeking to revitalize space budgets.

Political leaders increasingly justify rising space expenditures by framing them as necessary for maintaining global competitiveness with adversaries. Using numerous quotes, we highlight that government officials from many nations leverage comparisons with adversaries' space capabilities to argue for increased space funding. However, research has yet to investigate whether this geopolitically comparative rhetoric convinces citizens to support increases in space spending. The impacts of such rhetoric is a sensitive topic, given its potential to induce negative societal effects such as xenophobia (Gerber, 2014). Geopolitically aggressive rhetoric also hinders future international cooperation in space by reducing citizens' appetite for compromise (Gottfried and Trager, 2016). This can be particularly damaging because cooperation is often in the best interests of humanity, as the case of the International Space Station (ISS) shows.

Politicians' declaration of a new space race may nevertheless have less impact on public opinion than expected, as private companies have become increasingly important in the space sector. Today, "New Space" companies with increased customer focus, new product development approaches, and new business models (Golkar and Salado, 2021: 1) possess space capabilities formerly exclusive to states. By offering services rather than products and using agile development approaches such as rapid prototyping (Weinzierl and Sarang, 2021), New Space companies can significantly lower the costs of conducting space activities (Weinzierl and Sarang, 2021). SpaceX, the rocket and satellite communication company led by Elon Musk, has clearly demonstrated this cost-cutting capacity (NASA, 2011). However, as a quasi-monopolist in the rocket launch market, SpaceX also has the ability to delay military satellite launches and has actively intervened in the Ukraine war through its Starlink communications network. Various other New Space companies act as geopolitical assets for their nations, reducing the marginal cost of effort in the new space race for areas like remote sensing. At the same time, most New Space companies joining the USD 464 billion space economy (Euroconsult, 2023) still rely on governmental entities as anchor customers, underlining the importance of public space funding. This raises the question of how citizens' opinions about space funding shift when they learn that a significant proportion of public funds will not remain with public space agencies but rather will be awarded to private companies through contracts or grants. With public funding justified by public approval as an essential asset for New Space companies, politicians must thus understand whether citizens support the currently

pursued strategy of outsourcing geopolitically relevant capabilities to more efficient, privately controlled companies. This leads us to three research questions, which we will answer below:

RQ1. How does citizens' approval for an increase in the national space budget change if they are informed about their actual national space budget?

RQ2. How does citizens' approval for an increase in the national space budget change if they are presented with an adversary's space budget?

RQ3. How does citizens' approval for an increase in the national space budget change if tax money is known to finance private companies instead of public space agencies?

Contest theory, which can be applied to examine the effect of information in a geopolitical contest (Tullock, 1980), allows the derivation of testable hypotheses for RQ2 and RQ3. A contest is a competition in which participants expend resources or effort for a chance of winning a specified prize. In the original Space Race, the prize was to be the first nation to put a man on the Moon and the prestige that came with that accomplishment. Regarding RQ2, optimal responses to varying levels of adversary effort (or, more precisely, space budgets) can be derived for contest models, such as the widely used Tullock contest. RQ3 also has a connection to contest theory, because efficient private firms could increase the effectiveness of investments in the new space race contest.

To investigate our three research questions, we recruited 2,135 citizens from the nine most heavily invested spacefaring nations: China, France, Germany, India, Italy, Japan, Russia, the UK, and the US. We conducted a survey experiment, which included one baseline pathway and two treatments. Each treatment consists of two distinct interventions, resulting in five possible experimental conditions to which participants were randomly assigned. Three of the five groups received either no information, information on their national space budget, or information on both their own and adversaries' national space budgets. The remaining two groups were informed about cost-efficient private space endeavors by New Space companies or learned about the experience of their national space agency.

We then measured the change in support for an increase in the national space budget, consistent with recent increases in the public space budget and the rhetoric of government officials in favor of further increases. Recent evidence on information effects shows that respondents changed their opinion once they realized that their choices entailed real costs such as accruing debt or cutting

other programs due to limited resources (Abel et al., 2021; Cattaneo and Grieco, 2021). We therefore also measure citizens' revealed preferences. We incentivized participants in order to elicit their actual preferences about public budgets by allowing them to distribute a donation to three charities, one of them being a charity advocating for space funding and education.

We derive three key findings from our analysis. First, for RQ1, we find that providing citizens with additional information about their respective national space budget increases their approval for raising the space budget by 7 percentage points (pp) compared to the baseline. While almost all citizens overestimated national space funding, we cannot unambiguously identify overestimation as the main channel for the positive treatment effect. Importantly, the already very high willingness to increase the space budget in the baseline (in which no additional information is provided to citizens) hardly allows for a further increase in some countries such as India or China.

Second, citizens are 9pp less likely to advocate for an increase in the national space budget after being confronted with geopolitically comparative rhetoric (i.e., information about their own and their adversaries' national space budgets). Even after several robustness checks that consider the individual preferences of a large number of participants and a possible overestimation of national or adversary budgets, our results remain consistent with respect to RQ2. One possible explanation for why information about one's own and adversaries' national space budgets negatively affects willingness to increase space budgets may be citizens' realization that their country has little chance of winning the battle for space dominance at current spending levels and therefore reducing spending might be the best response (Cason et al., 2020; Mueller, 2012). Fittingly, confronting citizens with a higher adversary budget amplifies the negative information effect on citizens' approval of a budget increase. This effect contradicts politicians' argument that increased rival efforts in a space race call for a corresponding expansion of the national space budget, but can be rationalized as optimal behavior in a Tullock contest.

Third, in the overall sample, citizens' support for an increase in the space budget is not influenced by whether government agencies or private companies conduct space activities. However, in the US (the nation with the largest commercial space sector), we find that mentioning efficient private enterprises instead of legacy governmental agencies significantly lowers approval for national space budget increases by 26pp.

Our findings contribute to the literature on how information effects influence misinformed citizens and shape public opinion about various domestic (Bertoli et al., 2023; Cattaneo and Grieco, 2021) and foreign policy issues (Delavande and Zafar, 2018). In addition, we present survey measures related to the space industry that we experimentally validate and which predict field behavior. Our findings on the effect of geopolitically comparative rhetoric on citizen support for a space budget increase have significant implications for government officials advocating for more funding. As we demonstrate, government officials are unlikely to be able to convince citizens to agree to an increase in the national space budget with geopolitically comparative rhetoric. Considering the negative effects of comparative rhetoric, such as xenophobia and reduced international cooperation, politicians should refrain from using this kind of comparative rhetoric in advocating for space budget expansions (Gerber, 2014; Gottfried and Trager, 2016).

We also contribute to the extensive literature on privatization (Galiani et al., 2005; Gupta, 2005; Megginson et al., 1994). Unlike many other studies, we do not focus on the economic or managerial outcomes of privatization, but rather contribute to the understanding of how privatization is perceived by citizens (Legge and Rainey, 2003). Given that private companies in this industry challenge the geopolitical power of governmental organizations, we also contribute to the literature on geopolitical companies (Do et al., 2023; Klein, 2024; Scherer and Palazzo, 2011). Our findings should demonstrate to policymakers that citizens in all except the US are indifferent as to whether public or private entities carry out space activities, enabling politicians to choose the most efficient options in a potential space race without fearing opposition from citizens. However, in the US (the most important nation for New Space companies), stakeholders should be aware of citizens' bias against private companies when advocating for funding increases.

The remainder of this article is structured as follows. In Section 2, we provide background information on public opinion regarding space funding, the geopolitical implications of space, and the growing geopolitical power of private space companies. In Section 3, we describe our sample and method, including our experimental design and empirical strategy. We present our results in Section 4 and discuss them in Section 5. Section 6 concludes.

2. Background

2.1. Public Opinion on Space Funding

Public opinion on the space sector has been and continues to be highly idealized. Many recall widespread space euphoria in the US during the 1960s (Launius, 2003). In reality, space enthusiasm existed only during and shortly after the first Moon landing in 1969. In 1966, almost 30% of Americans stated that public spending on space should be reduced, an opinion that rose to 55% in 1975 (Launius, 2003). In contrast, recent reports have found that 85% of Americans are in favor of increasing NASA's budget (Mosher and Lee, 2018). At the same time, scholars have provided evidence that space ranks among the least important programs to citizens when government resources are constrained, especially compared to areas like health care (Lehming et al., 2010). The heterogeneity of public opinion on space contrasts with public opinion in areas such as migration (Dylong and Uebelmesser, 2024; Grigorieff et al., 2020) or public debt (Roth et al., 2022), which is typically more consistent.

One explanation for the sometimes extraordinarily high level of support for the space budget in popular science surveys is the priming effect (Delavande and Zafar, 2018; Mosher and Lee, 2018) of space receiving a disproportionate amount of media attention compared to its budgetary value. An empirical study shows that in 2007, four of the top five news stories by minutes covered in TV segments on science, space, and technology were solely dedicated to space (Lehming et al., 2010). As a result, citizens might be primed to overestimate what is a reasonable amount of public space funding. Priming or salience-based updating occurs when additional information influences citizens' opinions by heightening attention to a certain topic, making citizens more likely to approve of this topic (Delavande and Zafar, 2018). For example, if a survey question probes public approval of the federal budget, citizens might only see NASA and recall the countless positive media reports they have seen in the past, which induces them to state a high approval for a space budget funding increase. In contrast, unbiased updating explains the effect of information on citizens' opinions after comprehending and evaluating the new information (Delavande and Zafar, 2018). Returning to the hypothetical survey question, citizens using unbiased updating not only

recognize the name NASA but also evaluate whether the federal space budget of 0.69% aligns with their personal preferences.¹

To test whether treatment effects are driven by salience-based or unbiased updating, scholars compare the different effect sizes of ex-ante well-informed and poorly informed citizens (Schueler and West, 2016). Unbiased updating is assumed to impact ex-ante less-informed citizens more strongly, as these citizens update their policy preferences based on new information (Schueler and West, 2016). Well-informed citizens should only marginally change their policy preference, as they are already knowledgeable, and register that the information provided does not represent new information. For salience-based updating, the effect size should be similar in the subgroups of well- and poorly informed citizens, as both groups should be influenced by the availability of information to a similar extent. An initial under- or overestimation of the number of interest is a key channel in explaining unbiased information effects. For example, scholars have shown that overestimating the number of migrants and a subsequent information treatment correcting that belief leads to a more positive post-treatment sentiment against migration (Dylong and Uebelmesser, 2024; Grigorieff et al., 2020). Lergertporer et al. (2018) find that, in Germany, support for public funding for education decreases after citizens are informed about the current higher-than-expected spending level. Roth et al. (2022) find that information about the current amount of national debt, which citizens underestimate, reduces support for governmental spending.

Citizens also hold significant misconceptions about space budgets, often greatly overestimating the national space budget (Launius, 2003; Steinberg, 2013). Fittingly, scholars using a student sample have also identified a positive information effect after citizens who overestimated the national space budget were educated about the actual funding level (Steinberg, 2013). However, it is unclear whether salience-based or unbiased updating drives this effect. Identification of the channel of an information effect about the national space budget would have significant implications for the communication strategy of space advocates. For this reason, we examine this channel in detail below.

¹ All current numbers on the national space budgets of different nations used in this paper are derived from calculations based on each nation's total public space budget (Vanleynseele, 2022) and the total public expenditure of that respective country (IMF, 2023).

2.2. Geopolitical Implications of Space

Space also differs from other public policy topics because of its geopolitical importance. Geopolitics and space have been intertwined since the Cold War, with space's geopolitical implications becoming more evident to citizens through recent conflicts (Hines, 2022). For example, hours before Russian troops crossed the Ukrainian border on February 24, 2022, Russian hackers targeted American satellite communication company Viasat (United States Department of State, 2022). The attack disabled thousands of satellite terminals in Europe, and likely targeted terminals used by the Ukrainian military (United States Department of State, 2022). Geopolitical actors are now addressing the military importance of space more openly, with the establishment of space-focused military branches in China, Russia, and the US (Defense Intelligence Agency, 2022) and the adoption of space command structures in France in 2019 and Germany in 2021.² Japan and the European Union have also stated that security interests are among their primary motivations for space activities (Grimard, 2012).

Besides the relevance of space in providing concrete advantages in geopolitical conflicts (e.g., satellites for reconnaissance, communication, and navigation), space is also strongly connected to national prestige. As Lyndon B. Johnson once summarized: “Failure to master space means being second best in every aspect, in the crucial area of our Cold War world. In the eyes of the world [...] second in space is second in everything” (Hirsch and Trento, 1973: 107). Being a space power is still strongly connected with being a superpower, as indicated by the quote at the beginning of this article, which is why emerging superpowers like China and India invest heavily in space (Launius, 2003). The current increase in attention to space, along with rising governmental budgets, is reminiscent of the Space Race of the 1960s (Grimard, 2012; Vanleynseele, 2022). During the Space Race, it was not military confrontation that decided which economic system was viewed as superior by citizens. Rather, economic perseverance determined which nation emerged victorious.

Politicians often employ comparative rhetoric to justify increased space spending, addressing citizens' concerns about rising space expenditures by referencing adversaries. The quotes from the US presidents Trump and Johnson are examples of such comparative rhetoric in the US. We have

² For details on the inception of the French space command, see the order “Arrêté du 3 septembre 2019 portant création et organisation du commandement de l'espace” of the French Ministry of Armed Forces. For Germany, see <https://www.bundeswehr.de/de/organisation/luftwaffe/aktuelles/das-weltraumkommando-der-bundeswehr-5443406> on the website of the armed forces of Germany.

also extracted at least one similarly framed quote for each nation analyzed in the present study to highlight how similar the motivations are for increased space funding worldwide (Appendix A1). Notably, geopolitically comparative rhetoric in any form always builds up an adversary, the steep cost of which comes in many forms. First, in conflicts where prior rhetoric has strongly shaped perceptions of adversaries as enemies, citizens perceive compromises as concessions rather than the mutually beneficial collaboration that is perceived when prior rhetoric has been more moderate (Gottfried and Trager, 2016). As a result, ambitious projects such as the ISS that rely on cooperation between competing nations become less likely (Grimard, 2012). Second, public rhetoric raises audience costs, increasing the likelihood that leaders end up in an irreconcilable dilemma. For example, if both nations claim more than 50% of the same good, their positions become incompatible, making compromise difficult (Leventoğlu and Tarar, 2005). Finally, repeated naming of an adversary can nurture xenophobia (Gerber, 2014). Given the potential costs associated with geopolitically comparative rhetoric, it is remarkable that scholars have yet to determine its effectiveness in persuading citizens to support increased spending, and if it is ineffective, the question arises of how citizens should theoretically react to such rhetoric.

A Tullock (1980) contest represents a useful tool for answering this question. A Tullock contest is a contest where the probability of winning is proportional to one's exerted effort in relation to the total effort expended by all participants. The Space Race during the Cold War is a perfect example. The contest's prize was to be the first nation to put a citizen on the Moon and thus demonstrate technical and systemic leadership. However, to have a chance of reaching the Moon first, each nation had to exert a certain amount of effort, represented by massive expenditures toward their respective space programs. The US, for example, spent over 3% (Launius, 2003) of its federal budget on NASA, which is significantly more than the 0.69% of the present federal budget being spent on all space activities, including military space projects (IMF, 2023; Vanleynseele, 2022). The US ultimately won the Space Race by putting American boots on the Moon, rendering all previous achievements by the USSR irrelevant in the eyes of the public. The specific goal defining victory in today's space race remains to be determined; however, at the time of early human spaceflight in the 1960s, the goal was also vague until President Kennedy declared the race to the Moon.

If citizens view the space race as a contest, they might respond, as in a Tullock contest, to competitors with support of higher public space budgets representing greater chances of winning.

Faced with an adversary with a far greater space budget than one’s own country, citizens might realize their nation has little chance of winning the contest for space supremacy at current effort levels (Cason et al., 2020). If the difference between the national budget and that of the adversary is so large that it would require unfathomable resources to match the opponent’s efforts, citizens might reduce their support for further increases in funding or even advocate for cuts.³ With this strategy, citizens could maintain a non-zero chance of winning the competition while minimizing their effort levels. As a result, politicians and other space industry stakeholders might induce the opposite of the intended effect of their comparative rhetoric, with citizens lowering their approval instead of increasing it.

2.3. Geopolitical Private Space Companies

As the quote at the beginning of this article shows, space companies now wield geopolitical power that was once reserved exclusively for nations. Following Russia’s cyberattack on Ukrainian satellite terminals, Ukraine switched to Starlink satellites, offered by the private space company SpaceX (Abels, 2024). While the digital minister of Ukraine described Starlink as “the blood of our entire communication infrastructure now” (Satariano and Khurana, 2023: 1), SpaceX restricted the use of Starlink in offensive maneuvers in 2023, harming Ukraine’s military capabilities and highlighting how intertwined commercial space companies are with geopolitical power (Abels, 2024).

The concept of geopolitical companies is not confined to the space sector. While space companies can exert geopolitical influence through their products and services, other sectors are more concerned with managing geopolitical risks directly in their business models. Oil companies, for example, have always had to manage geopolitical risks in their production area and the nation in which their headquarters is located (Gamso et al., 2024). Consequently, such companies seek to

³ The central feature of a Tullock competition is that a participant’s probability of success is proportional to their invested resources and relative to the total investment of all participants. For example, the expected payoff function of a two-player Tullock contest for nation i is given by $U(x_i) = P_w^i W - x_i$ with a probability P_w^i to win prize W , with x_i being the invested amount. In the simplest and most prominent version, P_w^i is given by $P_w^i = \frac{x_i}{x_i + x_j}$.

Maximizing expected utility with respect to x_i yields $x_i = \sqrt{Wx_j} - x_j$, which is a concave function peaking at $x_j = \frac{W}{4}$. Hence, for $x_j > \frac{W}{4}$ the optimal investment is decreasing in x_j .

exert geopolitical power indirectly through lobbying (Alam et al., 2024). In some cases, geopolitical tensions are not merely a source of threat that requires additional effort to resolve; companies can use geopolitical advantages and move their production from democratic nations to non-democratic nations to exploit comparative advantages in, for example, geopolitical risks and regulations (Scherer and Palazzo, 2011). There are also firms that benefit from geopolitical conflicts, particularly arms companies capitalizing on increased demand for military equipment (Apergis and Apergis, 2016).

A key difference between the space industry and other geopolitical sectors is the heightened awareness of its geopolitical importance among citizens, investors, and politicians (Burbach, 2019; Do et al., 2023; Hines, 2022; Klein, 2024). For example, a vast majority of Chinese citizens agree that a space race between China and the US is inevitable. On the stock market, geopolitical news explains a significant part of the realized volatility of aerospace stocks (Klein, 2024). Additionally, military satellite launches by adversaries divert attention away from the market as measured by share turnover (Do et al., 2023). Moreover, foreign policy hardliners (“hawks”) generally advocate for a larger space budget, in contrast to those who favor a more moderate geopolitical rhetoric (“doves”) (Burbach, 2019).

In view of a new space race, countries with efficient New Space companies could increase their chances of winning a Tullock contest at lower costs, potentially justifying higher space spending.⁴ To understand the geopolitical power of New Space companies, it is essential to understand how New Space companies can lower the marginal cost of effort compared to legacy aerospace conglomerates. New Space companies do business in and about space in radically different ways; in addition to technical innovations such as reusable rockets, space companies apply corporate innovation to target their business models. Space agencies and private customers no longer exclusively finance the development of entire missions, but rather purchase the desired services, such as data or bandwidth (Weinzierl and Sarang, 2021). Efficiency gains and outsourcing are made possible by companies that, unlike traditional space companies, sell their services to multiple customers rather than relying on a single government customer. New Space companies can also capitalize on economies of scale, for example by producing large numbers of similar, affordable

⁴ In Tullock contests, increasing the effectiveness of investments is equivalent to increasing the price and leads to higher equilibrium investments.

satellites rather than building costly, custom-made satellites from scratch for every individual customer. These characteristics significantly reduce the marginal cost of space efforts compared to the aerospace conglomerates contracted by space agencies, making New Space companies a valuable geopolitical asset.⁵ Nevertheless, it is questionable whether New Space companies have sufficient incentives to care about and internalize the space debris caused by the launch of thousands of satellites (Weinzierl, 2018). Scholars also point out that all major space treaties from the 1970s are designed to govern nations, not profit-oriented firms (Genta, 2014).

The space sector is therefore embroiled in a debate similar to that in many privatized or partially privatized industries. There is abundant evidence that privatization positively affects productivity and efficiency, mainly due to relying on fewer workers to supply equal or even better results (Galiani et al., 2005; Lähdemäki, 2024; Megginson et al., 1994). Even partial privatization can positively impact managerial efficiency (Gupta, 2005). However, research also continues to identify confounding variables explaining the success of privatization, such as various political and organizational factors (Estrin et al., 2009; Villalonga, 2000). It is also questionable whether privatization benefits all of society through gains in efficiency or rather leads to greater inequality (Birdsall and Nellis, 2003).

Whatever its aims, the academic discussion often neglects the opinions of citizens, whose voices (at least in democracies) are needed to legitimize privatization (Legge and Rainey, 2003). Here, the space industry serves as a compelling object for research. On one hand, New Space companies clearly offer a lower marginal cost of effort for nearly every aspect of space (Weinzierl and Sarang, 2021). If space agencies such as NASA were initially seen as a response to market failure (Weinzierl, 2018), then New Space companies should now receive whatever funding is necessary, if the state needs to access geopolitically important space capabilities. On the other hand, New Space companies are not as sensitive to the public good (e.g., the prevention of space debris) and at least for now remain dependent on government funding. For example, the European Investment Bank (2019) estimates that 40% of all space start-ups require public funding before being able to receive venture capital. Given the potential downsides of privatization and the growing importance

⁵ A famous example of the concrete cost difference between New Space companies and projects managed primarily by NASA can be found in the Commercial Market Assessment for Crew and Cargo Systems (NASA 2011). In the report NASA predicted that it would have taken \$1.7-4 billion for NASA to develop a rocket similar to SpaceX Falcon 9 rocket. SpaceX has spent around \$390 million on the development of the Falcon 9 rocket.

of space, policymakers must assess whether citizens support the current strategy of partial privatization in the space industry.

3. Method and Data

3.1. Experimental Design and Empirical Strategy

Our online experiment was preregistered at the AEA RCT Registry. Appendix A2 and A3 show the preregistration and the complete online experiment. Our experiment contained one baseline path and two treatments with two experimental interventions each, allowing participants to be assigned to one of five experimental interventions. Because participants were randomly distributed to the five interventions, we did not expect that the different interventions would have systematically different demographic characteristics. Nevertheless, we ran balance checks on different control variables using a Kruskal-Wallis test. No control variable was significantly unbalanced between the five groups, confirming a successful randomization (Appendix A4).

First, we asked all participants to guess their own nation's space budget to identify potential over- or underestimation as a channel for RQ1 and RQ2. Answers were solicited in percentage points from 0–100 of the overall federal budget of the participant's nation. Participants were then randomly assigned to one of the five experimental interventions. To investigate RQ1 and RQ2, participants were randomly assigned to one of the interventions in Treatment 1 (T1) (Budget Information) and were asked to rank the other eight space nations from ally to adversary (see Appendix A5 for a table on nation-specific adversaries). We subsequently asked participants assigned to T1 (Budget Information) to guess the budgets of their top three adversaries. Afterward, one-third of the participants in T1 (Budget Information) did not receive any further information (Baseline). Another third of the citizens in T1 (Budget Information) were given information about their national space budget. The last third of the participants assigned to T1 (Budget Information) were given information about their national space budget and additionally information about the space budget of the nation they deemed most likely to be an adversary.

More precisely, we presented participants with the following text: “[Your nation] spends about [national space budget] of its federal budget on space exploration. [Adversary] spends about [adversary budget] of its federal budget on space exploration. In your opinion, should funding for space exploration in [your nation] increase, decrease or stay the same?” The aim of this text is to

imitate geopolitically comparative rhetoric, as seen in the quote at the beginning of this article and the quotes in Appendix A1. Instead of the adversary's national space budget as additional information in T1 (Budget Information), a possible alternative treatment could have been information about a specific event, such as a recent satellite weapon test or a successful rocket launch by the participant's nation or an adversary. However, we wanted to measure citizens' opinions on the national effort exerted in space competition. For this reason, we have decided to provide information on the national space budget, which is arguably a direct indicator of the effort nations are making in the space race.

To investigate RQ3, participants were assigned to Treatment 2 (T2) (Public vs. Private). In this treatment, participants received either information about the public or private space sector. For information about the private sector, we choose to highlight the cost savings that reusable launchers have brought to the space industry. We explicitly refrained from using specific company names in order not to induce unwanted effects associated with a participant's attitude towards a particular company. For those receiving public-sector information, we provided participants with positively connotated information about their respective national space agency. We decided to highlight the years of experience the respective space agency has. Experience is often used to justify limiting public funding of private space companies to prevent loss of expertise (Weinzierl, 2018). Notably, all nations in our sample have long-established space programs that highlight the experience often cited in support of public space agencies (See Appendix A3 for the complete experiment).

After citizens had been subjected to one of our five experimental conditions, we investigated their approval for increasing their own national space budget. We queried participants using the following question, which was adapted from Lergetporer et al. (2018): "In your opinion, should funding for space exploration in [your nation] increase, decrease or stay the same?" Participants could then provide their answer on a five-item Likert scale ranging from "Greatly decrease" to "Greatly increase." We then coded a dummy variable, which takes a value of one if the citizen opted to "Increase" or "Greatly Increase" the national space budget. To stay consistent with recent expansions of public space budgets and the previously described political rhetoric, we chose to investigate the approval of a budget increase and not, for example, a budget reduction.

Information effects often decrease in magnitude when citizens realize that their decisions will entail real costs, such as debt or budget cuts in other governmental sectors (Abel et al., 2021; Cattaneo

and Grieco, 2021). Therefore, in addition to stated preferences, we also measured revealed preferences using an incentivized measure. We offered each participant the opportunity to allocate a \$1 donation across three organizations: the Planetary Society (which promotes space through advocating for funding and also finances space-related projects), the Red Cross (which provides humanitarian aid), and Atmosfair (which offers carbon compensation). By recording how participants apportioned the donation, we assessed the degree to which they prioritize space relative to other societal needs. Donations are commonly used to elicit revealed preferences through incentivized measures (Abel et al., 2021; Cattaneo and Grieco, 2021). For each charitable organization, we have explained to participants the potential use of the donations (Appendix A3).

[Figure 1 around here]

After measuring stated and revealed preferences, we also surveyed participants about their demographics as well as other space-related questions in order to construct control variables for our robustness checks. For example, to control for participants who could not identify a clear adversary, we asked participants whether they would still be willing to cooperate with other nations.

We adapted the experiment for each nation by modifying the language and inserting the specific budget values for that nation. Each text was translated twice, first from English into the respective language of a given nation and then by another translator back into English, to ensure the validity of the translation.

We relied on a between-subjects design to test how post-treatment beliefs differed between the participants in the baseline group and other treatment groups. Given that our balance checks indicated successful randomization across treatments, we were able to calculate the average treatment effect. We found the baseline approval for increasing space funding in the individual nations to be very heterogeneous. Because approval for a space budget increase varies greatly between nations, pooling the results may result in treatment effects canceling each other out. For example, in the baseline for India, 92% of citizens agree with a budget increase, compared to only 26% in the UK. Assuming an average support for a budget increase of 30% after an information treatment, this would represent a decline of 62pp in the case of India, but an 8pp increase for the UK. Hence, we also conducted a nation-specific matched analysis that only compared citizens from

the same nation to estimate effect size. We did not preregister this analysis, as we did not expect such considerable heterogeneity in baseline approval by nation.

3.3. Data

Our sample consists of citizens from all nations that spent at least USD 1 billion in federal spending on space in 2022 (Vanleynseele, 2022). The surveyed nations accounted for over 90% of worldwide public space funding in 2022. The required sample size per nation ($n = 235$) and per treatment was calculated beforehand using the program “G-Power” with the assumption of a medium effect size of 0.5 (Sullivan and Feinn, 2012). At the end of our survey, we ended up with slightly more participants than required (2,139 instead of the 2,115 ordered) because the survey distributor occasionally supplied slightly more participants than requested.

As in many other influential studies, we used an online platform to recruit citizens for our sample (Abel et al., 2021; Bertoli et al., 2023; Hines, 2022). We used SurveyMonkey’s “Audience” feature to recruit participants. Samples provided via “Audience” are comparable in their response quality to other online samples, such as those on Amazon Mechanical Turk (MTurk) (Bentley et al., 2017). However, we found the sample on SurveyMonkey to be much more demographically diverse compared to MTurk. Ultimately, we opted for SurveyMonkey to obtain a census-balanced sample in each nation based on age and gender data from the US Census Bureau International Database. We recruited our participants from the end of April 2023 to the beginning of May 2023.

4. Results

Fig. 2 shows the average treatment effects concerning RQ1–3. Fig. 3 presents an overview of the approval rating for the different experimental interventions. The approval varies greatly between nations. While baseline approval for a budget increase is roughly 74% in China and 92% in India, approval is only 26% in the UK and 41% in France, which highlights the importance of conducting a nation-specific analysis as shown in Fig. 4.

[Figure 2 around here]

[Figure 3 around here]

[Figure 4 around here]

4.1. Treatment 1: National Space Budget

Regarding RQ1, which asks how citizens' approval for an increase in the national space budget changes if citizens are informed about their actual national space budget, we find a weakly significant positive effect size. Nevertheless, when calculating nation-specific treatment effects, we find that providing citizens with the national space budget yields a 7pp increase in approval for space budget expansion (Fig. 4). The effect is statistically significant at the 5% level.

To investigate whether this information effect is driven by salience-based or unbiased updating, we compare a sub-sample of citizens from the baseline and T1 (Budget Information) groups who had received information about their national space budget. Specifically, we focused on citizens who had overestimated their national space budget by an above-median amount. If approval increases after providing additional information on the national space budget due to unbiased updating, the effect size should be larger for citizens who overestimated their budget significantly. These citizens would derive greater value from the information provided than citizens already well-informed about the national space budget (Schueler and West, 2016). However, we observe no statistically significant effect for citizens that overestimated the national budget by an above-median amount (Fig. 5).

Fig. 6 shows the deviation of citizens' guesses from the actual national space budget in percentage points. It explains why we could only analyze citizens with above-average overestimation, not those who underestimated the budget, as nearly all citizens overestimate it. For our incentivized measure, we measure no statistically significant treatment effect. We therefore conclude:

Result 1. *Citizens who have been informed about their national space budget are more likely to support funding increases.*

[Figure 5 around here]

[Figure 6 around here]

4.2. Treatment 1: National and Adversary Space Budget (Geopolitical Comparison)

Figs. 2 and 4 show the overall result for RQ2, asking how citizens' approval for an increase in the national space budget changes if citizens are confronted with an adversary's space budget. Citizens reduce their approval for expanding the national space budget by 9pp when informed about one's own and adversaries' national space budget. The treatment effect is significant at the 1% level for non-matched and nation-matched samples. The difference in revealed preferences between citizens who are only confronted with their national space budget and those who are also confronted with the adversary's budget is also negative but not statistically significant. We conduct ten additional sub-analyses for revealed and stated preferences to investigate the robustness of our results. We examine how the citizen's perception of geopolitics in space impacts the treatment effect for RQ2, using robustness checks 2.1–2.6, displayed in Fig. 7.

For robustness check 2.1, we examine only those citizens who perceived an actual opponent in the adversary nation they specified. Citizens may have felt compelled to name one of the nations as an adversary even though they would not classify any of the possible nations as their adversary. We used a control question asking citizens which of the other eight nations their government should refrain from cooperating with in space. If citizens stated that they would not cooperate with the nation rated as an adversary, we classified their adversary nation as a “real adversary.” If we are measuring a geopolitical channel, the effect size should be larger for 2.1, as the influence on the opinion of the citizen should be greater if it is a real geopolitical rival. Indeed, the effect size for the sub-sample analysis 2.1 (that is, citizens who stated that they would not cooperate with the nation rated as an adversary) is larger for the stated and revealed preference measures compared to the overall sample. Remarkably, for stated preferences, the effect size is also statistically significant at the 5% level, even though this sub-sample is much smaller than the overall sample.

We then analyze the impact of the various geopolitical perceptions of space on the information effect, considering geopolitical power as a potential priority and concern in robustness checks 2.2–2.5. In robustness checks 2.2 and 2.3, we investigate the influence of (de)prioritizing military capabilities in space. Robustness checks 2.4 and 2.5 are a sub-sample analysis for citizens who rated the militarization of space as their most (least) pressing concern in space. All of the statistically significant robustness checks in 2.2–2.5 are consistent with the overall sample analysis, with the exception of 2.3, which yields a weakly significant, positive treatment effect, but relies on

a sample size of only 64 citizens. We also checked whether citizens who categorized themselves as geopolitical “hawks” reacted differently from other participants to our treatment (2.6). To do this, we consider only citizens who indicated they do not want their nation to abide by international space law. We find a statistically significant negative effect size for the revealed preference, consistent with the treatment effect measured for the overall sample. However, with only 64 citizens, the sample size for the sub-sample analysis (2.6) is relatively small and results must be interpreted with caution.

Similar to RQ1, we check whether we can observe an under- or overestimation channel. In robustness checks 2.7–2.9, we analyze whether the above-median overestimation of the national and adversary space budget impacts the treatment effect. The negative information effects are consistent with the overall sample, with the stated preferences in 2.7 being statistically significant at the 5% level.

[Figure 7 around here]

Finally, we investigate whether being confronted with a higher or lower adversary budget drives the treatment effect. Fig. 8 shows our findings. With a negative 12pp difference, we find a stronger treatment effect compared to the overall sample when the adversary’s budget presented to the citizens is higher than their own national space budget. The treatment effect for adversaries with higher budgets is statistically significant at the 1% level, and likewise with the incentivized measure, where we observe a negative effect size of 10pp. However, when citizens are confronted with an adversary budget lower than their own national space budget, we find no statistically significant treatment effect.

[Figure 8 around here]

Overall, we find a consistent, negative treatment effect for our second research question. We therefore conclude:

Result 2. *Citizens who receive information about an adversary’s higher space budget are less likely to support increases in their national space budget.*

4.3. Treatment 2: Public and Private Space Activities

Next, we investigate citizens' approval for an increase in the national space budget if private companies benefit instead of public agencies (RQ3). Our findings are twofold. First, we do not find a significant effect for the unmatched and nation-matched samples (Figs. 2 and 4). However, Fig. 3 highlights the importance of a nation-specific analysis, with the US as a notable example. Table 1 shows that in the US, providing information about efficient private companies instead of the national space agency NASA reduces approval for an increased space budget by 26pp. Robustness checks accounting for varying levels of trust in the government do not result in a significant effect size (Fig. 9). However, we find that for the incentivized measure, more left-leaning citizens reduce their support for a budget increase by 14pp, which is statistically significant at the 5% level. We find no statistically significant effect size for the sub-sample of liberal or conservative citizens (Fig. 9).

Result 3. *Citizens are indifferent to whether public agencies or private companies profit from space funding. Only US citizens are significantly more likely to prefer public space agencies over private entities as potential beneficiaries of increases in their national space budget.*

[Table 1 and Figure 9 around here]

5. Discussion

The positive treatment effect regarding RQ1 investigating citizens' approval for the national space budget after being informed about their actual national space budget is in line with earlier findings for other domains. Research has shown that citizens become more supportive of unfavorable issues like migration (Dylong and Uebelmesser, 2024; Grigorieff et al., 2020) after overestimating the severity of the issue. We observe the same dynamic; however, we find no evidence of unbiased updating, which contradicts arguments that overestimation is the main driver in increasing approval for space funding (Steinberg, 2013). Overall, our treatment effect is less robust than other information effects observed in the literature (Lergetporer et al., 2018; Roth et al., 2022). As nearly all citizens consistently overestimate their nation's space budget, our findings only partially support correcting overestimation as the primary mechanism for approval increases, as suggested by other scholars (Cruces et al., 2013; Dylong and Uebelmesser, 2024; Lergetporer et al., 2018).

We provide two explanations for the comparatively weak effect in comparison to the extent of overestimation. First, our power analysis conducted before the experiment showed that we would need the entire sample size to measure a statistically significant treatment result. Therefore, we cannot expect significant effects if we substantially reduce the sample size in the salience-based vs. unbiased updating analysis. Second, exceptionally high levels of public support for space funding in China and India leave little room for positive treatment effects, with baseline approval levels for budget increases of around 74% and 92%, respectively. At the same time, this broad public support for space underpins China's and India's roles as major global space players and supports their respective governmental strategies fostering space capabilities (Grimard, 2012; Hines, 2022).

While we cannot unambiguously identify the channel for RQ1, the overall finding of a positive information effect still holds relevance for advocates of space funding increases and other state programs of comparably small size, such as development aid in the US (Diven and Constantelos, 2009). In the case of comparatively small but still controversial governmental programs like the space program, advocates seeking to argue for more spending should inform citizens about actual spending and put it into perspective before discussing the political issue itself (Diven and Constantelos, 2009). Contextualizing funding in space has been tried with the Penny4NASA campaign, proposing that NASA should get a penny of every tax dollar, i.e., 1% of the federal budget (Steinberg, 2013). The initiative spawned a petition that ultimately prompted a response from the White House.⁶ Note, however, that educating misinformed citizens is not always the most advisable strategy. For example, during the coronavirus pandemic, the actions of uninformed citizens were sometimes more socially beneficial than those of their informed counterparts (Abel et al., 2021).

We also measure citizens' revealed preferences using an incentivized measure. We find our measure of stated preferences for budget approval to be significantly positively related to our incentivized measure, the amount of donations forwarded to a space NGO (Appendix A6). Hence, our survey measures also have external validity and might be used in future research.

⁶ See <https://petitions.obamawhitehouse.archives.gov/petition/least-double-nasa's-annual-budget-one-penny-every-government-dollar-spent/>, which links to an archived version of the now-shut-down petition website "We the People."

Our results for RQ2 investigating the effect of geopolitical comparisons on public funding are consistent with contest theory. Citizens recognize their nation's minuscule chances of winning the new space race after being confronted with the higher budget of an adversary and opt for the valid strategy not to increase funding or even to reduce their effort to slightly above zero. Our finding regarding RQ2 therefore questions the effectiveness of geopolitically comparative rhetoric for convincing the public of space budget increases. Accounting for the potential social and diplomatic costs of a more aggressive rhetoric (Gerber, 2014; Gottfried and Trager, 2016), our findings suggest that policymakers should not depend solely on comparative rhetoric to garner support for public funding, especially without first considering the potential for such a strategy to backfire.

Our finding for RQ3, comparing public and private space actors, can be interpreted in two ways. Regarding the overall sample, it may be seen as evidence that citizens have already accepted powerful private companies in space, as they do not strongly prefer public agencies over private actors in space. On the other hand, even though the New Space economy is very popular with scholars (Weinzierl and Sarang, 2021), investors (European Investment Bank, 2019), and politicians (European Investment Bank, 2019, also see Trump's quote at the beginning of the article) their enthusiasm in advocating for New Space over public space agencies has yet to spill over to citizens.

Our results are more unambiguous for the US, with a 26pp reduction in approval for space budget increases when private companies are mentioned instead of public space agencies. We propose three factors potentially contributing to the difference in approval. First, established space agencies, especially NASA, have built established and trusted brands around their agencies (Schrogl, 2017). In contrast, few New Space companies have had a chance to build up an actual reputation due to their recency. Second, private New Space companies might be associated with eccentric and well-known founders such as Elon Musk or Jeff Bezos. It may be that citizens, including those who perceive these founders negatively, transfer their perception of these individuals to the overall New Space industry. Third, we find that left-leaning citizens prefer public agencies over private companies even more. Giving more funding to private companies that accumulate wealth after making a profit would run counter to this preference. Given the advantage that efficient companies can offer nations when exerting efforts in a contest like the Space Race, US politicians should be especially concerned about the potential negative bias among their constituents towards New Space companies and adapt their campaigning for space accordingly. Ultimately, shareholders of New

Space companies should also be aware of potential biases, given that their income is also based to a non-negligible extent on state funding, which is ultimately legitimized by the citizens of the respective nation.

It should be kept in mind that the results of any experiment depend on a representative sample, and while we did our best in selecting a gender- and age-representative sample, we still relied on an online population. Generalization should thus be limited to the results for those nations with the least restricted access to the internet (Hines, 2022). Especially in nations like India or China, selecting an online sample could lead to selection bias, representing only above-average-educated and wealthy individuals. On the other hand, the comparably low remuneration could lead to unmotivated participants in high-wage nations like the US, resulting in citizens not paying attention to the questions and biasing the results. To address this, we conducted an additional analysis, excluding all citizens who failed an attention check at the beginning of our survey. The results are identical to those in Fig. 2 (see attention check in Appendix A7).

6. Conclusion

We conducted a survey experiment among respondents from the nine most important spacefaring nations to investigate how providing citizens with information about their own nations' and adversaries' space budgets influences public opinion on expanding space budgets. Additionally, we investigate citizens' preferences on whether public or private space entities should conduct space activities. Table 2 summarizes our results.

We find that, among those who initially overestimate the national space budget (comprising a vast majority of respondents), an information treatment revealing the actual budget increases approval for space budget expansion. Providing citizens with both their own nation's and an adversary's space budget does not cause citizens to increase their approval for expanding the national space budget, as politicians seem to expect. Instead, citizens decrease their approval for space budget increases, especially when confronted with an adversary's space budget that is higher than their own national space budget. Given that this negative effect on citizen approval persists across different robustness checks, our results call into question the usefulness of geopolitically comparative rhetoric, especially given the costs such rhetoric entails, such as increased xenophobia and damage to international cooperation (Gerber, 2014; Gottfried and Trager, 2016).

We further show that in the US, the nation at the forefront of the New Space economy, citizens are less willing to give their tax money to private companies, even though they can carry out space-related ventures more effectively than government-led initiatives. For the New Space companies in the US and the politicians who want to use them for geopolitical capital, this means that there is still a long way to go before these companies can gain public trust comparable to that enjoyed by NASA. In other nations, we find no significant difference in preferences regarding whether private firms or state agencies conduct space activities. This difference might of course have a lot to do with the polarizing personalities of well-known New Space entrepreneurs and the absence of similar figures in the space sector outside the US.

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Figures

Figure 1. Experimental Interventions

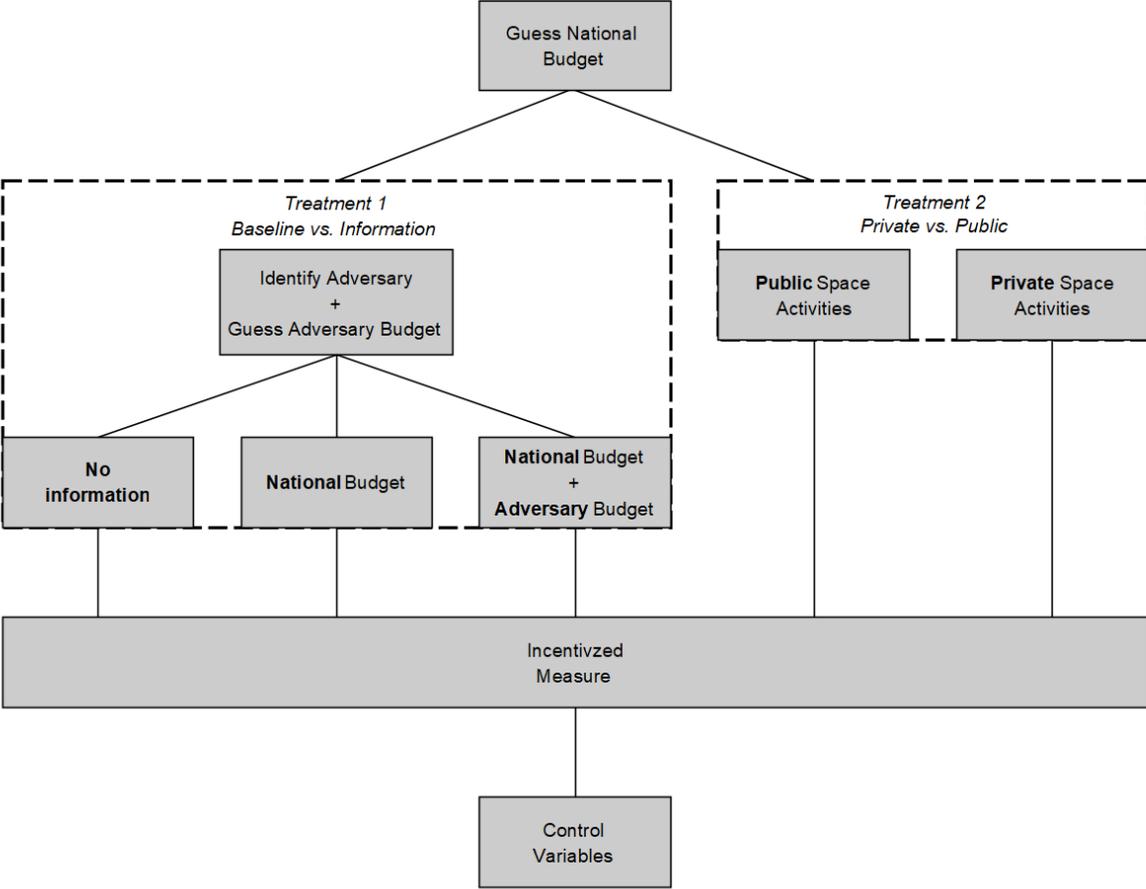
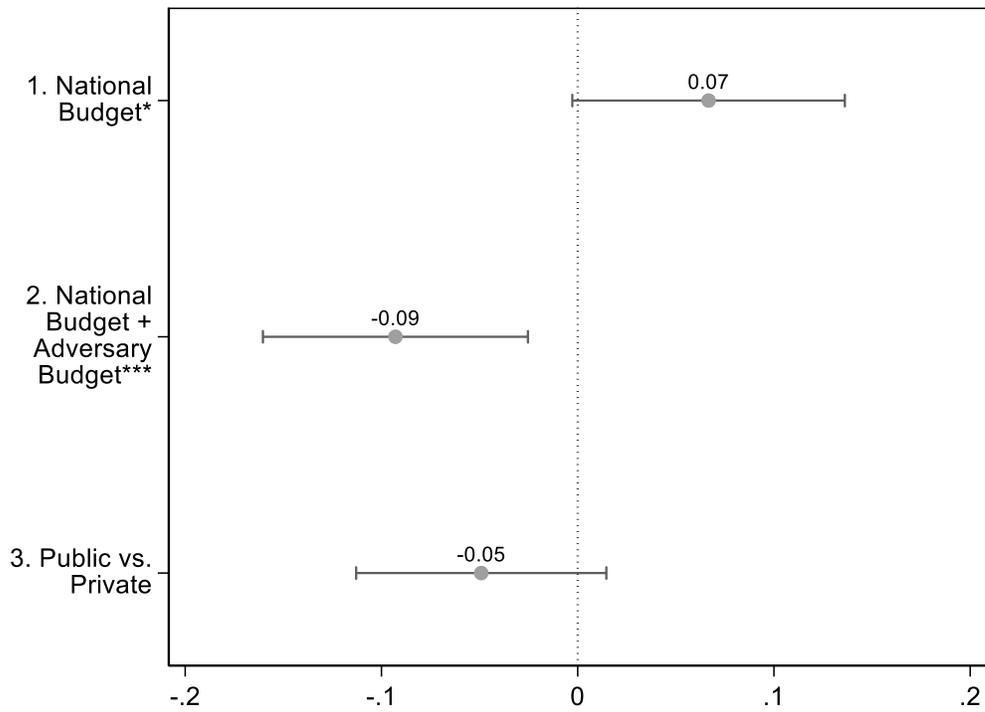
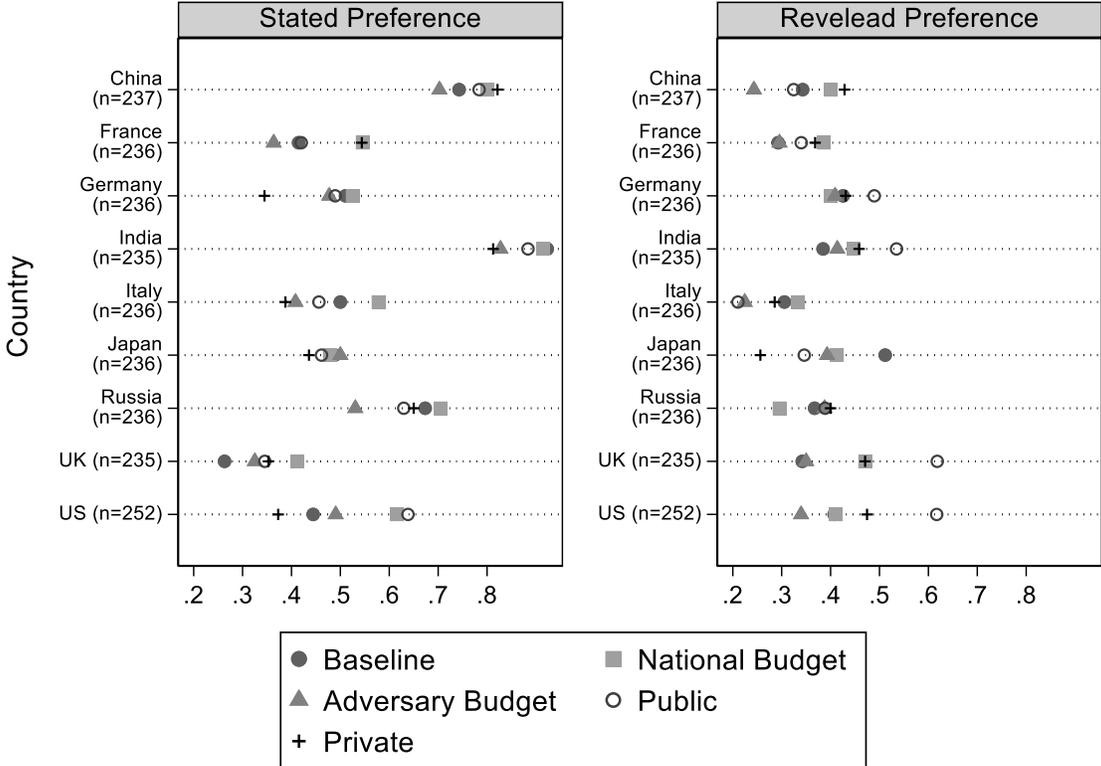


Figure 2. Treatment Effects for Experimental Interventions



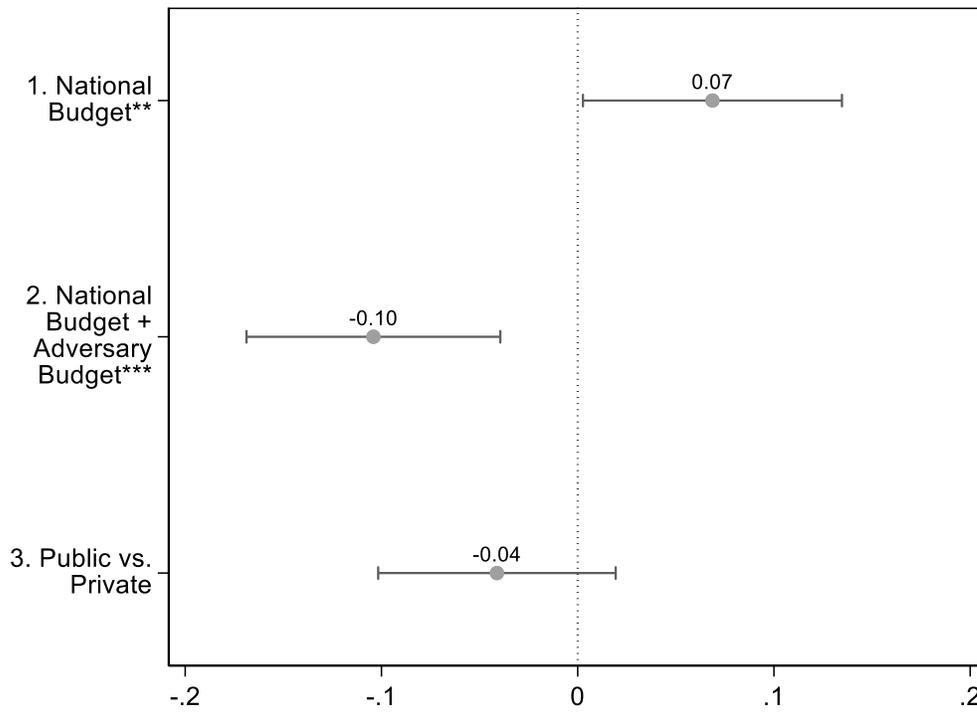
Graph displays the effect size of our three research questions with a 95% confidence interval.
* $p < .1$; ** $p < .05$; *** $p < .01$.

Figure 3. Experimental Interventions Per Nation



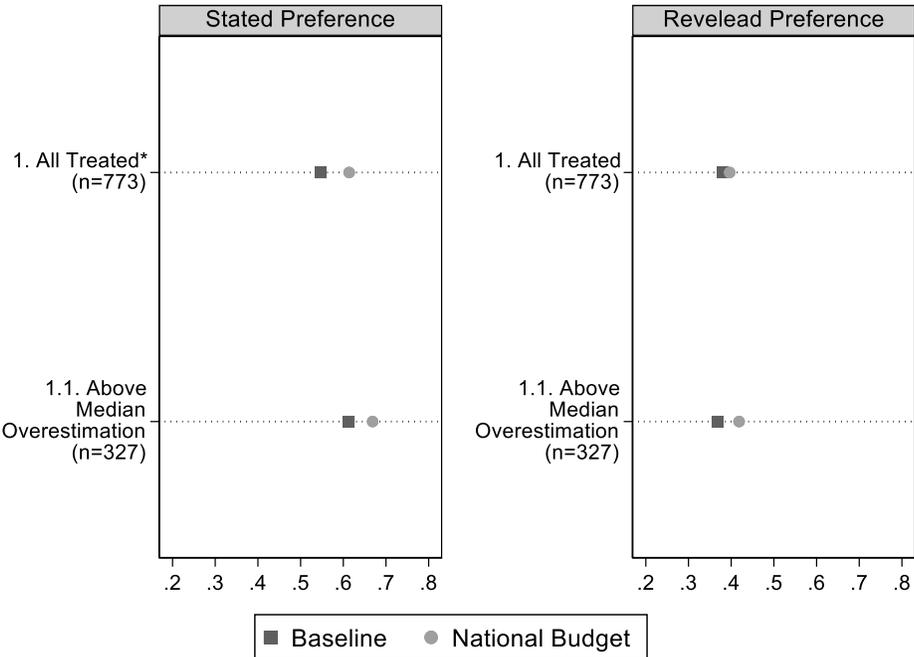
The graph displays the percentage of citizens advocating for a budget increase in the baseline or specific experimental intervention.

Figure 4. Treatment Effects for Experimental Interventions with Nation-Specific Effects



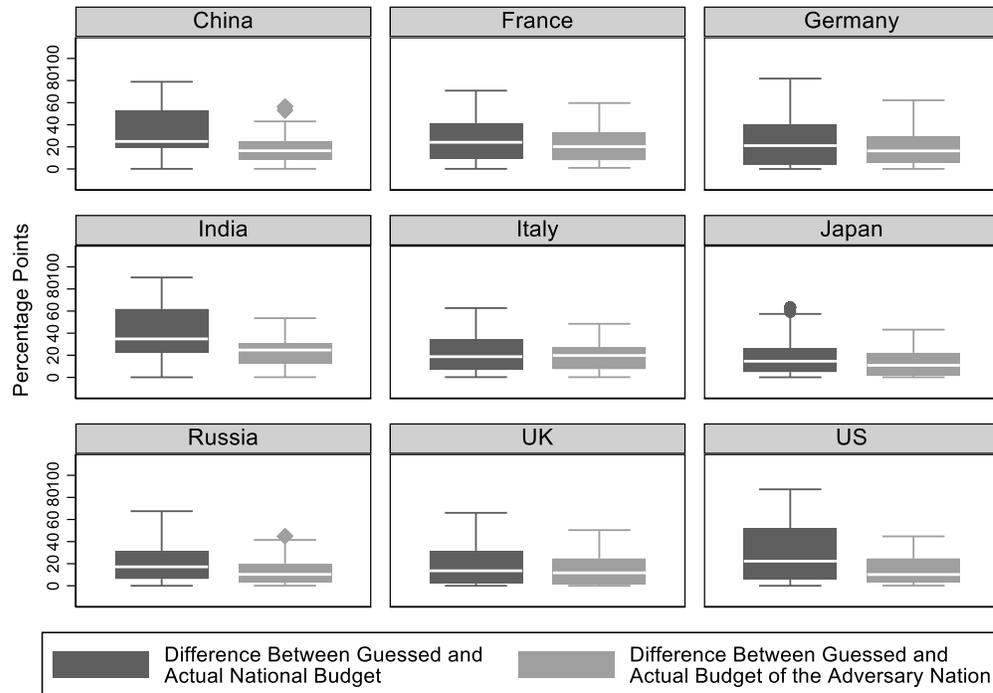
Graph displays the effect size of our three research questions with a 95% confidence interval.
* $p < .1$; ** $p < .05$; *** $p < .01$.

Figure 5. Treatment 1 – Budget Information – National Budget – Robustness Check



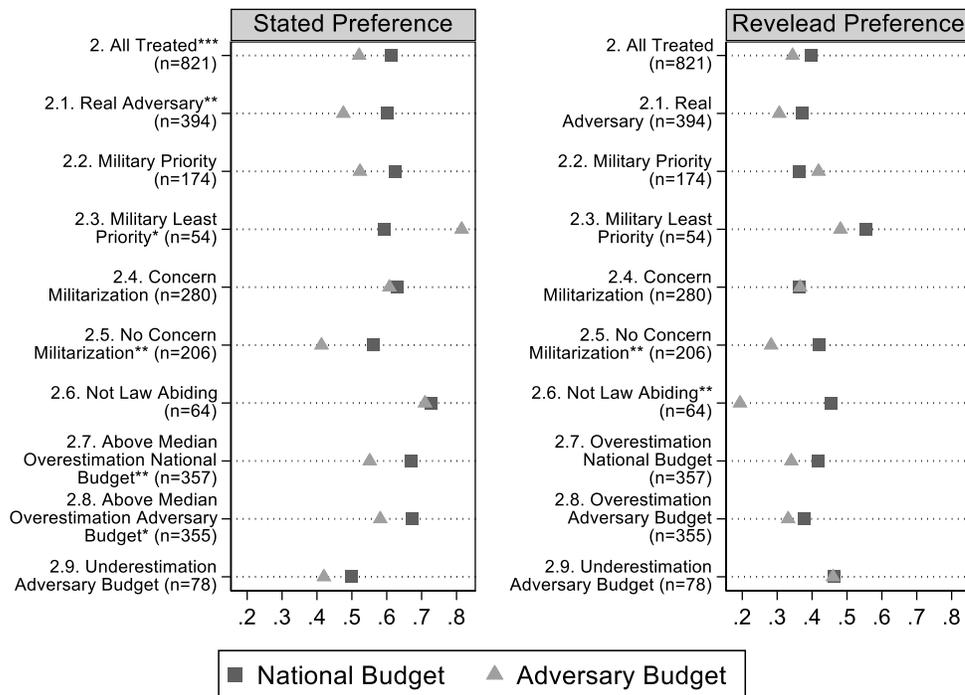
Graph displays the effect of our treatment for different sub-samples. * $p < .1$; ** $p < .05$; *** $p < .01$.

Figure 6. Difference between the Gessed and Actual Budget of the Respective Nation and the Citizen's Adversary



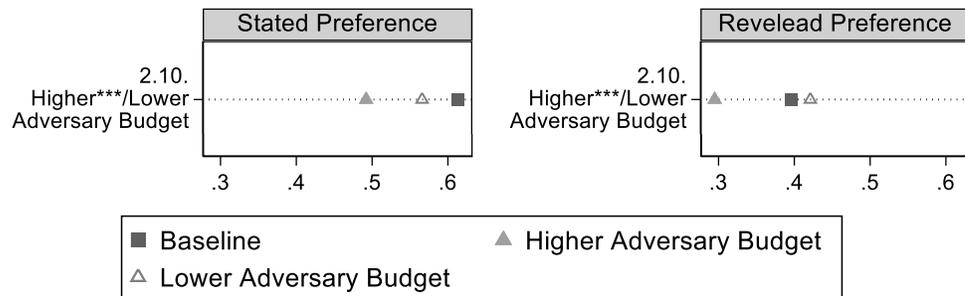
A one-sided matched-pair signed-rank test against the null hypothesis that the respective distribution has a median of zero reveals that all overestimations regarding national and adversary budgets are significantly different from zero at the 1% level.

Figure 7. Treatment 1 – Budget Information – National Budget + Adversary Budget – Robustness Check



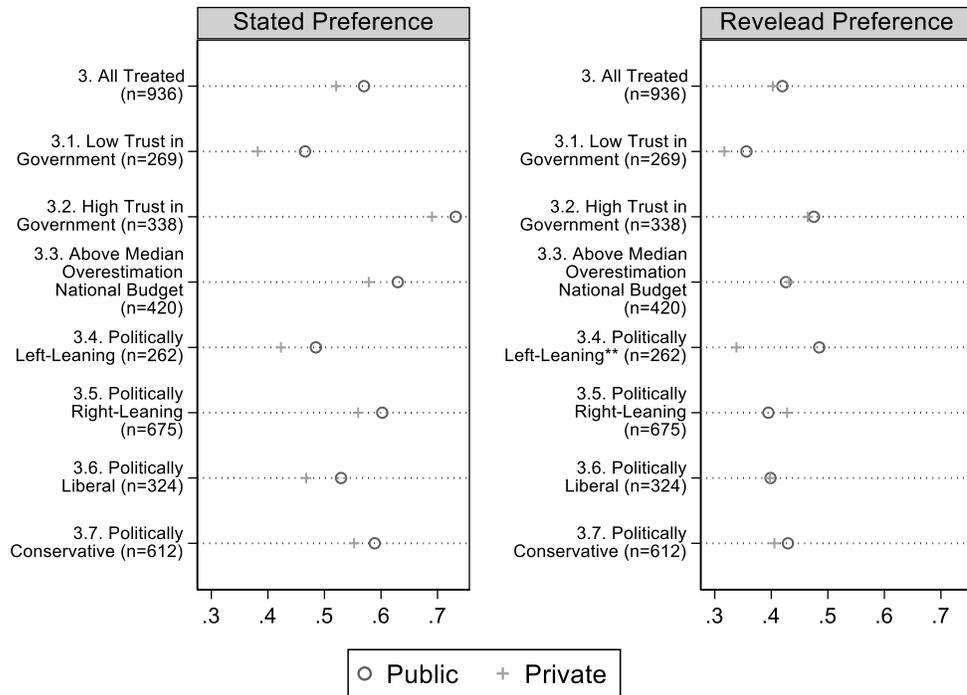
Graph displays the effect of our treatment for different sub-samples. * $p < .1$; ** $p < .05$; *** $p < .01$.

Figure 8. Treatment 1 – Budget Information – National Budget + Adversary Budget – Robustness Check



Graph displays the effect of our treatment for different sub-samples. * $p < .1$; ** $p < .05$; *** $p < .01$.

Figure 9. Treatment 3 – Public vs. Private – Robustness Check



Graph displays the effect of our treatment for different sub-samples. * $p < .1$; ** $p < .05$; *** $p < .01$.

Tables

Table 1. Treatment 3 – Public vs. Private by Nation

Nation	Average Treatment Effect (Private vs. Public)
China	3.76%
France	12.39%
Germany	-14.45%
India	-7.12%
Italy	-6.84%
Japan	-2.56%
Russia	2.04%
UK	0.01%
US	-26.54%***

The table shows the results of a Kruskal-Wallis test, with the null hypothesis that all subgroups share the same population for the respective control variable. * $p < .1$; ** $p < .05$; *** $p < .01$.

Table 2. Comprehensive Overview of Our Results

No.	<i>Research question</i>	<i>Result</i>	<i>Possible explanation</i>
	“How does citizens’ approval for an increase in the national space budget change if ...”	“We find that...”	“We find that...”
1	... they are informed about their actual national space budget?	...citizens who have been informed about their national space budget are more likely to support funding increases. This effect is not driven by unbiased updating	...citizens across all nations overestimate national space funding. But we find no robust evidence of unbiased updating.
2	... they are presented with an adversary’s space budget?	...citizens who receive information about an adversary’s higher space budget are less likely to support increases in their national space budget.	...citizens act optimally, according to Tullock (1980). We base our explanation on the finding that citizens are even less likely to support funding increases when their adversary’s budget is higher, and hence, their nation has a relatively small chance in the all-pay, winner-take-all Tullock contest for space hegemony. As a result, citizens lower their exerted effort (national space funding) while securing a non-zero chance of winning (Cason et al., 2020).
3	...tax money is known to finance private companies instead of public space agencies?	...citizens are indifferent whether public agencies or private companies profit from space funding. Only US citizens are significantly more likely to prefer public space agencies over private entities as potential beneficiaries of increases in their national space budget.	We propose three possible explanations. First, space agencies have built up trusted brands compared to New Space companies. Second, private companies might be connected to eccentric individuals, which could potentially bias citizens' opinions of these companies. Third, left-leaning citizens exhibit a heightened aversion to private profits, opposing private companies.

Appendix

A1. Geopolitical Rhetoric in Relation to Space

Table A1. Examples of Geopolitically Comparative Rhetoric in Relation to Space

Nation	Quote	Source	Link
China	“In recent years, some Western countries have formed space combat forces, exercised space action capabilities and even regarded (China) as a major competitor in the space field.”	Ministry of State Security, China	https://www.reuters.com/world/china/china-says-foreign-spies-trying-steal-space-program-secrets-2024-10-24/
	“As a result, the development of space technologies is both a display of a country’s technological capability and by extension a display of its military, economic, and scientific capabilities, but also a necessary move for a country that wants to strengthen its national power.”	China Dream Space Dream China’s Progress in Space Technologies and Implications for the United States A report prepared for the U.S.-China Economic and Security Review Commission, US	https://www.uscc.gov/sites/default/files/Research/China%20Dream%20Space%20Dream_Report.pdf
France	“Space itself is becoming an area of possible confrontation in which alternative adversary strategies could be developed, below or beyond the threshold of armed conflict. [...] The major space powers are currently developing new systems capable not only of protecting their space capabilities but also of carrying out aggressive action against those of their adversaries.”	Space Defence Strategy, Armed Forces Ministry, France	https://cd-geneve.delegfrance.org/IMG/pdf/space_defence_strategy_2019_france.pdf?2194/80ea1f07a5171e4ee796a52752c9bce695d34acb
Germany	“It is true for more and more industries: If you are not at the forefront in space, you will not be a technology leader on Earth.”	Federation of German Industries, President Siegfried Russwurm, Germany	https://www.dw.com/en/taking-on-spacex-why-germany-is-building-its-own-spaceport-w2/a-67166692
	“Germany needs outer space. [...] By establishing the Bundeswehr Space Command, the German armed forces have responded to the increasing demands of the space domain. [...] In the event of conflict, this will ensure that the operational readiness of the Bundeswehr is maintained.”	Federal Ministry of Defence, Germany	https://www.bmvg.de/en/news/combined-space-operations-first-vision-paper-presented-5358016

India	<p>“India shot down one of its own satellites in low-Earth orbit with a ground-to-space missile on Wednesday, Prime Minister Narendra Modi said, hailing his country's first test of such weaponry as a breakthrough establishing it as a military space power.”</p>	Prime Minister Narendra Modi, India	https://www.reuters.com/article/world/modi-hails-india-as-military-space-power-after-anti-satellite-missile-test-idUSKCN1R80I6/
	<p>“Defence Space Agency of Headquarters Integrated Defence Staff successfully conducted the Space Table Top Exercise [...], a significant milestone aimed at bolstering the strategic readiness of the Indian Armed Forces in the domain of space warfare.”</p>	Ministry of Defence, India	https://pib.gov.in/PressReleasePage.aspx?PRID=2073082
Italy	<p>“Space is one of the sectors Europe must focus on to be globally competitive.”</p>	Industry Minister Adolfo Urso, Italy	https://www.reuters.com/technology/space/italy-urges-tighter-european-cooperation-compete-space-2024-10-14/#:~:text=%22EU%20regulation%20should%20take%20into,attention%20to%20its%20launcher%20policy.
Japan	<p>“We will utilize [...] 1 trillion Yen [...] to implement this strategy to ensure the autonomy of Japan's space activities and to achieve dramatic growth to keep up with the intensifying global competition in space development.”</p> <p>“Today, space has become a major arena for geopolitical competition for national power over diplomacy, defense, economic, and intelligence, as well as the science and technology and innovation that support these national powers.”</p>	Minister of State for Space Policy, Sanae Takaichi, Japan	https://sj.jst.go.jp/news/202405/n0509-02k.html
Russia	<p>“The world’s leading countries fast-track the development of modern space systems of military and dual use and complement and expand technical parameters. The US military-political leadership openly regards outer space as a theater of military operations.”</p>	President Vladimir Putin, Russia	https://tass.com/science/1095757

UK	<p>“The importance of space to Defence is irrefutable. It affords us operational advantage against potential adversaries and, as a nation, we depend on it for resilience and our way of life. [...] Adversaries understand this reliance and are increasingly able to exploit vulnerabilities, threatening our strategic stability and security.”</p>	<p>Secretary of State for Defence Rt Hon Ben Wallace MP, UK</p>	<p>https://www.gov.uk/government/publications/defence-space-strategy-operationalising-the-space-domain/defence-space-strategy-operationalising-the-space-domain</p>
	<p>“However, the UK is not keeping pace with the threat as adversaries invest more in space capabilities.”</p>	<p>Prime Minister Boris Johnson, UK</p>	<p>https://www.gov.uk/government/publications/national-space-strategy/national-space-strategy</p>
US	<p>“China and Russia each have weaponized space as a means to reduce U.S. and allied military effectiveness and challenge our freedom of operation in space.” & “As a result, space is a domain that has reemerged as a central arena of great power competition, primarily with China and Russia.”</p>	<p>Defense Space Strategy Summary p.1 & p. 3, US</p>	<p>https://media.defense.gov/2020/Jun/17/2002317391/-1-/1/1/2020_DEFENSE_SPACE_STRATEGY_SUMMARY.PDF</p>
	<p>“Russia and China are building capabilities to challenge us in space because if they can challenge us in space, they understand as dependent as we are in space capabilities that they can challenge us as a nation.”</p>	<p>Vice Chairman of the Joint Chiefs of Staff Air Force Gen. John E. Hyten</p>	<p>https://www.defense.gov/News/News-Stories/Article/Article/2480459/space-force-exists-to-deal-with-threats-in-space-domain-vice-chairman-says/</p>

A2. AER Preregistration (AEARCTR-***Blinded for peer review***)

The Public Economics of Space Exploration

General Information

Blinded for peer review

Initial registration date is when the trial was registered.

It corresponds to when the registration was submitted to the Registry to be reviewed for publication.

First published

April 13, 2023, 3:49 PM EDT

First published corresponds to when the trial was first made public on the Registry after being reviewed.

Locations

Country

China

Region

Country

Germany

Region

Country

France

Region

Country

United Kingdom of Great Britain and Northern Ireland

Region

Country

India

Region

Country

Italy

Region

Country

Japan

Region

Country

Russian Federation

Region

Country

United States of America

Region

Primary Investigator

Blinded for peer review

Other Primary Investigator(s)

Blinded for peer review

Blinded for peer review

Additional Trial Information

Status

In development

Start date

2023-04-20

End date

2023-04-27

Keywords

Other

Additional Keywords

Public policy, Public opinion, Cross-country comparison, Space exploration, New space

JEL code(s)

H59, L33, F50

Secondary IDs

Prior work

This trial does not extend or rely on any prior RCTs.

Abstract

Public support is vital to the space industry because the sector still receives about one-third of its funding from governmental budgets. Therefore, research and the media have extensively investigated and debated citizens' opinions toward space expenditures. Various factors, for example, the overestimation of the actual space budget and sociodemographic characteristics have been identified as relevant determinants of public support for space funding. Existing research is insufficient for two reasons. First, research is primarily concerned with the public opinion toward government space agencies. With the emergence of the new space industry, this approach is no longer valid, as public support might change depending on whether a governmental agency or a private company receives funding. Second, while literature primarily focuses on the United States (U.S.), other nations have taken on significant roles in space exploration as well. We extend existing literature by

analyzing nine leading space nations and considering the impact of the new space industry on the public opinion of space expenditures. We will investigate the public opinion of space funding and the effectiveness of different communications strategies using statistical hypotheses testing and regression analysis. Our data will be extracted from an online experiment with over 2000 citizens.

External Link(s)

Registration Citation

Blinded for peer review

Interventions

Intervention(s)

Intervention (Hidden)

Intervention Start Date

2023-04-21

Intervention End Date

2023-04-22

Primary Outcomes

Primary Outcomes (end points)

We investigate citizens' opinions on funding for space exploration. We examine if it is relevant for public opinion whether taxpayer money benefits public or private entities. We also test whether the efforts of competing nations in space influence public opinion on domestic space budgets.

Primary Outcomes (explanation)

Participants state their opinion on funding for space exploration on a five-point Likert scale. The dependent variable is the answer to the question: "In your opinion, should funding for space exploration in [YOUR COUNTRY] increase, decrease or stay about the same?". Scale: 1 = Greatly Increase; 2 = Increase; 3 = Stay about the same as it is now; 4 = Decrease; 5 = Greatly Decrease, with [YOUR COUNTRY] being a placeholder for the respective country of the respondent.

Secondary Outcomes

Secondary Outcomes (end points)

In addition to our dependent variable, we also record multiple control variables. Some of these questions are also of interest outside their function as control variables for this experiment.

Secondary Outcomes (explanation)

We ask the participants with several statements and a 5-point Likert scale about their attitudes towards specific types of space missions and global cooperation in space. We also survey citizens about their overall priorities and concerns for space policy.

Experimental Design

Experimental Design

Using an online experiment, we plan to test our hypotheses while relying on a between-subject design. The participants are divided into a total of five groups (One treatment with two scenarios and one treatment with three scenarios). After their respective treatment, participants will answer a survey to control for any relevant variables and characteristics.

Experimental Design Details

We use an online study with two treatments to test our three hypotheses. To test our first hypothesis, we ask all participants to estimate their nation's space budget as a percentage of the total budget using a slider. Participants are then assigned to one of the two treatments. For treatment 1, participants are presented with either a scenario in which the space budget benefits government agencies or a scenario in which the money benefits private space companies. Subsequently, their attitude towards space funding is queried using the Likert scale explained in the "Primary Outcomes" section.

Alternatively, those participating are assigned to treatment 2. First, participants are asked which country they consider to be in competition with their own nation. They are then randomly assigned to one of three different scenarios. These three scenarios consist of one control group and two different information treatments. Afterward they answer the same Likert scale as the other group, which received treatment 1.

After answering this question, the two groups answer various control questions as well as an incentivized question. This question is designed to control for their general attitude toward space and gives the participants a real budget that they can donate to different causes.

Our hypotheses will be tested with citizens from nine different countries. Our sample is provided by SurveyMonkey. The composition of our samples in the various countries is based on the latest census in terms of age and gender.

Randomization Method

Participants are randomly instructed by the survey program to select one of two treatment paths.

Randomization Unit

The individual participant is randomly assigned to one of the two treatments. All participants in a given treatment are then randomly assigned to a specific scenario within the treatment.

Was the treatment clustered?

No

Experiment Characteristics**Sample size: planned number of clusters**

Nine Countries with 235 participants per country.

Sample size: planned number of observations

2215 participants from 9 different countries. That number includes 100 participants for a pretest in the USA.

Sample size (or number of clusters) by treatment arms

Five scenarios with 47 participants each.

Minimum detectable effect size for main outcomes (accounting for sample design and clustering)

The calculation for our sample size is based on an expected medium effect size, which equals $d=0.5$ according to Cohen 1992 Cohen, J. (1992). Statistical power analysis. Current Directions in Psychological Science, 1(3), 98-101.

Documents**Institutional Review Boards (IRBs)**

IRB Name

IRB Approval Date

IRB Approval Number

Analysis Plan Documents

Post-Trial

Study Withdrawal

This trial has not been withdrawn.

Intervention

Is the intervention completed?

No

Data Collection Complete

Data Publication

Is public data available?

No

Is there a restricted access data set available on request?

Program Files

Program Files

Relevant Paper(s)

Reports & Other Materials

A3. Online Experiment and Survey

The translated versions of our survey experiment for Hindi, French, Italian, Japanese, Russian, and simplified Chinese are available on request. Square brackets are placeholders for country-specific variables, such as the adversary of an individual participant or the specific space budgets. We used Vanleynseele (2022) for information on public space spending and the IMF (2023) for data on total federal spending.

Variable	Possible Values of the Variable
[your nation] [adversary]	China, France, Germany, India, Italy, Japan, Russia, the UK, the US
[national budget] [adversary budget]	China: 0.22, France: 0.26, Germany: 0.13, India: 0.23, Italy: 0.16, Japan: 0.24, Russia: 0.57, the UK: 0.09, the US: 0.69
[your space agency]	China: CNSA, France: CNES, Germany: DLR, India: ISRO, Italy: ASI, Japan: JAXA, Russia: Roskosmos, the UK: UK Space Agency, the US: NASA
[years of experience]	China: 29, France: 55 years, Germany: 53 years, India: 53 years, Italy: 35 years, Japan: 53 years, Russia: 31 years, the UK: 13 years, the US: 64 years

Online Experiment

Page 1

Welcome to our Survey "The Public Economics of Space Exploration"

Attention Check 1

Option 1 (p=40%)	Option 2 (p=60%)
This survey is investigating the public opinion on space exploration. It is run by ***blinded for review***. To demonstrate that you have read the text carefully, please tick the "/" symbol below. Your answers will be anonymized and used for scientific research.	This survey is investigating the public opinion on space exploration. It is run by ***blinded for review***. To demonstrate that you have read the text carefully, please tick the "%" symbol below. Your answers will be anonymized and used for scientific research.

Questions / Concerns

Please contact the researchers behind the study if you have any questions or concerns via ***blinded for review***.

/

%

+

If Participants failed Attention Check 1:

Attention Check 2

Option 1 (p=40%)	Option 2 (p=60%)
Please tick the "/" symbol below.	Please tick the "%" symbol below.

/

%

Baseline

As a share of the federal budget, what do you think is [your nation] spending on space exploration? Choose your answer on the slider as a share of the whole federal budget of [your nation]. Interpret the scale as percentages of the absolute federal budget of [your nation]. For example move the slider to 23 or 230 if you believe [your nation] is spending 2.3% or 23% of the federal budget on space exploration.

A horizontal slider scale ranging from 0 to 1000. The number 0 is at the left end and 1000 is at the right end. A circular handle is positioned at the 0 mark. To the right of the slider is an empty rectangular input box.

Baseline & Treatment 1

Rank these countries according to your attitude towards the specific country from 1 (ally) to 8 (enemy). Note, that even if you do not have clear friend or foe attitude towards a country, it is important that you rate your attitudes towards these countries relative to one another. A value on the scale can only be assigned to one country.

	1 (ally)	2	3	4	5	6	7	8 (enemy)
China	<input type="radio"/>							
Japan	<input type="radio"/>							
France	<input type="radio"/>							
Russia	<input type="radio"/>							
Germany	<input type="radio"/>							
India	<input type="radio"/>							
Italy	<input type="radio"/>							
United Kingdom	<input type="radio"/>							

As a percentage of the federal budget, what do you think are the following countries spending on space exploration? Type your answer as a percentage of the whole federal budget of the respective country. Two decimal numbers are allowed. For example you can type 0.01 meaning you think 0.01% are spend on space exploration in the given country, or you could write 40.91, which means you believe 40.91% of the federal budget are spend on space exploration.

- China
- Japan
- France
- Russia
- Germany
- India
- Italy
- United Kingdom

Treatment 1 (Budget Information)

Option 3 (p=33.33%) Baseline	Option 2 (p=33.34%) National Budget	Option 2 (p=33.34%) National Budget + Adversary Budget
<p>In your opinion, should funding for space exploration in the [your nation] increase, decrease or stay the same?</p>	<p>[Your nation] spends about [national budget] of its federal budget on space exploration.</p> <p>In your opinion, should funding for space exploration in the [your nation] increase, decrease or stay the same?</p>	<p>[Your nation] spends about [national budget] of its federal budget on space exploration. [Adversary] spends about [adversary budget] of its federal budget on space exploration.</p> <p>In your opinion, should funding for space exploration in the [your nation] increase, decrease or stay the same?</p>

- Greatly increase
- Increase
- Stay about the same as it is now
- Decrease
- Greatly decrease

Treatment 2

Treatment 2 (Public vs. Private)

Option 1 (p=50%) Public	Option 2 (p=50%) Private
<p style="text-align: center;">In the [your nation], efforts in space exploration are led by [your space agency], a governmental agency, with over [years of experience] in space exploration.</p> <p style="text-align: center;">In your opinion, should funding for space exploration in the [your nation] increase, decrease or stay the same?</p>	<p style="text-align: center;">Not only states are involved in space exploration, numerous privately or partially privately financed companies have entered the space market in recent years. These firms were able to introduce innovations such as reusable rockets and significantly reduced development times for new spacecraft. A portion of the [your nation] budget for space exploration goes to these companies as subsidies or fees, when governmental agencies use the services of these private companies as customer.</p> <p style="text-align: center;">In your opinion, should funding for space exploration in the [your nation] increase, decrease or stay the same?</p>

- Greatly increase
- Increase
- Stay about the same as it is now
- Decrease
- Greatly decrease

Additional Questions

Please rate the degree to which you agree with the following statements:

	Strongly disagree	Disagree	Neutral/Uncertain	Agree	Strongly agree
"The U.S. should abide by international laws governing the peaceful use of space."	<input type="radio"/>				
"The U.S. should take part in a manned Mars mission."	<input type="radio"/>				
"The U.S. should prioritize human missions over robotic missions."	<input type="radio"/>				

Should the [your nation] cooperate with the countries below? Cooperation may enable more ambitious projects, but also means sharing expertise about cutting-edge technology.

	Do not cooperate	Neutral	Cooperate
→ <i>China</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
→ <i>Japan</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
→ <i>France</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
→ <i>Russia</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
→ <i>Germany</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
→ <i>India</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
→ <i>Italy</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
→ <i>United Kingdom</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

The authors offer you, that they will donate a total of \$1 of taxpayers money to the organizations of your choice. Distribute 100 points (each worth \$0.01 or 1 cent of a US Dollar) among the organizations listed below as you like. There are no wrong or right answers. The money will actually be donated by the ***blinded for review***.

The Planetary Society
(Promotes the exploration of space through education, advocacy and self-funded space projects)

Red Cross
(Offers humanitarian aid in disaster areas as well as welfare and social work in other countries)

Atmosfair
(Offers carbon offset through different projects, \$1 corresponds to approx. 83 lbs of CO2)

Which areas should be a top priority for funding related to space exploration by the [your nation]? Sort the answers from most relevant to least relevant.

<input type="checkbox"/> Searching for raw materials/natural resources for use on Earth	<input type="button" value="↑"/>	<input type="button" value="↓"/>
<input type="checkbox"/> Sending astronauts to Mars	<input type="button" value="↑"/>	<input type="button" value="↓"/>
<input type="checkbox"/> Searching for life and planets that could support life	<input type="button" value="↑"/>	<input type="button" value="↓"/>
<input type="checkbox"/> Sending astronauts to the Moon	<input type="button" value="↑"/>	<input type="button" value="↓"/>
<input type="checkbox"/> Conducting research on how space travel affects human health	<input type="button" value="↑"/>	<input type="button" value="↓"/>
<input type="checkbox"/> Removing space debris	<input type="button" value="↑"/>	<input type="button" value="↓"/>
<input type="checkbox"/> Increasing military capabilities in space	<input type="button" value="↑"/>	<input type="button" value="↓"/>
<input type="checkbox"/> Monitoring key parts of Earth's climate system	<input type="button" value="↑"/>	<input type="button" value="↓"/>
<input type="checkbox"/> Developing technologies that could be adapted for other uses	<input type="button" value="↑"/>	<input type="button" value="↓"/>
<input type="checkbox"/> Conducting basic scientific research to increase the understanding of space	<input type="button" value="↑"/>	<input type="button" value="↓"/>
<input type="checkbox"/> Monitoring asteroids/objects that could hit the Earth	<input type="button" value="↑"/>	<input type="button" value="↓"/>

What is your biggest concern regarding the future of space exploration? Sort the answers from most concerning to least concerning.

- Ongoing militarization of space ^ v
- Growing amount of space debris ^ v
- Environmental impact (Through for example rocket launches) ^ v
- Damage through crashing rockets, satellites and other man-made objects ^ v

What would make you more supportive of spending parts of the federal budget on space exploration?

Demographics

Do you describe yourself as male, female, or transgender?

- Transgender
- None of these
- Male
- Female

In what year were you born? (enter a 4-digit birth year; for example, 1976)

What is your race or ethnicity?

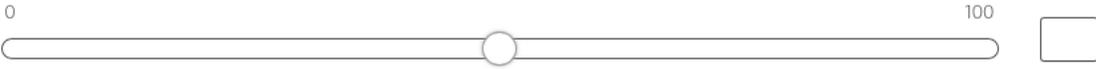
- Asian
- Black or African American
- Hispanic or Latino
- Middle Eastern or North African
- Multiracial or Multiethnic
- Native American or Alaska Native
- Native Hawaiian or other Pacific Islander
- White
- Another race or ethnicity, please describe below

Self-describe below:

Here is a 100 point scale on which the political views that people might hold are arranged from extremely left—point 0—to extremely right—point 100. Where would you place yourself on this scale?



Here is a 100 point scale on which the political views that people might hold are arranged from extremely liberal—point 0—to extremely conservative—point 100. Where would you place yourself on this scale?



What is the highest grade or level of school you have completed or the highest degree you have received?

- No Formal Schooling
- 1st-5th Grade
- 6th-10th Grade
- 11-12th Grade, No Diploma
- High School Graduate
- General Equivalency Diploma
- Some College, No Degree
- Bachelor Degree
- Master's Degree
- Doctorate Degree
- Don't Know
- Other (please specify)

How often do you believe the government is doing what is right for the people?

- Always
- Mostly
- Sometimes
- Rarely
- Never
- Don't know

Do you have any additional comments regarding the survey or the subject?

If you have already taken part in our pretest on April 15, and have therefore already completed or seen the survey, please indicate this here. Your answer will not affect your payment and will help us to filter out duplicate answers. Thank you!

- I just saw and answered this survey for the first time
- I have already completed this survey on April 15.

A4. Balance Checks

Table A4. Balance Checks

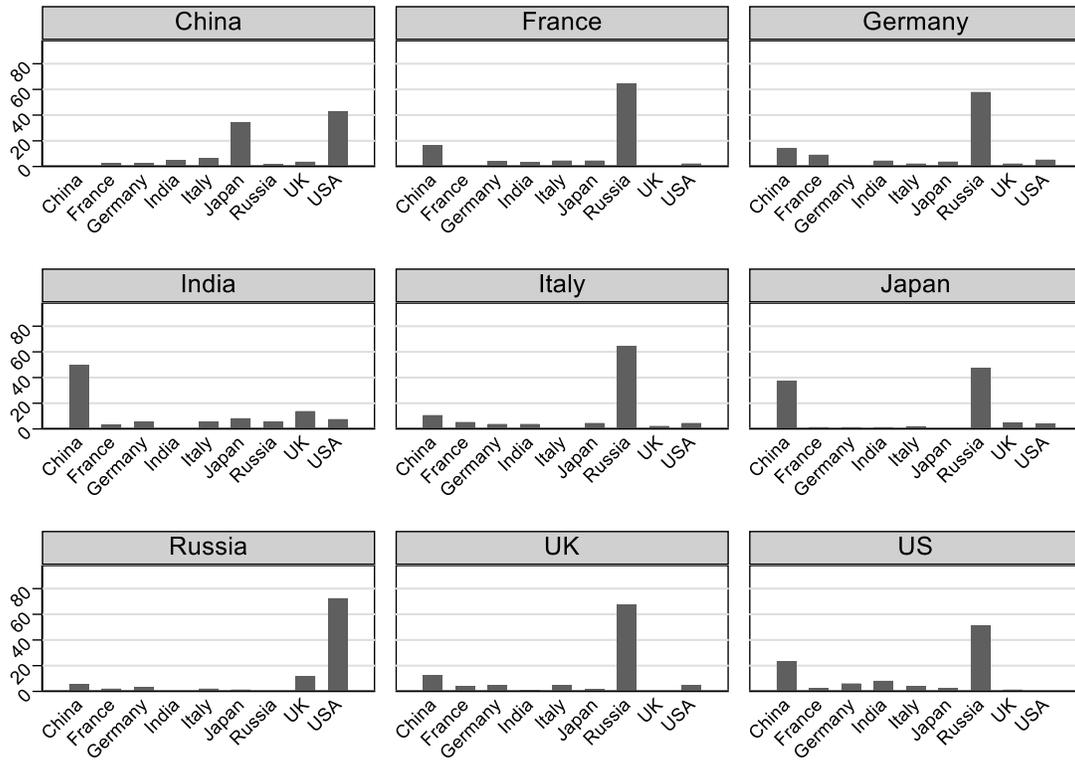
Variable	χ^2 -Value with ties
Age	2.08
Female	1.72
Education	3.10
Cooperation	3.17
Ethnicity	0.90
PoliticalOrientation1 (Left vs. Right)	2.93
PoliticalOrientation2 (Liberal to Conservative)	6.54

Table displays the result for a Kruskal-Wallis test with the null hypothesis that all subgroups from of a respective control variable originate from the same population.

* $p < .1$; ** $p < .05$; *** $p < .01$.

A5. Adversary Nations

Figure A5. Adversary Nations by Home Nation of Respondents (in Percent)



A6. Validity Incentivized Measure

Table A6.1. Stated vs. Revealed Preferences Matched for Participants' Nation and Treatment

Variable	Coefficient	Standard Error	[95% Confidence Interval]	
Decline increase vs. Support increase	0.12***	0.02	0.08	0.16

Table gives the average treatment effect on above-median donation to the space-related charity, after participants stated that they want to increase their national space funding. * $p < .1$; ** $p < .05$; *** $p < .01$.

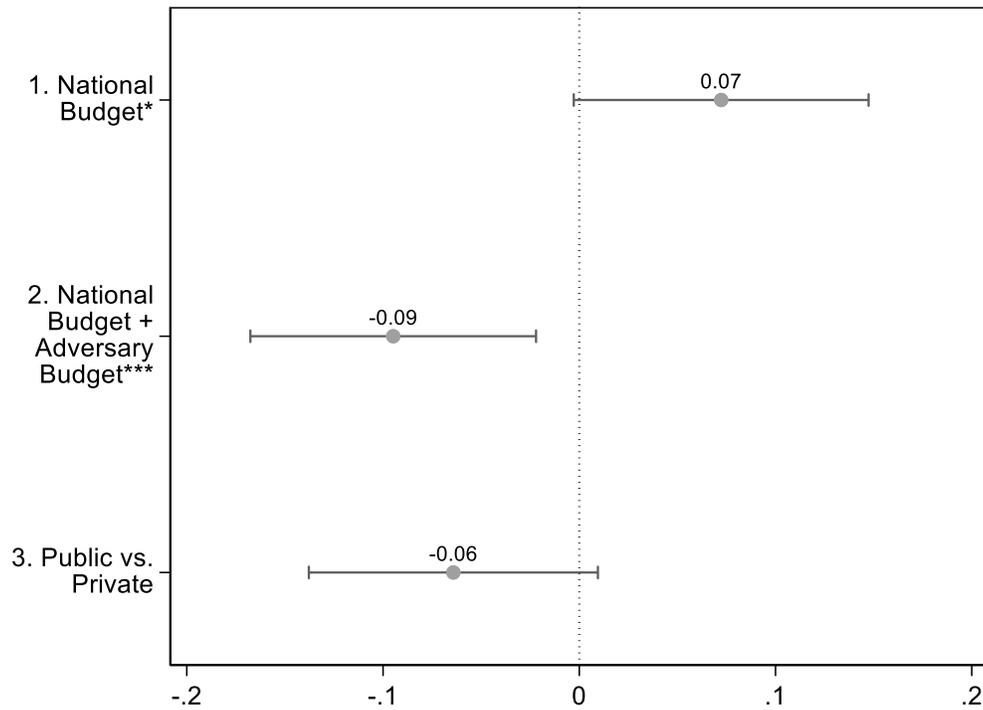
Table A6.2. Stated vs. Revealed Preferences Unmatched Analysis

Variable	Coefficient	Standard Error	[95% Confidence Interval]	
Decline increase vs. Support increase	0.13***	0.02	0.09	0.17

Table gives the average treatment effect on above-median donation to the space-related charity, after participants stated that they want to increase their national space funding. * $p < .1$; ** $p < .05$; *** $p < .01$.

A7. Attention Check

A7. Experimental Interventions with Citizens Who Passed an Initial Attention Check



Graph displays the effect size of our three treatments with 95% confidence interval. * $p < .1$; ** $p < .05$; *** $p < .01$.