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ASTRO-*NOTS* BEZOS, BRANSON, AND MUSK COMPARED TO NASA AND THE ESA: USING TWITTER TO ASSESS PUBLIC SENTIMENT DIFFERENCES BETWEEN COMMERCIAL AND GOVERNMENT SPACE PROGRAMS

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CHEYENNE BLACK

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ASTRO-*NOTS* BEZOS, BRANSON, AND MUSK COMPARED TO NASA AND THE ESA: USING TWITTER TO ASSESS PUBLIC SENTIMENT DIFFERENCES BETWEEN COMMERCIAL AND GOVERNMENT SPACE PROGRAMS

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Dr. Joseph Ripberger, Chair

Dr. Carol Silva

Dr. Colin Barry

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Acronyms

(CSLA) Commercial Space Launch Act of 1984

(COTS) Commercial Orbital Transportation Service

(CSA) Communications Satellite Act of 1962

(COMSAT) Communications Satellite Corporation

(GSS) The General Social Survey

(ESA) European Space Agency

(NPF) Narrative Policy Framework

Abstract

In recent years, the endeavors of commercial entities in space travel have increased dramatically outside of government contracts. What was traditionally a granted contract system with NASA, has now become the “New Age Space Race” or “Billionaire Space Race”. This has subverted previously held norms of how private entities participate in space exploration. Billionaires, i.e. Jeff Bezos, Richard Branson, and Elon Musk, have, and are, increasingly funding their own private programs and missions in space. As the polarization between traditional government space exploration and private entities’ engagement in space increases, there is a notable difference in public perceptions towards these two groups. My thesis uses an international scope to examine how sentiments expressed towards commercial entities engaged in space exploration differ in comparison to American and European space programs. Further, this study expands Jones and McBeth’s Narrative Policy Framework (NPF) by using text and sentiment analysis of Twitter data to build space policy narratives. In turn, these can be used to assess how policy outcomes influence policy narratives and public opinion. Finally, a discussion of future directions in space policy research and understanding narratives towards commercial and government space programs is presented.

KEYWORDS: space policy, Narrative Policy Framework, text analysis, sentiment analysis, Twitter, Elon Musk, NASA, Blue Origin, SpaceX, public opinion

2. Introduction

Commercialization of space-related activities, such as travel, manufacturing, and research, has shaped government institutions and the way the public perceives and interacts with space policy topics and actors. Social media provides new opportunities for policy scholars to assess sentiments towards specific topics, identify key themes in public opinion, and fill gaps in previous data. The purpose of this thesis is to discuss current trends in space policy; posit a need for new data retrieval techniques; use Twitter data to detail the differences in public sentiment between commercial and government space exploration, and contextualize the results with the Narrative Policy Framework (NPF). Finally, the importance of incorporating text-as and sentiment analysis in future research applications to understand the policy process will be posited.

3. Background

3.1 Space Commercialization

NASA has been historically supported by Americans but has received opposition because of program costs (Launius, 2017; Steinberg, 2013). In the past, the public and government concerns with NASA brought on policy changes. In the 1980s, growing uneasiness with administrative fragmentation, program costs, and efficiency of NASA were addressed when the Commercial Space Launch Act (CSLA) of 1984 was passed (H.R. 3942, 1984). This came shortly after Reagan's National Security Decision Directive, the Commercialization of Expendable Launch Vehicles, was signed (Keeter, 2018). The reasoning for these policy changes was on the basis of commercialization as a means to address and circumvent concerns with costs, fragmentation, and

efficiency of NASA programs. Though the earliest forms of commercialization were seen in the mid ’60s when the first commercial satellite was launched into orbit for telecommunication purposes (Velocci, 2012), the passing of certain policies, such as the CSLA, ignited the interest of private industries in space missions, manufacturing, mining, research, and tourism.

The landscape of the space industry has changed following the passage of the CSLA. Its passage sets the stage for the space industry to move away from a centralized state-owned model to a shared commercial realm. It addressed criticisms of NASA regarding costs, administrative fragmentation, and efficiency by providing ways for the government to circumvent budget restraints. The commercialization of space created new venues for technology development, ensured competitive standing internationally for the U.S., increased economic and national interests in space-related fields, and encouraged government and private partnerships (The Federal Register, 2020). Since 1984, more policies in favor of space commercialization have been passed. For example, the Commercial Orbital Transportation Service (COTS) by the Bush administration was formed to provide commercial launch services to resupply to International Space Station (Keeter, 2018). Presidents Obama and Trump continued the commercialization process by promoting commercial crew services and launching DEMO-1 in May of 2020 (Keeter, 2018).

Commercialization of international space has expanded alongside U.S. space programs. Intelsat, previously the International Telecommunications Satellite Organization, is a telecommunication company formed by a public-private consortium of telecommunication agencies from 18 nations (Encyclopaedia Britannica, 2022). The Early Bird satellite, also known as Intelsat I, was launched in 1965 and became the first operating commercial satellite to prove broadcasting and telecommunication service between Europe and North America (Intelsat,

2022). Spurred by JFK signing the U.S. Communications Satellite Act (CSA) of 1962, the commercialization of space quickly spread to an international scope to provide telecommunication services to other countries shortly after (Mai, 2015). Further, the passing of the CSA allows the Communications Satellite Corporation (COMSAT) to form. COMSAT has continued to grow the satellite industry with both government and commercial partnerships and services (Comsat, 2022).

Ultimately, this led to the rise of commercial space companies and "space mavericks". Elon Musk's SpaceX and Jeff Bezos' Blue Origin are the combined product of the CSLA and other commercialization policies. As these commercial space entities have come to fruition, it is important to assess the public perception differences between government and commercial space programs. As discussed in later sections, there is a shortage of data on how the public views space exploration in general. This thesis intends to not only contribute to the literature on how the public views space exploration programs, but discern whether there is a difference in how the public views commercial and government space exploration.

3.2 Institutional Changes of Government Space Programs

The CSLA changed the trajectory of space policy drastically since the 1980s. The CSLA was created with hopes of creating new venues for technology development, increasing national and economic interests, and ensuring an international and competitive standing for the U.S. This act created a trend of commercialization that has come to fruition in the 2020s. Ultimately, changes in policy that led to commercial involvement in space have dramatically changed the space policy field and its traditional government institutions.

The surge of growth in the space industry was unprecedented. The space for earth economy, goods and services produced in space and used on Earth, has grown exponentially

from internet infrastructure, earth observations, satellites, and telecommunications (Weinzierl and Sarang, 2021). Further, lowered costs of space-related technologies, launch equipment, and the opportunity to compete for scarce resources has spurred wealthy individuals and firms like Jeff Bezos' Blue Origin, Elon Musk's SpaceX, and Richard Branson's Virgin Galactic to emerge in the space exploration market. What was traditionally a centralized government realm, space exploration has evolved to a new market in which public and government initiatives coincide with private interests (Weinzierl and Sarang, 2021). Additionally, the CSLA opened up significant opportunities for NASA to become a customer to private firms. This is apparent in the increase of contracts, manufacturing, and investments in operating space infrastructures (Weinzierl and Sarang, 2021).

As the number of contracts and commercial space entities increased, coupled with cheaper technologies and incentives for resources, NASA has adapted and developed to become more efficient and cost-effective. NASA has changed significantly in three ways because of this. First, private individuals are enabled to take on more risk than is tolerable in a government realm. Therefore, NASA has transferred risk to the contracted firm, freeing them up to focus on other projects. Second, NASA has changed its methods of implementing government regulation and support. Third, NASA has become an international competitor. It must navigate geopolitical rivalries while regulating and supporting commercialism in the space industry (Weinzierl and Sarang, 2021).

To assuage public concerns of program costs and efficiency in the 1980's, NASA had to adapt to a commercially compatible structure. NASA's adaptive capabilities are derived from their hierarchical structure and inter-governmental and commercial networks (Heracleous et al.,2019). NASA's organizational culture, rational, and technological capabilities are dynamic.

They actively respond to demands from mission agendas and the policy environment (Heracleous et al. in 2019). NASA's adaptability and positive impact on the space sector is demonstrated by their use of input-output analysis to predict what industries benefit from the growth of the general space industry. Their findings show that commercial space industries positively impact state's economies through increases of jobs and labor income.

3.3 Modern Public Perceptions of Space Flight

Though there have been concerns with NASA's costs, efficiency, and administrative fragmentation, opinions towards commercialized space have not always been positive either. In a 2017 survey of college students' perceptions towards SpaceX's plan to colonize Mars, Platt et al. (2019) found standing doubts of success for SpaceX missions. Respondents indicated that feasibility, costs, and individualized risks were concerns. Further, respondents doubted being able to colonize Mars in their lifetime. However, there were some positive points of views toward space tourism. Platt et al. (2019) posits that young adults view space exploration as favorable to society. They perceive space tourism as an exciting possibility for the adventurous, but that colonization of Mars as a questionable response to ecological problems on Earth.

Pomeroy's (2019) review of the public opinion and support for space is comprehensive and illuminating towards future trends in research. Public opinion studies in space policy have been primarily utilizing survey data, summary statistics, statistical hypothesis tests, inferential models, and regression. These have been fruitful endeavors, such as showing higher support for space exploration in those who are younger, male, have a higher socioeconomic status, or higher education attainment (Whitman Cobb, 2011). Demonstrating awareness and information of space activities was higher in North American individuals than in European individuals (Detsis & Detsis, 2013), and levels of support for space were lowest among evangelists in the GSS data

(Ambrosius, 2015). Though these, and other studies discussed in later sections, have been instrumental in collecting and assessing public opinion data about space policy, Pomeroy posits that the future of analysis in space policy should use text-as-data and social media analysis to fill gaps in current literature and begin new trends of analysis. Additionally, these approaches provide the ability for researchers to easily quantify large numbers of open-ended texts in a consistent manner and communicate these results. This thesis intends to utilize these recommendations to quantify and study text data pulled from Twitter.

3.4 Current Space Policy Literature

Studies of space policy have developed into a broad-based and multidisciplinary field. Derived from understandings of legislative behavior, economic assessments, theoretical implications in international relations and security, public opinion of space programs, and policy prescriptions and their implementations, space policy research encompasses a diverse agenda. The field is continually developing and it has been suggested that new data retrieval methods are needed to address policy, public opinion, and economic questions in a more comprehensive way.

Research on space policy is historically embedded in economic assessments in both the private and public sector. NASA Authorization Acts are useful for studying the economic developments of the government and commercial space sectors and have been utilized by researchers. They detail an agenda of research developments for government programs while stimulating the private sector through contracts. Using these, it was found the factors that assist in understanding Congressional support for the NASA Authorization Acts and levels of federal spending are rooted in economic opportunism (Machay & Steinberg, 2015).

The metric for understanding economic opportunism is not always apparent. It is based on the potential of the aircraft manufacturing industry, NASA procurements, and NASA centers to

affect jobs and money; thus, conditionally affecting space policy votes in the Congressional arena. Economic opportunism is subject to constant influence from politicization and/or partisanship (Machay & Steinberg, 2015). Further studies by Machay and Steinberg address this concern. Using bills concerned with federal spending and space-related economic opportunism, it is suggested that individual members of Congress are concerned with monetary incentives related to Authorization Acts through NASA procurements. Legislative support in the Congressional arena is focused on these procurements and tends to increase when NASA spending is affecting a legislator's constituency. Legislators have also demonstrated interests in protecting the space industry. When a bill harmed space industry funding in particular states, legislators voted against it in hopes of a more beneficial bill. Some opponents of bills were subject to factors of politicization where the economic benefits for their constituents did not outweigh their political concerns of spending, environmental issues, and safety. However, this can be countered by the bipartisan drafting of space policy legislation (Machay & Steinberg, 2015).

Policy responsiveness, when policy shifts in response to public opinion, (Stimson & Erikson, 1995) has been used to assess the difference between public opinions about space exploration and NASA's budget. It has been found that the U.S. Government has not engaged in policy responsiveness to public opinion, rather, they increased NASA's budget when public support for space exploration was low and decreased the budget when public support was higher (Wenecke, 2021). Congress and the President have always been the policy actors that mandate how much money is spent on space exploration programs. Funding level fluctuations under different administrations and party control in Congress. These are congruent to public approval based on the political party rationales (Burbach, 2019).

In recent research on space policy, it is apparent that there are increased public, government, and commercial interests in space exploration because of the economic opportunities and the adventurous idea of space tourism. However, though both public and government interests in space exploration have increased, government considerations of NASA's budget does not respond to the public's interests. Though Wenecke's study demonstrates a lack of economic response by policy makers to the public, the relationship between space policy makers and the public needs to be articulated past an economic sense. This thesis intends to do that by examining the response to the commercialization of space and contextualizing the results with the Narrative Policy Framework.

4. Theory

This section argues that the Narrative Policy Framework (NPF) is a useful framework to apply towards contextualizing the different narratives towards space policy as a result of the CSLA and other commercialization policies. Not only is it suited for text and sentiment analysis, but it has a cyclical and dynamic nature that can be used to understand public opinion shifts to policy changes and vice versa. First, the main developments and components of the NPF will be discussed and applied to the space policy realm and this study. Second, the application of NPF to text and sentiment analysis will be discussed. Finally, current and future directions of applying the NPF to this study will be explored.

4.1 The Narrative Policy Framework

The development of narratives in policy and administrative studies has been a product of building theory, developing methodologies, and testing hypotheses (Jones & McBeth, 2020). The NPF has expanded greatly in policy literature and has been used in a variety of policy subfields (Jones and McBeth, 2010). It has also been used in a postmodernism application to assess

Trump's narrative tactics and assert its strength as a framework in a changing society (Jones & McBeth, 2020). Ultimately, it is posited that the NPF is still good enough to be relevant. This thesis agrees with that, specifically in the space policy realm.

The NPF is not new to a space policy application. It was utilized previously to examine the development of the U.S. Space Force and the framing of rationales towards space programs by partisanship. The U.S. Space Force was created with the signing of the National Defense Authorization Space Act in 2019.[1] Ruff and Stelmach (2021) examine the narratives for advocating and opposing the creation of this new branch of the U.S. Armed Forces. Their study uses a content analysis of congressional testimonies to derive narratives created by Democrats and Republicans. This expanded on previous indications of a necessity to use text-analyses of data for space policy research (Pomeroy, 2019).

The NPF is useful in Ruff and Stelmach's study because it moved away from the traditional economic and historical methods and used media documents, and commercial and government sources for analysis. It is demonstrated that Republicans and Democrats described the importance of space policy in different ways. Republicans show that they view the space domain as a war domain, President Trump as the narrative's hero, China and Russia as the narrative's villains, and increased concern for cooperation in U.S. commercial groups (Ruff & Stelmach, 2021). Conversely, Democrats were more likely to indicate a narrative of cooperation at the international level that reinforced previous analysis in the space policy realm (Johnson & Freese, 2017; Smith, 2018; Moltz, 2019).

[1] In December 2019, the National Defense Authorization Space Act was signed by President Donald Trump. The United States Space Force Act, expanded by Democratic representative Jim Cooper and Republican representative Mike Rogers, reorganized the Air Force Space Command into the United States Space Force.

I intend to further build on this application of the NPF to space policy. Not only is this an appropriate application for the multidisciplinary topic of space policy, but the use of text analysis also provides the opportunity to identify powerful policy narratives. In turn, these can be used for assessing public opinion towards policies and how, which way, and why narratives impact them. Using a macro level of analysis in the NPF, it is possible to analyze the policy narratives that pervade cultural norms, society, and institutions (Shanahan et al., 2017). Additionally, an NPF macro-analysis focuses on how narratives change and their stability influence policy. The application of the NPF in this study advances previous literature by arguing that the dynamic nature of the framework can be used to assess how policies affect public narratives. In the case of the billionaire space race, these narratives are formed by commercialization policies since the 1980's. Narratives towards billionaires involved in space exploration, and how they compare to government programs, have been formed over time. Using text analysis of Twitter data, narratives are used to contextualize the differences in public sentiments towards commercial and government space programs. Further, the sentiments and key words of these narratives are used to identify *types of characters (such as heroes victims, and villains), belief systems (policy stances),* and potential effects of the CSLA of 1984' and other commercialization policies on narratives.

4.3 Assumptions of the Narrative Policy Framework and this Study

The NPF is used under core theoretical assumptions based in social construction, bounded relativity, generalizable structural elements, three interacting levels of analysis, and narratives playing a central role in human cognition (Shanahan, 2017). These theoretical assumptions have been formed under postructural narrative approaches (Hajer, 1993,1995; Fischer & Forrester; Fischer, 2003; 1993; Roe, 1992, 1994; Stone, 2002). This laid the

groundwork for the philosophical orientation and methodological design of the NPF (Jones & McBeth, 2010). Though the original NPF identifies two levels of analysis, micro and meso, this study joins additional literature to build on the macro level of analysis that seeks to analyze how policy narratives permeate institutions, society, and cultural norms (Shanahan, et al., 2017). Using a macro analysis, this study seeks to assess how changes in macro-level narratives towards space policy have developed.

Embedded within the NPF are assumptions about how the world works. The NPF model of the individual, and what defines reality, is broken into five main components (Shanahan, et al., 2017). First, the social construction of meaningful parts of policy reality. Second, social constructions' meaning vary and create different policy reality that is bounded to some stability over time. Third, narratives being studied have generalizable and identifiable structural elements. Fourth, narratives are constantly operating at three levels of analysis, micro (individual), meso (group), and macro (cultural and institutional). Finally, the *homo narrans model of the individual* posits that narratives play a central role in human cognition and communication. Under these assumptions, the policy process of space commercialization and its effects on public opinion will be examined for common narrative elements.

Using Twitter text data and sentiment analysis, setting, context, plot, characters, and macro-level narratives will be assessed. This study identifies settings with space missions and topics. The launch of Bezos's New Shepard rocket, Branson's VSS Unity rocket, NASA's Perseverance rover, the European Space Agency's CHEOPS mission, and the general topic of the space race, or billionaire space race, are used as the settings observed. The context, plot, and characters are identified from commercialized space policies, like the CSLA, that affected government agencies and stimulated the rise of commercial space firms like SpaceX, Blue

Origin, and Virgin Galactic and their owners. Using these, coupled with sentiment analysis, the macro-level difference of narratives between commercialized and government space programs will be contextualized.

5. Assessing Public Sentiment Using Twitter

5.1 Text Analysis

Due to limitations of public opinion and survey data, being able to apply narratives to public perceptions of space exploration has not always been easily attainable. Calls for new data retrieval methods in space policy have turned to big data to answer lingering and developing questions because of this. Moving from traditional means of studying public opinion towards space programs, funding, and activities (Launius, 2003; Steinberg, 2011; Whitman Cobb, 2011; Nadeau, 2013), big data on social media and online engine searches are used to further understand public salience, sentiment, and perceptions of space policy topics. This is beneficial as previously used methods from Gallup, CBS/New York Times, Yankelovich, and Media Central were not consistent in question measures. Often they were compiling from different polling sources, had intermittent interval of questioning, or vague space related topics (Whitman Cobb, 2015). The General Social Survey (GSS) by NORC does inquire on how interested respondents are in space and attitudes towards spending in space. However, the GSS question on interest in space is a new question with data only available for 2008 in all ballots and partial ballots past 2010. The question inquires respondents in a Likert scale on how they feel about how much money is being spent on space programs, however, these are limited to only an economic understanding. Further, questions from the GSS on interest in space are too vague to be conducive of any specific overall public opinion or policy recommendation.

Google data trends are relatively new, with only begun 2004. These are important for understanding public attention to specific events as they have a drastically shorter interval of search from just an hour trend that can be eventually compiled into multiple years of search engine histories. Countries, regions, and states can be specified to view the targeted population's interest in a subject. Moreover, Twitter data, though more difficult to collect than Google trend data, is promising. It is likely that Twitter data will fill gaps in public opinion through receiving expressed opinions in text data and assessing sentiments of the texts. Further, Twitter data provides an indication of attention and valiance that Google data cannot provide.

In this same manner, Pomroy conducted a vast review of quantitative space policy literature and recommended further expansion in data, methods, and topics of inquiry (2018). The purpose of this thesis is to take Pomroy's recommendations into account by conducting text-analysis of social media data to identify differences in sentiment towards commercial and government space endeavors. There are many limitations on public opinions expressed towards space exploration and there needs to be an in-depth inquiry into how the public feels about space exploration entities, both in the government and the private sector, and how the public's expressed sentiments towards the subjects differ. Without more studies that address these limitations, the status of how the public views government and commercial space exploration in comparison to each other is unclear. Text and sentiment analysis using social media is an emerging practice that can address these needs.

Using the scope of United States and European space exploration, NASA, the European Space Agency (ESA), Jeff Bezos, Richard Branson, Elon Musk, and the general subject of the space race, new public sentiment data is studied to further understand how the public perceives differences between government and private space exploration. Jeff Bezos' and Elon Musk's

space programs, Blue Origin and SpaceX, are fundamental in this research design as they are garnering the most attention and accumulating public perceptions that provide fruitful data (Waters, 2021).

5.2 Sentiment Analysis

This thesis uses an emerging research method. I use sentiment-analysis on social media posts to gauge public opinion on the entities in the new age space race. Public opinion is reflected in the sentiments that social media users, like those on Twitter, mirror in their posts. Computed aided, sentiment analysis allows analysts to capture text sentiments. Twitter provides an ideal outlet to capture these sentiments and map out how they change over time. On Twitter, users express thoughts via tweets to their followers. I use the text of users' tweets about space topics to understand how users feel about NASA, the ESA, Blue Origin, SpaceX, Virgin Galactic, or the general space race. The sentiments expressed through text of tweets is of interest to this study. Tweet text comprises the entire text of the users' tweet. By breaking down each word in the tweet text, this study examines the sentiments expressed by the words used to author the tweet.

Using the "SentimentR" package in the open source statistical software R, each tweet is assigned a polarity or sentiment score. In other words, each tweet is assigned a value based on how positive, neutral, or negative, words within the text are. This is done by utilizing a dictionary created by Mathew Jockers that combines the a word-emotion association lexicon with other online dictionaries.[2] The Jocker's dictionary is an online list of English words and their associations within eight basic emotions. These emotions are anger, fear, anticipation, trust,

[2] Dictionaries can be personalized to changed sentiment scoring of words. For the purpose of this study, no words were changed from their previously assigned sentiment score. The entire dictionary and guides can be found on Sentimentr. Cran R Project, 2021.

surprise, sadness, joy, and disgust. The sentiment analysis is built upon an augmented dictionary that assigns sentiment values to each word (and Emoji) in a text and then assigns a weighted average aggregate score across all of the words in a given bit of text (e.g., tweet).

This is a complex calculation as there are 14,182 words in the dictionary and some fall into multiple emotion categories.[3] This, however, does not change in word sentiment score. For example, the word "abandon" falls within the negative sentiment category as well as the fear and sadness emotions. Words in multiple categories are coded to not affect the aggregate sentence score more than any other words based on valence shifters. Two sentiments are expressed in the connotation of the word, negative and positive. This method is best as it examines individual words in the tweet's sentence and aggregates a sentiment score for the entire tweet. To make this more concrete, some examples of positive and negative tweets' aggregate sentiment scores are provided below. Words underlined read as positive or negative that are used to calculate the aggregate sentiment score of the text.

Negative:

USER1: Jeff Bezos' very negative rocket launch: One minuscule fix could have avoided it [LINK TO NEWS STORY] SCORE: -0.878

Positive:

USER2: [LINK TO VIDEO] @elonmusk really cool! Definitely celebrating the progress in @SpaceX #ElonMusk SCORE: 1.275

[3] See Appendix entry A.2

Valence shifters' effects, negators, amplifiers (or intensifiers), de-amplifiers (or downtoners), and adverse conjunctions further the basis for comprehending the aggregate sentiment of the text in these sentiments. For example, the word "really" is an amplifier that intensifies the sentiment. Text as analysis interprets these as texts' words with negative and positive sentiments, or signals of openness or resistance, to the perception of the space race at a more general population level. A visual breakdown and assignment of connotation by word and the process of aggregating to sentence for usage is provided in appendix A.3. Before analysis, punctuation is removed for word and sentence connotation assignment. This is done to eliminate some of the noisiness in data and account for emoticons users may make out of punctuation.

5.3 The Sentiment Analysis Equation

The equation for the average sentiment score of tweets within text is as follows. This equation is showing the assignment of aggregate average sentiment score by sentence using the augmented dictionary lookup.

$$p_{i,\delta i,j} = 1/n \cdot \sum \delta_{i,j}$$

Here, $pi, \delta i, j$ denotes the cluster of words by sentence and text. The content cluster of pi and the unbounded polarity, $\delta i, j$, score of the text in the sentence is determined by the entire sentence and its polarity. 1 denotes the number of positive or negative words applied to the sentence and is divided by the number of words in the tweets' text, n. This is then multiplied by the sum of the unbounded polarity score and the number of words within the sentence, j.

5.4 Emoji and Emoticon Conversion and Usage

There are functions to convert emoticons and emojis to text.. For example, a popular emoji used in tweets depicts a picture of a thumbs-up emoji. This is converted to a text for analysis in this study. A tweet by USER 3 has been converted and shows this:

USER 3: @Erdayastronaut @SpaceX Good job clapping hands . Very nice! thumbs up thumbs up thumbs up thumbs up thumbs up.

The conversion of emojis to text contributes to the word sentiment score, therefore, it contributes to the aggregate sentence sentiment score. This is an important function to consider as social media users often use emojis to express sentiment towards topics and should be considered in the overall sentiment of a text. However, this thesis accounts for the differences emojis contribute to the sentiment and will not be using emoji conversion to text. It was found that certain texts were populated by large numbers of positive or negative emojis that caused extremely positive or negative sentiment scores. For example, when emojis are converted to text, this tweet by USER is the most positive tweet in the Musk category, with a sentiment score of 4.33, because of emoji conversion to word.

USER: "@SpaceX Good luck rocket sparkles dizzy"

Without emoji conversion, the only words read into this tweet's sentiment score are "good luck". This then provides a sentiment score of .866. Given the large effect emojis can have on

sentiment scores given the frequency, this study will not be using emoji and emoticon conversion in the final sentiment analysis.[4]

6. Hypotheses

The growing field of commercialized space exploration, changing institution of NASA, and the emergence of billionaires' space programs is spurred by policy changes. This study assumes that the sentiments towards commercial and government space exploration have diverged since commercialization. Following the passing of the CSLA and other policies, perceptions have changed as a response. This change, coupled with the narrative identification strategies of the NPF, drive the investigation of this study. Using the context, plot, and characters of space commercialization identified in earlier sections, the following hypothesis is posited. Further, this study will be using the NPF to contextualize and explain differences in sentiments towards government and commercial space programs.

Hypothesis 1: *Sentiments expressed by Twitter users in their tweets will differ in sentiment towards commercial space actors (Jeff Bezos, Richard Branson, and Elon Musk) than those expressed towards traditional government space programs (NASA and the ESA).*

As a form of storytelling, people are inclined to share things they believe with. Under the NPF, narratives serve as a form of communication (Herman, 2002, 2003, 2009). This hypothesis

[4] Though, the author believes that emojis and emoticons can be used to express sentiment in texts, the difficulty presented by the conversion to text are numerous. In addition to the frequency of emojis skewing sentiment scores, emoticons such as "xp" were being identified in words incorrectly. "Explore" or "experience" were being read with a emoticon in the middle. This is avoided by not converting them or using them in the aggregate sentiment score.

seeks to answer whether sharing of narratives, or tweets, is higher when they have a sentiment score farther from neutral.

Hypothesis 2: *Groups of tweets with more negative sentiment will be shared (retweeted) more than groups with a positive sentiment.*

7. Methods

7.1 Data Selection Using Twitter

For this study, I collected a sample of 555,961 tweets based on the time frame of creation and content of text using Twitter API. Using this sample, I identify the setting, context, plot, and characters with the NPF. The sample of tweets is then broken up into 6 categories by space-related *characters*, these are tweets about Jeff Bezos, Richard Branson, Elon Musk, the ESA, NASA, and the general topic of the new age space race. In turn, the sentiment of tweets and the NPF are used to identify whether these characters are viewed as a hero, villain, or victim. The *context* of the tweets consists of the mission or time period it took place. In this study, that is considered the day of the event and the six days after. Though, the space race group uses a much larger time interval. The time for this group of tweets is much longer as there is not a signifying "space race" event and attempts to capture the overarching sentiments towards a time that is often referred to as the new age space race of commercialized, governmental, and general interest in space exploration.

Tweets about Jeff Bezos contain phrases such as, "Bezos rocket", "Bezos New Shepard", or "Bezos space exploration" among others based on a search inquiries of the mission and associated names, companies, etc. (see appendix A.1) compiled by the author. These tweets were pulled from the entire week of space flight missions, New Shepard Launch by Jeff Bezos, from July 18th, 2021 to July 25th, 2021. The Bezos sample includes 27,769 tweets in this timeframe.

The same methods were used to pull tweets on NASA's Perseverance Rover that landed on Mars on February 18th, 2021. 44,193 tweets of the sample are in the NASA group. The third group, space race, comprises 119,754 tweets from January 1st, 2021. The fourth group comprises 333,370 tweets about Elon Musk's commercial space involvement. Twitter users authored these tweets from May 29th, 2020 to June 5th, 2020 during the launch of the Crew Dragon Demo-2 launch. Tweets about this topic contained phrases that included Musk's name and phrases such as, "Commercial Crew Program", "Dragon 2", and "SpaceX". Additionally, the ESA and Richard Branson are examined for an international scope on space commercialization. The ESA grouping had 2,487 tweets pulled the week of December 17th for the anticipated CHEOPS launch. This grouping is much lower as the launch was delayed due to technical difficulties with the launch. Though these tweets are a much smaller sample compared to other groups, it is expected to be a good measure of narrative building and assessment during a time of government inefficiency. 28,573 tweets comprise the Richard Branson grouping of tweets that were pulled July 10th, 2021, or the week of the Virgin Galactic Unity launch. Of these groupings, Elon Musk garners the most tweets based on the retrieval criteria used. Table 1 on the next page provides an overview of summary statistics of the tweets pulled via Twitter API to form the sample.

Table 1: Summary Statistics

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Sensitive Content	556,146	0.008	0.087	0	0	0	1
Reply Tweets	200,108						
Verified User	556,146	0.062	0.242	0	0	0	1
Protected User	556,146	0.000	0.000	0	0	0	0
Retweet Count	556,146	2.893	165.902	0	0	0	63,498
Like Count	556,146	18.125	847.248	0	0	2	237,762
Quote Tweets Count	556,146	0.525	59.530	0	0	0	29,890
User Tweets Count	556,146	47,805.170	151,377.300	1	1,938	33,849.8	5,779,700
User Lists Count	556,146	427.425	4,991.056	0	0	34	214,715
User Followers Count	556,146	80,832.440	1,354,896.000	0	84	1,858	108,888,881
User Following Count	556,146	1,768.588	10,103.590	0	168	1,411	1,067,670
Tweet Word Count	556,146	23.508	13.126	1	14	32	118
Average Tweet Sentiment	556,146	0.113	0.199	-3.266	0.000	0.230	2.645

7.2 Concepts and Variables

This dataset is useful for assessing the core questions of this research as it has constructed sentiment variables for groups of tweets by subject. In turn, these can be compared to rates of interactions, such as retweets and likes. Sentiment is constructed as a continuous variable that indicates level of positive, neutral, or negative tweet text sentiment. In addition to text sentiment, the number of retweets are examined to assess whether sentiment effects the sharing, or retweeting, of narratives.

8. Models

8.1 Linear Regression

A linear regression approaches modelling the relationship between sentiment and tweet grouping topics. Further, an additional model is run to measure the level of effect emoji conversion to text has on the model.

8.2 Poisson Regression

A Poisson regression assesses the relationship between counts of retweets by sentiment, groups of tweet subjects, user verification, followers, and number of words per tweet. The implications and results of this model are discussed in later sections.

8.3 Zero Inflated Model

A zero-inflated model is additionally run to understand the effect of tweets with zero retweets in the models. The purpose of this model is to further understand tweet text interactions, their retweets, and their potential effects on other variables.

Below is a visual representation of the relationship between sentiment and grouping of tweet topics. Here, *figure 1* shows the density and mean of sentiment scores by group of tweet.

Figure 1: Average Sentiment by Group Tweet Topics

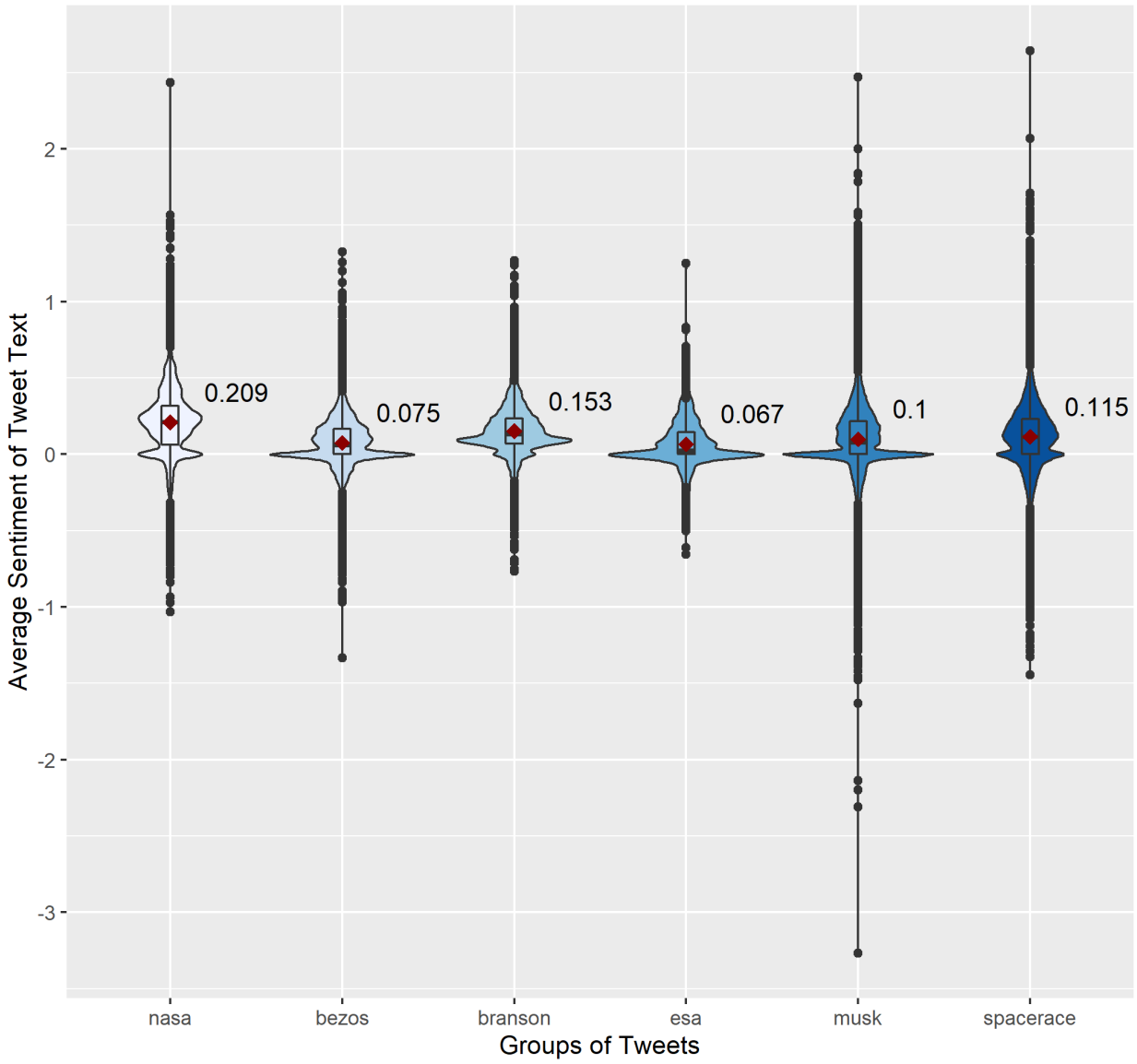

Figure 2 in appendix entry A.4 shows the same visual representation of the relationship of average sentiment to group of tweets that used emoji conversion. Here, we can see more extreme values in sentiment scores that justify the use of non-emoji/emoticon conversion in the final analysis. To statistically assess the difference between these categories, I used a linear model to assess the magnitude of the relationship between sentiment, group tweet topics, and other variables. This is shown below in *Table 2*.

***Table 2*: Effects of Group Topic on Sentiment**

	Emoji/Emoticon Text Conversion		No Emoji/Emoticon Text Conversion	
	β	SE	β	SE
Bezos Tweets	**-0.012*****	(0.001)	**-0.133*****	(0.002)
Branson Tweets	**-0.002*****	(0.001)	**-0.056*****	(0.001)
ESA Tweets	**-0.023*****	(0.004)	**-0.142*****	(0.004)
Musk Tweets	**0.014*****	(0.001)	**-0.109*****	(0.001)
Space Race Tweets	**-0.014*****	(0.001)	**-0.094*****	(0.001)
Constant	**0.087*****	(0.001)	**0.209*****	(0.001)
Observations	**555,961**		**556,146**	
R^2	**0.005**		**0.025**	
Residual Std. Error	**0.179**		**0.197**	
F Statistic	**511.316***** **(df = 5; 555955)**		**2,850.238***** **(df = 5; 556140)**	

Note: Reference group is NASA Tweet Group. Dependent group is sentiment score. Tweets obtained via Twitter API from 2020-2021. Standard errors located in parenthesis. ***p**p***p<0.01**

In *Table 2*, we see there is a negative relationship between sentiments expressed in tweets about Bezos, Branson, the ESA, and the general space race when compared to sentiments expressed in tweets about NASA. Using different data sets with and without emoji conversion to word, it is apparent that emojis play a compelling influence on the magnitude of relationship.

Without emojis, sentiments expressed towards Elon Musk are negative in magnitude in comparison to NASA. Given this, it is apparent that the use of emojis particularly skews Elon Musk's sentiments to be more positive. As articulated in the previous discussion of all-emoji-based texts creating extreme sentiment scores, they should not be considered in the final analysis or when drawing conclusions.

Given the above arguments, this study considers the models and datasets that do not use the emoji conversion to be more representative of a population's baseline sentiment. Tweets filled with emojjis can potentially skew the sentiment score of a grouping, they should not be considered in interpreting results. For the Poisson regression and zero-inflated models, the dataset that has texts without emoji conversion will be used. These models are shown in *Table 3* on the next page.

***Table 3*: Effect of Sentiment, Group, and Other Variables on Retweet Count**

	Dependent variable:		
	Retweet Model		
	Poisson	**Logit**	**Zero Inflated Poisson**
Average Sentiment	**-0.279*****	**-0.103*****	**-0.356*****
	(0.005)	(0.021)	(0.005)
Bezos Tweets	**-0.421*****	**0.285*****	**-0.324*****
	(0.005)	(0.022)	(0.005)
Branson Tweets	**0.093*****	**0.353*****	**0.190*****
	(0.004)	(0.022)	(0.004)
ESA Tweets	**-0.698*****	**-0.424*****	**-0.869*****
	(0.016)	(0.058)	(0.017)
Musk Tweets	**0.724*****	**0.409*****	**0.834*****
	(0.003)	(0.015)	(0.003)
Space Race Tweets	**0.334*****	**0.186*****	**0.377*****
	(0.003)	(0.016)	(0.003)
User Verification	**3.702*****	**-2.403*****	**2.118*****
	(0.002)	(0.012)	(0.002)
Tweet Word Count	**0.031*****	**-0.027*****	**0.017*****
	(0.0001)	(0.0003)	(0.0001)
Constant	**-1.476*****	**2.412*****	**0.929*****
	(0.004)	(0.016)	(0.004)
Observations	556,146		556,146
BIC	13420734		10910487

***Note*: *p**p***p<0.01**. *555961 Tweets pulled in 2021 using Twitter API. Standard errors are located in parenthesis. Reference group of tweets are NASA tweets.*

These models show rates of retweets of other tweet groups, Musk, Branson, and the general space race are higher than NASA retweets. Additionally, it is demonstrated that retweets occur at higher rates the more negative the sentiment is. In the following section, these results will be discussed further and then contextualized through the NPF.

9. Results

We see that the average sentiment for the NASA grouping of tweets are most positive, at a mean positive sentiment score of .209. Further, the largest density of positive tweets occurs in the NASA grouping above .5 in sentiment scores. This demonstrates that not only do sentiments about NASA have the highest positive mean, they have the highest density of positive sentiments away from a neutral sentiment score of 0. In the linear model, sentiments towards the space race in general, Elon Musk, Jeff Bezos, and Richard Branson are all negative in comparison to NASA. Interestingly, tweets about Elon Musk's Commercial Crew launch and the general topic of the space race has quite a large range in sentiments in comparison to other groups. This shows that some of the most extreme sentiments are towards the space race or Elon Musk tweet groupings. Further, we see a much smaller range of sentiments expressed about Bezos' New Shepard Launch and Branson's VSS Unity. Finally, the ESA tweet grouping is most negative in average sentiment score. This is indicative of the sentiments towards the delayed launch, but needs to be explored further on whether the results are generalizable. Overall, there is a significant relationship between the grouping of tweets and their sentiment. This, and the relationship between retweet counts, sentiments, and tweet grouping will be discussed further here and in the conclusion.

There is a significant relationship between both grouping of tweets and aggregate sentiment within the text. All groups of tweets, Bezos, Branson, Musk, the ESA, and the space race are all negative in magnitude of sentiment when compared to NASA. With all else held constant, Jeff Bezos, the ESA and Elon Musk had the most negative effect on sentiment score. This substantiates the hypothesis of this study, but it needs to be articulated on with the NPF.

The Poisson and zero-inflated Poisson models in Table 3 indicate similar results about the effect of sentiment, group, and other variables on retweet counts. They indicate a strong negative relationship between sentiment and re-tweet count, suggesting that negative messages are more likely to be retweeted. They also indicate similar results about the impact of group (topic) on retweet counts. In comparison to tweets about NASA (the reference groups), tweets about Bezos and ESA were retweeted less often, whereas tweets about Musk, Branson, and the Space Race were retweeted more often. On average, tweets in the Musk group had 2.06 times more retweets than tweets in the NASA group. User verification also had a significant impact on retweet counts. On average, tweets from verified users got more than 40 times more retweets than tweets from non-verified users.

This study answers questions on whether the sentiments expressed towards space exploration are more negative for commercial entities than government entities. Using six groupings of tweet subjects about NASA's Mars Perseverance Rover, Elon Musk's Dragon 2 Commercial Crew launch, Jeff Bezos' New Shepard rocket launch, the ESA's CHEOPS mission, and Richard Branson's VSS Unity launch, and the general topic of the space race, this analysis shows that Twitter users express more negative sentiments towards commercial entities engaged in space exploration and the general topic of the space race. Additionally, it shows more positive sentiments are expressed toward the US's space program, NASA.

9.2 Discussion of Narratives in Commercial Space Policy

Using the results of the previous section, it is possible to use narratives to address why public perceptions of commercial entities, the space race, and the ESA, are negative in comparison. Using the NPF, this study has already identified the setting, context, plot, and characters. Now, the macro-level narratives will be assessed. When looking at texts of tweets, this study elaborates on narratives to assess *why* public perceptions are more negative towards commercialized space programs and actors than those towards NASA's Perseverance Rover. When looking at tweets about Musk, Bezos, and Branson, it is clear that, though the public is talking about space programs, they are more morally invested in topics like police brutality, the relationship between billionaires and taxes, the pandemic, and the environment. This is shown in the tweets provided below.

Elon Musk Tweet Grouping

"Sorry did I miss something I thought America would be more concerned about police brutality instead of SpaceX"

Jeff Bezos Tweet Grouping

"@Tasuric Bezos and Blue Origin are not the first to invent Space Tourism and it is perfectly acceptable, maybe even virtuous to despise a tax-evading wage-slaver who has done nothing but ruthlessly profit and hoard in the midst of a pandemic killing millions"

Richard Branson Tweet Grouping

"Given the climate crisis we face as a human race this feels so dated and a huge waste of resources/innovation. Not to mention the carbon emissions required to fuel Branson's ego! https://t.co/EK4CRJtkoo"

In these tweets, we see that narratives towards billionaires Branson, Bezos, and Musk depict them as *villains* when sentiments are negative. These narratives reveal Twitter users are more concerned with societal and environmental issues than billionaires participating in space

exploration. In regards to the space race, negative sentiments are drawn from concerns with the pandemic and growing socioeconomic concerns. This is shown in the tweet below.

Space Race Tweet Grouping

"Excuse my (definitely) incurable pessimism, but could taxing billionaires spending entire government program budgets on a private space race as up to 13 million Americans face potential eviction in 11 days be something Americans rally around together?"

However, not all Tweets towards government space programs were positive. The tweets below provide expressed sentiments that hint at concerns with efficiency. These concerns, either with fuel use or delayed launches, show that the public is willing to express dissatisfaction with government space programs, though not at the same rates they do with commercial space programs.

NASA Tweet Grouping

"I think my SUV burns fuel like this Mars Rover does."

ESA Tweet Grouping

*"*The launch of @ESA_CHEOPS is delayed, unfortunately."

Even though the sentiment of tweets towards commercial entities are negative in comparison to NASA, they are not all negative. Below are tweets that build positive narratives towards space exploration that are centered around leadership, exploration, and scientific endeavors. These narratives depict characters Branson, Bezos, Musk, and NASA as heroes of scientific endeavors.

Branson Tweet Grouping

USER:
"Accumulation of personal success, yes - I am by name. Most successful merchant : @JeffBezos Most accomplished Scientists in independent space exploration: @richardbranson Most Golden Hearted Sustainable Innovative Space Faring Explorer & Leader of The largest: @elonmusk"

Elon Musk Tweet Grouping

USER:

"Congratulations on 10 successful years, I'm completely totally proud of you @elonmusk @SpaceX wishing you many more years of unparalleled success happy anniversary https://t.co/cOceQb47jG"

NASA Tweet Grouping

USER:

"Woah, These new badges are really so Awesome! I love it Thanks to NASA for making continue our enthusiasm towards the launch and space exploration Eagerly waiting for Launch Day Wishing all the best to our Space Hero (Crew) #NASA #NASASocial #LaunchAmerica #SpaceX https://t.co/1KfMe4SOgQ"

Using these texts on an individual level, it is shown sentiments concerned with space exploration are more positive towards NASA than commercial space entities. Tweets express concerns with the environment, social issues, and socioeconomic divisions, more when discussing Bezos, Branson, and Musk, than when discussing NASA. Further, the space race general tweet subject is often associated with Bezos, Branson, and Musk with fears of growing socioeconomic divides during the pandemic. Though, negative sentiments are expressed towards government programs when there are concerns with efficiency. Ultimately, the NPF advances this study by illustrating the differing narratives towards commercial and government space endeavors. The application of the NPF to contextualize this study reveals that sometimes characters in the billionaire space race can be perceived as both heroes and villains by the public. NASA is also viewed more positively with users expressing less desire for NASA to address societal issues outside of space exploration. Further, narratives help us explain *why* sentiments towards commercial entities are lower when compared to NASA. Twitter users are concerned with billionaires participating in resolving broad societal issues while they do not expect NASA to move past its traditional institutional goals.

10. Conclusion

10.1 Impact on Theory

This study advances the NPF and space policy literature by examining the relationship between public sentiments and the increasingly commercialized space realm. Further, the macro-level of analysis is utilized to understand the societal narrative response to the commercialization of space. This moves on from previous space policy literature and the use of the NPF with a research design that utilizes text and sentiment analysis to compose narratives. This study addresses previous limitations of public opinion data in space policy being limited to focusing on government spending, not private enterprise.

The commercialization of space, through the CSLA and other policies, has spurred changes in public perception of space policy actors and programs. This study concludes that this has resulted in more negative sentiments being expressed towards commercial actors and the general space race. Text narratives show that this is on account of concerns with the environment, the pandemic, growing socioeconomic tensions, and social issues. Although they are more positively perceived by the public in sentiments, concerns with NASA were about efficiency. In turn, this shows that the public is concerned about the perceived consequences of space commercialization and expresses this in narratives on social media.

10.2 Limitations and Threats to Validity

This research design is limited as only six cases were analyzed to compare how public sentiments towards commercial entities differ from government entities. Moving forward, text analysis should be used to understand more events and widen the study application. More private space engagement, space programs in other countries, and international events would provide additional and complementary understandings of public perceptions towards space exploration.

Further, there are limitations of Twitter data. On average, Twitter users are primarily between the ages of 18 and 40, educated, make more money, and typically vote Democratic (Statista, 2021; Wojcik & Hughes, 2021). To account for these limitations in the future, other social media platforms offer a hopeful data substantiation. With the recent data publishing announcements by Facebook's parent company, Meta, gaps in age, income, and educational attainment can be used to address some Twitter data shortcomings.

10.3 Future Research (To Infinity and Elon)

The implications and research model of this study are promising in many future applications. Researchers in the space policy realm have advocated for more use in big data, text analysis, and social media data retrieval to expand the realm of study. Text analysis, sentiment analysis, and use of social media data within this research design can fill gaps in current data, provide more holistic understandings of public perceptions on a wide array of topics, and substantiate previous research. Further, the NPF is advanced through this macro application to assess how to public builds narratives in response to the commercialization of space.

This study shows an interesting relationship between sentiments from the public regarding space exploration topics and effects on interactions Twitter users engage in because of the text content of the tweets. Moving forward, this should be considered when observing the expanding relationship from NASA's traditional relationship between the U.S government with private entities to the "New Age Space Race" and "Billionaire Space Race". As the rate of private actors increasingly moves past government contracts to private space exploration, there needs to be an equivocal research agenda in response to understand the changes in public perceptions of space policy and space exploration.

☆☆☆

11.References

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Appendix

A.1 Temporal and Content Dictionary Used to Pull Tweets for Sample

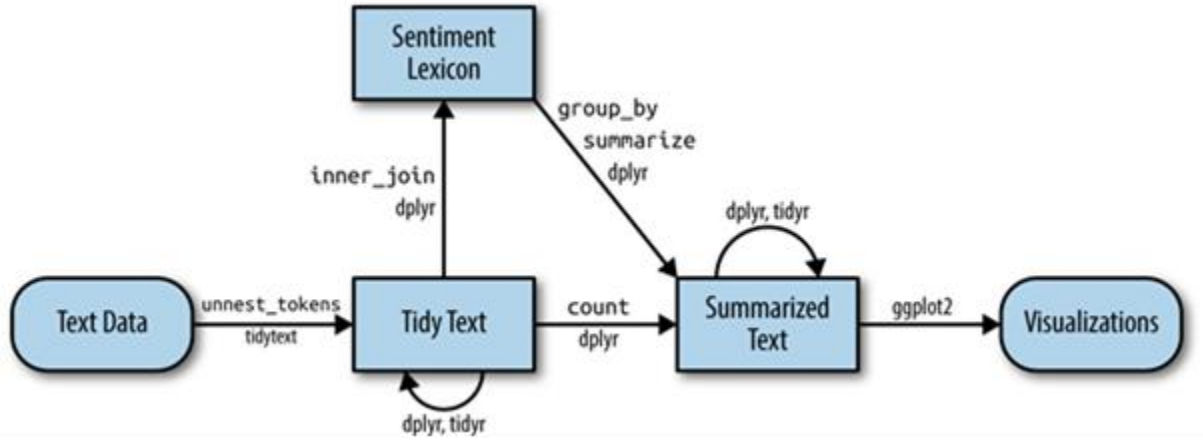
Tweet Grouping	**Words or Phrases used in Text Inquiry (Can be pulled in random order. Text contains the combination of phrases or words)**
Jeff Bezos July 18-25 2021	"New Shepard Launch" ,"Bezos New Shepard, "Bezos Space Exploration", "Bezos Rocket", "Bezos Rocket Launch", "Blue Origin", "Jeff B*zos", "J*eff B*zos","Jeff Bez*s"
Elon Musk May 29-June 5 2020	"Dragon 2 Launch", "Dragon 2 Commercial Crew Launch", "SpaceX Dragon 2", "SpaceX Dragon 2 Commercial Crew", "SpaceX Dragon 2 Launch", "SpaceX", "El*n M*sk", "Elon M*sk", "El*n Musk"
NASA Feb 18-25 2021	"Mars Perseverance Rover", NASA Mars Rover", "Perseverance Rover Launch", "NASA Mars Rover Mission", "Percy"
ESA Dec 17-24, 2019	**"**European Space Agency", "ESA", "CHEOPS", "Exoplanets", "Planets", "Cosmic Vision"
Richard Branson July 10-17, 2021	"Virgin Galactic", "Sir Richard", "Rocket Plane", "Virgin Galactic Unity 22", "VSS Unity"
Space Race Jan 1- Aug 15 2021	"Billionaire Space Race", "Space Race", "New Age Space Race"

A.2 Investigate.Ai. *An introduction to the NRC emotional lexicon*.

negative	3324
positive	2312
fear	1476
anger	1247
trust	1231
sadness	1191
disgust	1058

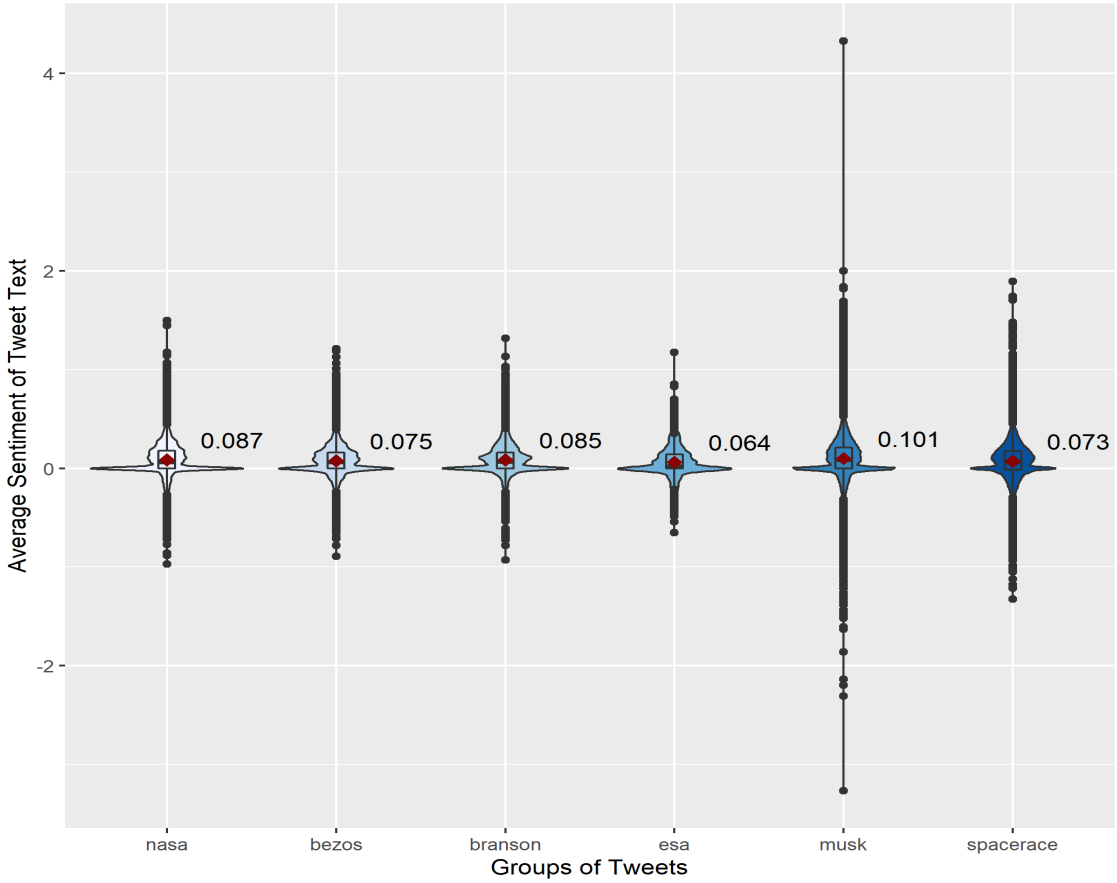
anticipation	839
joy	689
surprise	534

A.3 Robinson, J. S. and D. (n.d.). *2 sentiment analysis with Tidy Data: Text mining with R*. 2 Sentiment analysis with tidy data | Text Mining with R. Retrieved October 21, 2021, from https://www.tidytextmining.com/sentiment.html#most-positive-negative.



A.4 Sentiment Scores by Group Without Emoji Conversion

Figure 2: Average Sentiment with Emoji Conversion by Groups of Tweet Topics



Note: 555961 Tweets pulled from 2020 to 2021 and sorted by tweet subject into groups