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The Corporacy of the Cosmos: A Privatization of Space Research

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ABSTRACT

This article explores the evolution of space research conducted under agents of both federal and non-federal funding; current industrial trends have shifted the center of space research to immediate commercial applications. The rise of patent laws in private industry, utilization of research/technology spillovers from basic research, and efforts to retain appropriability have all incited private space companies to divert from basic space research. Therefore, applied space research receives much more prominence and publicization as does cosmological research that is primarily theoretical in nature. Firstly, this paper discusses the importance of basic space research in the astronomical field. Subsequently, this paper details the distinction between federal and private space research, and specifically the dangers of the trend towards monetization versus theoretical research in the latter. Lastly, this paper presents a possible solution that seeks to address the lack of funding of basic space research: this solution would allow for the private space industry to be financially collaborative with NASA, for research-specific purposes, and would provide for a mutualistic relationship between both agents. An explicit congressional standard should be set that mandates private space companies to return a portion of company profits to Congress, that of which must be injected back into basic space research--five cents of every dollar generated by private space commercial projects should be taxed to Congress. Allocation of these funds towards basic space research projects will allow for a harmonious relationship between industry and federal-agents in the cosmological research arena.

INTRODUCTION TO SPACE COMMERCIALIZATION

The complexity of outer space has incited extensive cosmological scholarship, propelling our cosmos into an instrument of national interest. Accordingly, space research requires copious funding to scientifically progress and ensure the development of private and federal space-based agencies. This research is often classified as basic research, defined as a "systematic study directed toward greater knowledge of the fundamental aspects of phenomena and of observable facts without specific applications towards processes/products in mind" (Science Philanthropy Alliance, n.d.).

The National Aeronautics and Space Administration (NASA, 2005) is the main federal agent that conducts space research and development (NASA, 2005). According to the National Aeronautics and Space Act of 1958, one of NASA's primary objectives is to promote the expansion of human knowledge of the Earth and of phenomena in the atmosphere and space (NASA, 2005); most of this discovery is highly dependent on research that is theoretical/conceptual (Reichhardt, 1988). In a cosmological context, theoretical research is synonymous with basic (space) research.

NASA's discoveries allow for a fundamental understanding of what is cosmological, as theories themselves aid in explaining and predicting phenomena. For example, studies of fluctuating particle radiation and cosmological redshift -- historically promoted through NASA initiatives such as the Van-Allen Probes Mission and Cosmic Background Explorer (NASA, 2018) -- identified concepts such as high-energy particle behavior and universal expansion. This finding has paved the way for the expansions of contributions in the world of academia and the fulfillment of NASA's commitment to understand the formation and framework of outer space (Dumont & Meeusen, 2000).

Due to the conceptual nature of basic research, findings often generate "knowledge spillovers", those of which are defined as the "involuntary and uncompensated transfer of ideas or techniques that affect subsequent innovations both within and across industries" (Dumont & Meeusen, 2000). A knowledge spillover in the cosmological realm is largely generated by a federal agency (NASA) and utilized by a private one (i.e. a private aerospace company such as SpaceX, Virgin Galactic, and Boeing). NASA's own regulation of basic research has fluctuated over time; NASA abolished basic

research divisions in 1970 (Rose, 1986). This, which would later be challenged by the NASA Advisory Council's recommendation that NASA should establish a space basic research (engineering science) program, suggested that the Chief Technologist of NASA collaborate with both its Chief Scientist and the Chief Engineer to seek future funding for space basic research in engineering science (Rose, 1986). However, NASA's response to this recommendation entailed that their research investment plan would mirror the pre-established Strategic Space Technology Investment Plan (Terrier & Chandler, 2012). This plan ensures that efforts are focused on higher technology readiness levels, and tends to emphasize the incorporation or packaging of new technologies into subsystems with particular mission applications—thwarting an intended counteraction of basic research's decline in the cosmological arena.

Additionally, NASA has historically been financially dependent upon an uneasy relationship with Congress and governmental regulation. NASA's long-term relationship with Congress formed in 1959 as one of uncertainty; congressional ambivalence framed the initial proposal of funding for NASA initiatives. This was particularly due to a dissent of agreement regarding how much power NASA would have to delegate to Congress (Rose, 1986).

This regulatory relationship is what currently dictates NASA's financial relations with the government; federal agencies, such as NASA, are intended to receive their research funding from the federal budget. After the President submits his initial budget request for annual fiscal spending, independent appropriation subcommittees of both the House and Senate determine the budget allowance that feeds into these programs--including what are denoted as "annually-appropriated programs" (A brief guide to the federal budget, n.d.).

Annually-appropriated programs, comprising approximately one-third of all federal spending, leave Congress with the full responsibility to change and renew the amount of funding afforded to them by the federal budget (Rose, 1986). In the duration of the congressional federal budget process, the president is informed by both his nominated science advisor and the director of the White House Office of Science and Technology Policy in order to receive scientific and technical advice in areas of national concern (Rose, 1986). In contrast with federally funded basic research, "applied research" includes the investigation of the findings of 'pure' or basic research in pursuit to determine if they could be used to develop new products or technologies (Terrier & Chandler, 2012). Most commonly, it is buoyed by an industrial hand.

In this article, I discuss the evolution and influences of space research in both government-sponsored and private laboratories; I argue that there has been a resultant shift of cosmological research agenda. Current trends suggest that the shift of space research centers on immediate commercial applications (that of which is primarily founded by private companies). The rise of patent laws in private industry, utilization of research/technology spillovers from basic research, and efforts to retain appropriability have all incited private space companies to divert from basic space research. Thus, this form of research receives much more prominence and publicization as does cosmological research that is majorly theoretical/based in deep space. Firstly, I will discuss the importance of basic space research in the astronomical field. Resultantly, I will detail the distinction between federal and private space research, and specifically the dangers of the trend towards monetization versus theoretical research in the latter.

UNDERSTANDING THE IMPORTANCE AND INFLUENCES OF BASIC SPACE RESEARCH

IMPORTANCE OF BASIC SPACE RESEARCH

The significance of basic space research is documented throughout its continuous role in both earth centric and space centric discovery. Basic space research is integral to scientific innovation; our general understanding of certain cosmological concepts is vital to scientific development conducted on Earth. For example, theoretical research of cosmic plasmas has led to further development in thermonuclear research. The magnetic mirror approach to thermonuclear fusion is based on the "pinch effect" --that of which refers to the plasma confinement produced by an azimuthal self-magnetic field (Samec, 1976) --an effect only uncovered once we became able to fundamentally understand the mechanisms of cosmic plasmas" (Samec, 1976). This particular study of thermonuclear fusion is integral to the development of practical power production that is widely utilized on Earth (Shepherd & Shepherd, 1998). Basic space research on coronal mass ejections and solar flares established that non- recurrent geomagnetic storms are produced by CME's, effectively allowing for an efficient method of geomagnetic storm forecasting on Earth (Rose, 1986). Moreover, the study of universal expansion led to the development of the Hubble constant (h0)--now widely utilized on Earth to determine planetary age (Huchra, 2008).

The importance of basic research additionally extends to research conducted outside of the cosmological realm; basic research on game theory enabled the Federal Communications Commission to design complex auctions of the Nation's telecommunications spectrum, netting tens of billions of dollars to the U.S. treasury (Palca, 1992). In regards to basic research's influence, basic biological research has been an integral component in the furthering of the biotechnology industry and its subsequent creation of a plethora of antibiotics (AAU, 2015).

Funding Constraints of Basic Space Research

The impact of basic space research, however, is often only influential once financed by the federal government. The government has traditionally shouldered the burden for noncommercial science and technology research, typically garnering bipartisan support (Bayh-Dole Act, 1980) Contrarily, businesses tend to produce technologies that are proven to be conducive to commercialization (Rai & Sampat, 2012). The centrality of NASA as the main federal agent for basic space research is affirmed by the manner in which it is funded by the federal government. In 2017, NASA was afforded $5,601 million for research-oriented scientific pursuits and $827 million for the development of space technology -- less than a sixth of the allocation for research purposes (Thomas, 2017).

REPERCUSSIONS OF THE PRIVATIZATION OF BASIC SPACE RESEARCH

However, basic space research's sole financial reliance upon the federal government allows for three factors to jeopardize its integrity: the decrease of federal funding appropriations for basic space research, lack of ability for basic research to be patented, and inherent disadvantage that frames basic research due to the scientific lobbying of applied research.

The Decline of Federal Funding for Basic Space Research

Federal funding appropriations for NASA are linked to an evolving political atmosphere. NASA's portion of the federal budget was highest--4.31 percent (Thomas, 2017) --when it was the United States' sole means of challenging the Soviets in the giant 'space race' in the year of 1965 (Mervis, 2017). However, federal funding for NASA settled into a relatively steep decline immediately following the end of the Soviet Union in 1991 (Mervis, 2017); NASA's launch rate experienced a decline into approximately 80 orbital launches worldwide--a consequence of the resulting lack of competition for space dominance between the US and Soviet Union. Modern percentages for NASA's component of the federal budget are approximately half of a percent; they have not surpassed two percent since 1969. This lack of federal funding for basic research is part of a larger governmental mentality regarding the necessity of basic research; US federal investment in basic research still continues to decline. While U.S GDP nearly doubled from $6 trillion in 1980 to a current $12 trillion (Hiltzik, 2015), federal investment in R&D in the physical and mathematical sciences and engineering has now decreased to 37 percent (Hiltzik, 2015). President Bush's first budget request continued the trend of previous administrations--the overall research budget went down 1.8 percent (not including a 0.6% increase for the Department of Health and Human Services) (Hiltzik, 2015).

Two days after the announcement, the American Association for the Advancement of Science issued an analysis showing that the proposed Bush Administration's budget for the next five years would cut funding for basic research at 21 of 24 federal agencies, including NASA (American Council on Education , n.d.).

These decreases of federal funding for space research have thus incited and allowed other non-federal agencies to usurp basic research--particularly American universities. In the year of 2012, U.S universities performed the majority of basic research, with $40 billion in funding (National Science Foundation, 2014) —eclipsing the combined basic research performance of both federal and industrial agencies. While the future of basic space research is benefitted by a relationship with national universities, its current relationship poses an inherent danger to the impartiality of basic space research.

To illustrate this concept, the Bayh-Dole Act of 1980 is a key factor that contributes to this impartiality by allowing universities to retain title to inventions made under federally- funded research programs (Bayh-Dole Act, 1980). Due to these implications of the Bayh-Dole Act, universities are not able to act as impartial agents for basic space research--the Bayh-Dole Act has "provided important leverage in fostering voluntary moves towards more commercialization-friendly licensing by universities" (Rai & Sampat, 2012), including in such important cases as the foundational stem cell patents held by the University of Wisconsin (Wahlberg, 2012). This act has thus incentivized numerous universities to conduct research that would lead to patentable results, those of which directly counter the purpose of fundamental research. Additionally, many universities are financially sponsored by private companies in exchange for conduction of research (such as the University of Washington's Boeing sponsorship) -- creating a substantial conflict of interest (Washington Media Release, 2017).

Inability to Patent Results of Basic Space Research

Moreover, most basic space research results are unable to be patented as they are in the form of intangible knowledge--resulting in the widespread use of research/technology spillovers. While this may be extremely beneficial when used for the expansion of cosmological knowledge and the growth of Earth-based applications, the inevitable propagation of research spillovers in the realm of basic space research has prohibited basic space research from being non-appropriable (not being able to be easily imitated/reproduced). This lack of appropriability for theoretical space research additionally discourages both private space companies and universities to pursue basic space research-- knowledge spillovers generated

by federal agents such as NASA come at no cost to private space companies. Contrarily, private space companies—those of which include aeronautical/astronautical corporations such as Boeing, SpaceX, and collaborations with private research universities—are privately funded, and thus are not financially reliant on the federal budget for the majority of their research initiatives.

SpaceX, one of the most valuable privately-held companies in the world, doubled its net worth from $11 billion to approximately $22 billion in 2015 by means of investment from two private companies (Fidelity and Google) alone (Washington Media Release, 2017). The fiduciary relationship shared between Google and SpaceX is inherently mutualistic; Google's investment in SpaceX will help further its aim of bringing satellite internet to remote regions of the world while simultaneously subsidizing SpaceX's ambition of colonizing Mars (American Council on Education , n.d.). Due to their $1 billion investment into SpaceX, Google and Fidelity will collectively own 10 percent of SpaceX (National Science Foundation, 2014).

The SPACE Act of 2015 has additionally been an agent of space commercialization. Spearheaded by the company Planetary Resources, the SPACE Act of 2015 was launched-- allowing private space companies the right to engage in commercial exploitation of outer space resources. Private space companies, as a result, tend to focus their cosmological research on commercial spaceflight, satellite development, and missile defense systems—three research products that yield substantial profit (Bayh-Dole Act, 1980).

An Applied Shift of Cosmological Research through Scientific Lobbying

The final influencing factor of basic space research, scientific lobbying, similarly challenges the national integrity of basic space research. Scientific lobbying establishes a disadvantageous privatization of research agenda, as it may only be done by private space companies who primarily seek funding for applied space research.

For example, SpaceX hired seven lobbying firms in the year of 2017 alone (Rai & Sampat, 2012)-- with its total lobbying expenditures comprising approximately $1,460,000 (Wahlberg, 2012). SpaceX lobbied for 5 specific issues in relation to the creation of the 2018 federal budget--namely issues related to the funding of civil and defense space launches and the Space and Science sector of the federal budget (Washington Media Release, 2017). These lobbying practices inherently shift cosmological research agenda by allocating federal funding towards agents with lobbying abilities, and these agents typically lobby for monetizable, commercialized causes--such as private space launches.

These lobbying agents also include universities, who often proactively lobby their political representatives in Washington for academic earmarks (funds specifically set aside for university research) Moreover, universities who profess to eschew earmarks may lobby and receive these exact same earmarks they profess to avoid--according to some experts, these earmarks distort allocations away from the basic science and towards projects favored by powerful interest groups that often fund the universities themselves (Washington Media Release, 2017).

SOLUTION

Reasoning, Legal Precedent, and a Proposal for the Financial Accountability of Basic Space Research

Current funding mechanisms for basic space research have evolved into instruments that constrain rather than endorse, leaving less flexibility for an intellectual expansion of our mysterious cosmos. The lack of accountability of basic space research, coupled with a steadily decreasing availability of federal funding for basic space research and the prevalence of scientific lobbying for applied space research, have all proven to compromise the future of basic space research. Basic space research thus lies at the hands of its financing agent and the exterior actions of surrounding financing agents of space research/exploration.

While there may exist many possible methods of minimizing the effect of outside agents on the nature of basic space research, one proposal remains salient. A solution that allows the private space industry to be financially collaborative with NASA, for research-specific purposes, would allow for a mutualistic relationship between both agents. Specifically, an explicit congressional standard should be set that mandates private space companies to return a portion of company profits to Congress, that of which must be injected back into basic space research--five cents of every dollar generated by private space commercial projects should be taxed to Congress. The entirety of these funds should be annually allocated (in the congressional federal budget process) toward specific earmark spending projects that fund the conduction of basic space research in labs sponsored by federal space agencies (NASA).

This specific percentage is precedented by the average royalty range of 3-6 percent for American inventions (Schulz, 2015)--in this case, the licensing agreement is held between all private aerospace companies and federally-funded space research agents in the United States. While initially seeming unconventional, applying the concept of royalty to basic space research would secure both its preservation of protection—especially through the medium of appropriability.

This concept of research having appropriability (in certain situations) gains main legal precedent in the case Roche Products, Inc. v. Bolar Pharmaceutical Co . In this

case, ". . . Plaintiff sought to enjoin defendant from taking, during the life of a patent, the statutory and regulatory steps necessary to market, after the patent expired, a drug equivalent to the patented drug. On appeal, the court reversed since the court could not construe the experimental use rule so broadly to allow a violation of patent law in the guise of scientific inquiry when that inquiry had definite, cognizable, and not insubstantial commercial purposes" (Roche Prods v. Bolar Pharm.).

In summary, the court established that they could not use the experimental use rule so broadly as to allow a violation of patent law when the defendant explicitly used the research for a monetizable purpose. This legal precedent is foundational in the context of basic space research; private space companies utilize the results of this specific form of research primarily for financial gain. In 2008, the aerospace industry in the United States generated $372,438 million in product sales (Kennedy, 2012). In the same year, the aerospace industry spent $10,371 million on securing fundamental space/aerospace research--for every dollar designated to fundamental research, approximately three profit dollars were accrued (Schulz, 2015). In this case, the defendant--all federally-funded space research agents (primarily NASA) --would be owed financial accountability from said private aerospace companies.

Another case, Madey v. Duke University, provides similar legal precedent (Roche Prods v. Bolar Pharm.). In this case, Madey (the plaintiff) brought suit against Duke (the defendant) for patent infringement for using his lab equipment and certain results that it generated. Duke claimed its use fell within the experimental use exception. However, the Court eventually found that "in light of the Federal Circuit's Opinion narrowly construing the experimental use defense, Duke. . . failed to demonstrate that it is entitled to this defense as a matter of law" (Roche Prods v. Bolar Pharm.) and held that "where the research was consistent with the infringer's business, regardless of the research's immediate or ultimate commercial implications, the research exemption could not apply" (Kennedy, 2012).

What both Madey v. Duke and Roche Products, Inc. v. Bolar Pharmaceutical Co. hold in common is that they afford legal accountability to research (Roche Prods v. Bolar Pharm.). As paralleled by the situation presented in Roche Products Inc. v. Bolar Pharmaceutical Co, a certain medium of appropriability for federally-funded basic space research would be appropriate as all private space companies have, as previously stated, cognizable commercial purposes when they utilize basic research results to create commercially-applicable products.

Similarly, Madey v. Duke establishes the standard for the research exemption not to apply when private companies utilize research that is contingent to their business (i.e SpaceX utilizing research that they then intend to commercialize) (Madey v. Duke Univ.). This legal accountability of basic space research allows for a royalty-based approach to funding theoretical space research, through financial means of corporate tax. Thus, through the medium of royalty applied to basic space research, the appropriability of basic space research would be augmented through an ability to patent.

Lastly, it has been established that there is a complementary relationship between federal science funding and non-federal funders; the more funding given to federal science agencies will prove to additionally crowd in private investment, thereby furthering private objectives as well as federal ones (Lanahan, Graddy-Reed, & Feldman, 2016). Specifically, it has been estimated that a 1% increase in federal research funding is associated with a 0.468% increase in industry research funding--an increased approximation for industry research funding is estimated in regards to studies of engineering/science (Lanahan et. al, 2016).

Thus, an increase of federal funding for basic space research (through corporate taxation) further allows private space companies to retain their presence in the space realm. While the intersect of privately-funded applied research and federally-funded basic research does form a complex body of cosmological agenda—one that often exists disadvantageously for the latter—a corporate tax that bolsters federal funding will aid in evening the balance. This balance is necessary; for example, the contribution of solar research to geomagnetic storm forecasting would prove much less helpful without its commercialized result: the coronagraph---a device that examines the outer atmosphere of the sun (U.S.P.Q.2D, 2002).

Investments in science provide knowledge and discoveries that advance national priorities and drive economic growth. Every agent of academic science has unique objectives, those of which include commercial success for private industry, societal benefit for nonprofit organizations, and local economic development for state and local governments. These objectives provide the backbone for a mutualistic, non-exploitative relationship of all forms of space research; that of which is essential to their stimulating and successful atmosphere.

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Mentor Details

This article was prepared with mentorship from Nikhil Venkatasubramanian.

Nikhil Venkatasubramanian is a recent graduate of George Washington Universty, and a current investment banking analyst at UBS. His research interests included applied mathematics, finance and political science. He was an avid member of the GW Debate team and the Editor-in-Chief of the GW Undergraduate Law Review.