ARTICLE

<https://doi.org/10.1057/s41599-020-00570-3>

OPEN

On the problem of astronomy and popular prejudices: the case of ancient astronomers and NASA funding

Eleni Panagiotarakou ¹✉

The aim of this paper is to explore the popular prejudices faced by ancient and modern astronomers. In the case of the ancients, this entails examining the astronomer Thales of Miletus (ca. 620 BC–ca. 546 BC) via the analysis of various ancient texts, such as Aristotle’s *Politics*, Plato’s *Theaetetus* and Aristophanes’ *Clouds*. In the case of the moderns, this entails examining the National Aeronautics and Space Administration (NASA) agency via its funding history, public opinion polls, and spinoff reports. The findings suggest that NASA’s constant efforts to justify their existence in terms of practical outcomes, mirrors the experience of ancient natural philosophers who were depicted with their “heads in the clouds” and in possession of an epistemology devoid of any practical significance.

¹Concordia University, Montreal, Canada. ✉email: eleni.panagiotarakou@concordia.ca

Introduction

In this paper, I argue that ancient astronomers were perceived as lacking practical wisdom by the general public and were pressured to demonstrate concrete outcomes. I also argue that, in regard to NASA, the same pressures manifest themselves in state funding.

Namely, I suggest that spinoff reports—which list the practical outputs of NASA’s scientific endeavors to the general public—seek to influence public opinion. Granted that the link between public opinion and NASA funding is opaque at best, nonetheless, spinoff reports exemplify the essence of the spirit that one observes in Aristotle’s apocryphal tale involving the proto-astronomer, Thales of Miletus (more on this shortly).

At the risk of misunderstanding, this paper is not arguing that NASA should not be providing practical results as a result of its scientific endeavors. On the contrary. Many of NASA’s technologies have improved our lives for the better. Rather, this paper provides an interpretation that draws from an empirical and a normative framework alike.¹

The comparison between ancient Greek astronomers and NASA is interesting because it is a historical discussion that shifts the dialog in a novel direction, namely, the use of analogies with ancient astronomy/science. While it would be tempting to add that the comparison is also interesting because it highlights similarities that transcend time and place, limited evidence prevents such a bold assertion.

The paper is divided into three sections. The first section provides a background and analysis of NASA’s funding from its days of inception to the current administration, and a review of various studies measuring the link between American public opinion and space funding. The second section examines ancient Hellenic texts on natural philosophy with a special focus on astronomy that includes the works of Aesop, Aristophanes, Plato and Aristotle. The third section provides a synthesis followed by policy recommendations.

Background and historical analysis of NASA’s funding

While scholars debate the effectiveness of public opinion, NASA officials are busy raising public awareness. One of their methods involves the use of spinoff reports. These are publications that list NASA technologies that have been transformed for use in the private sector (NASA, 2017). The first spinoff report was published in 1973. However, as their products increased, NASA began publishing annual spinoff reports for presentation at congressional budget hearings (NASA, 2017). In 1976 NASA made the spinoff reports available to the general public in the form of glossy, color publications. Since that time NASA has featured over 2000 spinoff products and services including satellite communications, space-based navigations systems, and medical technologies among other things (NASA, 2017).

One of the main objectives of the spinoff reports is to shape a positive public opinion thereby enabling NASA to maintain a steady stream of governmental funding by elected politicians who are sensitive to electoral moods. While research has been conducted on the empirical relationship between public opinion and NASA’s governmental funding, nothing has been written about ancient historical antecedents (more on this shortly).

It could be argued that NASA’s spinoff reports have multiple target audiences. The general public and lawmakers appear to be one group. Another group are libertarians who advocate for a small government. As a political ideology, libertarianism has been growing in influence over the years, thanks in part to generous funding from wealthy libertarian patrons the likes of the Koch brothers. Various libertarian foundations and think tanks seek to influence public policy and often target NASA. These attacks come

in the form of various commentaries from The Foundation for Economic Education (FEE) such as “NASA Shouldn’t Be Funded” and the Cato Institute “Time to Privatize NASA” (Hudgins n.d.). The benefits of NASA’s spinoff reports become evident when one observes that numerous libertarian authors are forced to admit the many technological benefits of NASA. This, in turn, deflects the majority of criticisms aimed at NASA’s state funding.

This is not to say that libertarians are against space exploration per se. On the contrary. Some welcome space exploration and argue that “space travel is vital and beneficial to human well-being” (Nelson and Block, 2018, p. 1). Rather, their criticism stems from their fundamental anti-statism views which holds that nation-states should be excluded from space exploration because it is a system that is plagued by corruption and mismanagement and one in which “crony capitalists” are supported via “compulsory tax payments” (Nelson and Block, 2018, p. 2). Even if the state could be effective, the argument continues, it would still be improper because “its funds are mulcted, unwillingly, from their rightful owners, the long suffering taxpayers (Rothbard, 1998 as quoted in Nelson and Block, 2018, p. 3).²

Consequently, many libertarians advocate market-driven, private enterprises for space exploration such as Elon Musk’s SpaceX, Jeff Bezos’ Blue Origin, and Richard Branson’s Virgin Galactic. Space constraints prohibit me from offering a counter-argument to the libertarian position but I would note that “a feasible space program needs the unlimited financial resources of a wealthy nation-state” (Panagiotarakou, 2019, p. 57). Venture entrepreneurs can complement, but cannot replace the state in any space endeavor. Along similar lines, Shammas and Holen (2019) argue that while the “frontiersmen of NewSpace tend to think of themselves as libertarians” in reality their “entrepreneurial libertarianism of capitalistkind is undermined by the reliance of the entire NewSpace complex on extensive support from the state”. In the specific case of Elon Musk’s companies, Shammas and Holen (2019) point out that they have been “underpinned by \$4.9 billion dollars in government subsidies”.

Spinoff reports aside, NASA also engages in public outreach activities. These include educational programs (e.g., promotion of STEM education from K-12 to university), grants, internships, and media affair activities among other initiatives (NASA, 2012). In addition, NASA holds various events to raise awareness to budget cuts. One such event was a car wash and cupcake-giveaway at the Jet Propulsion Laboratory (JPL) research facilities in Pasadena, California (NASA, 2018). Planetary scientists at the JPL were gathering signatures for a petition urging Congress to reverse the proposed 2013 budget cuts, namely, 21% from the planetary budget and 38% from the Mars projects (Dance, 2012).

Some authors have argued that the pressure that NASA feels to justify its budget stems from popular prejudices. That is, the American public is of the mind that their tax money would be better spent on addressing social and environmental problems on earth. If money is to be given to NASA, the argument goes, it should be for earth-based space projects (DeGroot, 2009). Ironically, even earth-based projects by NASA are seen as suspect. Or, to put in the words of one vocal NASA critic:

NASA is a machine for spending money. That fact has been driven home by the ignominious failure of the Orbiting Carbon Observatory, a \$278 million package which blasted off from Vandenberg air force base on Tuesday and promptly crashed into the Pacific. The satellite, we were told, would advance the study of global warming. But NASA isn’t interested in global warming; it simply realizes that wearing green is a way to get government money (DeGroot, 2009).

While the above opinion might appear harsh, it is neither novel nor extraordinary. One of the earliest opponent of NASA was President Dwight Eisenhower despite the fact that he was also its founder. For instance, fearing uncontrollable financial spending, in one of his speeches Eisenhower asserted that: “Every gun that is made, every warship launched, every rocket fired, signifies in the final sense, a theft from those who hunger and are not fed, those who are cold and are not clothed. This world in arms is not spending money alone. It is spending the sweat of its laborers, the genius of its scientists, the hopes of its children” (Bury, 2013, pp. 47–48).

As historian Yanek Mieczkowski (2013, p. 143) points out, many average Americans shared Eisenhower’s reluctance to give the space program a *carte blanche* when it came to funding. As one constituent of Johnson put it: “We Texans believe in defending ourselves at all times, and will leave no stone unturned to ferret [sic] out our foes, but we are not pleased to see billions on top of billions of good hard cash being tossed aside in a ‘stunt race’ into outer space” (Mieczkowski, 2013).

Ironically, Eisenhower’s fears of extravagant funding proved to be unfounded. The end of Cold War and the diminished sense of urgent national needs resulted in draconian cuts to NASA’s funding (Logsdon, 2007). And if not for NASA’s earth-based programs such as radar topography, oceanographic satellites and communications satellites, the budget cuts would have been greater.

Public opinion and space funding

Governmental funding is of concern to NASA officials whether it relates to increased agency funding or to particular programs. A case in point was the passionate appeal by former NASA Administrator Charlie Bolden who, during his Congressional hearing on the presidential budget request, was quoted as saying that it was his intention to get down on his hands and knees and

“beg and plead and make [Congress] understand this country needs human access to space” (Clark, 2014). This brings us to the question “what (if any) is the relationship between public opinion and space funding?”

Recent findings on this question are inconclusive or contradictory. To begin, NASA historian Logsdon (2007) suggests that, with the exception of the Apollo 11 lunar landing in July 1969, public support for the Apollo program was weak. According to Launius, while the Apollo moon landing was popular, nonetheless, the majority of Americans believed that the government was spending too much on the spaceflight agenda (2003, p. 163). This means that there was no positive correlation between public support and space funding. The Apollo 11 received governmental funding simply because it was a matter of importance for American foreign policy (Logsdon, 2007).

Subsequent studies have suggested that public opinion fluctuates. For example, Steinberg (2011) suggests that public support after the Apollo program remained low. However, the advent of the Space Shuttle and a space station—another presidential initiative—brought space policy back into the American consciousness (Steinberg, 2011). Moreover, unlike the Apollo program, the space station had a “potential for business opportunities” involving private corporations (Steinberg, 2011, p. 242). As a result, the argument continues, NASA saw “renewed growth in its budget during the late 1980s” (Steinberg, 2011). Nonetheless, according to Steinberg, it is unclear if this was the result of positive public opinion or “yet another example of government action regardless of public opinion” (Steinberg, 2011). This contradictory evidence leads Steinberg to conclude that the various American administrations are giving the people

what they want. Namely, “more money each year but at the same time a smaller percentage of the federal budget” (Steinberg, 2011, p. 240). Indeed, this becomes evident when one takes into account that in 1966 NASA’s funding stood at 4.5% of the federal budget but today it is <0.5% (Heracleous et al., 2018).

Returning to the topic of public opinion, according to François Nadeau (2013), spending preferences for NASA are mostly free from religious, ideological, or political party affiliations.

Socio-economic demographics are said to be more accurate indicators. In particular, Nadeau argues that “white, male Baby-boomers with a higher socio-economic status, a fondness for organized science, and a post-secondary science education” are more likely to support governmental spending on space exploration” (2013, p. 158). Indeed, the argument that well-educated citizens support NASA funding has been reaffirmed repeatedly by various polls (Whitman, 2011).

By way of comparison Laura Delgado (2016), argues that the “inspiration approach”—or what she calls the “Apollo myth”—is not resonating with the millennial generation. According to Delgado, what is needed for continuing political and public support is the successful communication of the so-called “pragmatic approach” that consists of demonstrating the multiplicity of benefits stemming from the space program. Or, to put it in her words:

Space activities have continued to flourish not because of a wider hold of inspirational words, but because of the concrete purposes they serve. It would be no exaggeration to say that US power and projected leadership rest on its adept use of space capabilities and systems. From the 1991 Gulf war, dubbed the first space war because space capabilities led the US military to victory, it is mind blowing just how much the use of space systems for every stage of military support has evolved. The list grows even more expansive when one considers the advantages secured through satellite platforms in the commercial and civil sectors...To ask the value of space seems unnecessary, yet we still do” (2016, p. 192).

In the following section we will come to see that this so-called “pragmatic approach” has ancient antecedents.

Ancient Greek astronomers and popular prejudice: the case of Thales of Miletus

Plato describes proto-philosophy—also known as Natural philosophy—as “that wisdom which people call the inquiry regarding nature” (*Phaedo* 96a6–8). Natural philosophers—also known as Pre-Socratics in reference to Socrates who turned away from the study of nature and towards the philosophic study of human affairs—include: Anaximander, Pythagoras of Samos, Empidocles of Agrigentum, Heraclitus of Ephesus, Parmenides of Elea, Xenophanes of Colophon, Zeno of Elea, and Anaxoras of Clazomenae among others (Rowett, 2004). These men were the precursors to contemporary astronomers and physicists.

According to Aristotle the founder of natural philosophy was Thales of Miletus (*Metaphysics*, 983 b21–22). Unlike the Babylonian priests who studied the celestial bodies for the purpose of astrology, Thales looked to the heavens for scientific knowledge (Pigliucci, 2010, p. 63).

Thales of Miletus was also known for his depiction as the astronomer who fell into a well while studying the celestial bodies. That story is found in various sources but our purpose only two will be discussed: Plato’s dialog *Theaetetus* (ca. 369 BC) and Aesop’s fable. In Plato’s *Theaetetus* one reads: “...take the case of Thales...While he was studying the stars and looking upwards, he fell into a pit...” (174b). An older version of the same story is

found in Aesop, but in that story the astronomer is anonymous. The fable in question, similar to other Aesopian fables, is pithy. It reads: “The Astrologer falls into a well while walking about and gazing at the stars. He could see what was in the heavens, but not what was on the earth (Aesop Perry, 1965, p. 428, 40).³

Leaving aside Aesop’s less-than-flattering depiction of the astronomer, most scholars now believe that Aesop was a legendary figure and his fables the creation of the populace (Gibbs, 2002). This point cannot be overemphasized because it would corroborate the argument that the ancient general populace did not hold astronomers in high esteem. For example, in the specific case of Thales of Miletus, Aristotle tells us that his fellow Meletians were pressuring Thales to demonstrate the practical relevance of his astronomical knowledge.

Interestingly, the popular image of star-gazing astronomers accidentally falling into water wells is disputed by Patricia O’Grady (2002). This scholar argues instead that water wells were used by ancient astronomers as telescopes. She writes:

The ancient sources yield a number of references to the observation of heavenly bodies from cisterns and wells (φρεαρ, tank, well, cistern). Aristotle said that viewing through a tube ‘enables one to see further’ (Gen. An. 780 b19-21); Cleomedes said that when viewed from a deep cistern, the sun ‘appears larger’; and Herschel is quoted (by Humboldt, *Cosmos*, 73, n. 21), as stating that ‘when observed at night, through deep shafts, the sky appeared quite near, and the stars larger’. When I viewed individual stars through a tube, each one appeared to be brighter, but not larger or closer. Pliny (HN, 2.11) wrote thus: “The sun’s radiance makes the fixed stars invisible in daytime, although they are shining as much as in the night, which becomes manifest at a solar eclipse and also when the star is reflected in a very deep well”. Galen, *De Usu Partium* X 3, vol. 3, pp. 776–777; Karl Gottlob Kuehn, ed. *Medicorum Graecorum Opera*. Lewis, *Astronomy of the Ancients*, 248, remarks that ‘the stars can be observed from deep wells, especially when the sun is not standing at midday’ (O’Grady, 2002, p. 175, no. 164).

In specific reference to Thales of Miletus, O’Grady argues that the idea of Thales “stumbling around at night on unfamiliar ground” is entirely unconvincing. “Observation of the heavenly bodies” she contends,

would be a planned activity, with the most suitable sites being known in advance. From the chosen well or cistern, the astronomer could observe the movement of stars in relation to other stars and relative to the dome above, all this being more accurately perceived from a stationery position, with the edges of the well providing markers as an aid to observation of motion. Descending into a well, and peering up the extent of the well, would isolate areas to be observed, and the rim of the well, being similar to the tube about which Aristotle wrote, would be a sort of ‘telescope’, but lacking magnification.... If Thales knew that stars could be viewed to greater advantage from wells, either during day or night, one could expect that he would have descended a well to test the theory, or perhaps for his own enlightenment....

“It is my opinion”, O’Grady continues, “Thales is unlikely to have fallen into a well, which would probably be kept covered, both for the safety of animals and people, and to keep the water clean, but perhaps he fell or tripped as he was getting in or out of a well, and that the story grew up around a mishap” (O’Grady, 2002, p. 175, no. 164).

O’Grady’s hypothesis could also help explain a passage in Aristophanes’ comedy the *Clouds*. The passage under question occurs when the protagonist, a rustic Athenian by the name of Strepsiades, visits Socrates’ school and is given an ‘open house’ tour. During this tour Strepsiades inquires about some students who are looking down a deep pit—a passage that appears to support the hypothesis that the ancient astronomers examined the sky with the help of water wells. It reads as follows:

Strepsiades: “And these [students] here, what are they doing all bent over?”

Pupil: “They’re scrutinizing the murkiness (*erevodifōsin*) below Tartarus [deep abyss]”

Strepsiades: “Then why the arsehole (*prōktos*) peering (*vlepei*) at the sky?”

Pupil: “Learning astronomy on its own” (pp. 191–194).

While the political philosopher Alexander Nehamas is of the mind that this specific passage is in reference to geology (1999, p. 86), I would argue that this passage is in reference to astronomy. More recently, other scholars have been corroborating O’Grady’s hypothesis that ancient astronomers studied celestial bodies with the help of water wells. For instance, classical historians point to the doxographic tradition⁴ and assert that we now have evidence that Thales of Miletus realized that the moon was responsible for blocking the sun’s light after observing an eclipse in a dish and seeing the moon’s disc occlude the sun (Stobaeus *Eclogae* 1.25, 209–10 Wachsmuth as cited in Thibodeau, 2017).

Does this mean that Aesop and Plato were ignorant of how astronomers conducted research and as a result presented an erroneous view? In the case of Aesop’s fable I would urge suspension of judgment. In addition to providing entertainment, Aesopic fables were meant to convey moral or political messages; however, this fable is too short and ambiguous to draw any further inference.

Plato’s *Theaetetus*, Thales of Miletus and Philosophical Naturalism. Unlike Aesop’s fable, in Plato’s *Theaetetus* the anonymous astronomer is given a name—Thales of Miletus (Plato, 1921). For those not familiar with this work, the main focus is the concept of knowledge and the main interlocutors are Socrates, a young Theaetetus (a historical figure who would go on to become a well-known geometer in ancient Athens) and his mathematics teacher, Theodorus (Giannopoulou, 2013). Within the context of Socrates’ argument that the true philosopher is not interested in the everyday aspects of a society, the following dialog takes place:

Socrates: “...it is only his body [philosopher] that has its place and home in the city; his mind, considering all these things petty and of no account, disdains them and is borne in all directions, as Pindar says, “both below the earth”, and measuring the surface of the earth, and “above the sky”, studying the stars, and investigating the universal nature of everything that is, each in its entirety, never lowering itself to anything close at hand.

Theodorus: What do you mean by this, Socrates?

Socrates: Why, take the case of Thales, Theodorus. While he was studying the stars (*astronomounta*) and looking upwards, he fell into a pit (*frear*), and a neat, witty Thracian servant girl jeered at him, they say, because he was so eager (*prothimoito*) to know the things in the sky that he could not see what was there before him at his very feet. The same

jest applies to all who pass their lives in philosophy (pp. 173–174).

According to the above, astronomers are so preoccupied with abstract thought that they look ridiculous in the eyes of the common people in their ignorance of the legal and political aspects of their society.⁵

Another ancient figure who was motivated by intellectual curiosity but was dangerously ignorant of his political surroundings was the Greek scientist Archimedes of Syracuse (287 BC–212 BC). Archimedes was the son of an astronomer and he appears to have been interested in astronomy as well (Heath, 2002). According to the ancient historian Plutarch, Archimedes became so absorbed with a geometrical problem that he was oblivious to the fall of his town, Syracuse. When a soldier was sent to fetch him on the orders of the Roman General Marcus Claudius Marcellus he dismissed him with his famous line “Do not disturb my circles!” (Heath, 2002). Unfortunately for Archimedes, the soldier did not take kindly to those instructions and killed him. That said, Plutarch provides another version whereby Archimedes was killed by looting Roman soldiers who mistook his astronomical instruments for gold (Heath, 2002). Nonetheless, both stories speak of a man failing to appreciate his political surroundings.

In more recent times, the same could not be said for Wernher von Braun. He entered the USA via Operation Paperclip, a secret government program that was originally known as the “Exploitation of German Specialists in Science and Technology in the United States”. The objective of Operation Paperclip was the recruitment of hundreds of German aeronautic scientists after the fall of the Third Reich. Many top rocket engineers who were previously working in the design of the V-2 rocket in Nazi Germany, such as Walter Dornberger, Konrad Dannenberg and Wernher von Braun among others, eventually thrived with NASA in what turned out to be a mutually beneficial relationship. For example, von Braun was the chief architect of the Saturn V launch vehicle, which helped propel Americans to the Moon and he eventually became the director of NASA’s Marshall Space Flight Center (NASA, 2017).⁶ Unlike Archimedes and Socrates, von Braun remained aware of the changing political environment and adapted accordingly. This not only enabled von Braun to escape personal injury, but permitted him to continue his groundbreaking work in space exploration.

Aristophanes’ *Clouds* and astronomy. A somewhat similar warning finds a more elaborate expression in Aristophanes’ *Clouds*. In this comedy Socrates’ *dramatis personae* is depicted as an astronomer. This might come as a surprise to many who are familiar with Socrates as a moral and political philosopher from the writings of Plato. However, this is not necessarily a contradiction—in all likelihood Aristophanes depicted a *younger* Socrates more interested in natural science (Strauss, 1966).

In Aristophanes’ *Clouds*, Socrates enters the theater stage overhead while being suspended in a basket in a scene that some have described as a neat anticipation of NASA’s mission of human space exploration. When asked to explain what he is doing Socrates explains: “I tread the air and scrutinize the sun” (*Clouds* 225). And when asked why he does not study the heavens from the ground, Socrates replies: “Why, for accurate discoveries about meteorological phenomena I had to suspend my mind, to commingle my rarefied thought with its kindred air. If I had been on the ground and from down there contemplated what’s up here, I would have made no discoveries at all: the earth, you see, simply must forcibly draw to itself the moisture of thought.” (*Clouds* 227–233).

It should be noted that the protagonist in Aristophanes’ *Clouds* is not Socrates but an older, uneducated peasant by the name of Strepsiades⁷ who visits Socrates’ school in order to learn a form of sophistic rhetoric. Burdened by debts, Strepsiades believes that he needs to learn how “to win any argument whether it’s right or wrong” (*Clouds* 95) so that he may defeat his creditors in the Athenian courts. Despite repeated attempts Strepsiades proves to be an inept student and in desperation sends his son to Socrates’ school instead who quickly masters the persuasive technique. Unfortunately for Strepsiades upon graduation his son beats him up and attempts to justify his actions by an argument conflating human nature with animal nature (*Clouds* 1428–1429).⁸ The play concludes with a horrified Strepsiades burning down Socrates’ school.

I would argue that the co-existence of astronomy and sophistry in Aristophanes’ *Clouds* is not accidental. When Strepsiades enters Socrates’ school he is introduced to natural science and exclaims: “...why do we marvel (*thaumazomen*) at the great Thales? Hurry and open up the School, and show me this Socrates as soon as possible. I yearn to learn!” (180–183). By so doing Aristophanes implies that astronomy is a prerequisite to learning reasoned argument (*logos*). Consequently, it is Strepsiades’ failure to understand astronomy that prevents him from proceeding to the next educational level—to learning (*mathēsetai*) reasoned arguments (*logoi*) (*Clouds* 886).

Of course an unintended consequences of that education was the articulation of an immoral relativism that proved to be corrosive to traditional values. Granted that a son beating his father is far-fetched we need to keep in mind that the genre of comedy works via hyperbole. Besides, at an earlier point in the comedy Socrates was explaining to Strepsiades that the various weather phenomena (thunder, lightning, rain) were not the works of gods but natural phenomena with scientific explanations. In other words, there is a danger of a domino effect whereby science might lead to atheism (especially in young men), and that atheism might lead to moral decay (e.g., sons beating their fathers).

This danger was well understood by the historical Socrates who actually mentioned Aristophanes’ *Clouds* as a serious obstacle to his trial. For example, in Plato’s *Apology* (18b-c) Socrates claims that his image as a “...wise (*sophos*) man, who searches into things under the earth and in heaven (*meteora*), and he makes the worse appear the better cause; and he teaches the aforesaid doctrines to others....[and] those who hear them think that men who investigate these matters do not even believe in gods” was hard to overcome. Indeed, Socrates’ official charges included corrupting the young and refusing to acknowledge the traditional Hellenic gods.

Of course Socrates was not the only philosopher to have been persecuted for impiety. The natural philosopher Anaxagoras of Clazomenae (ca. 428 BC) was persecuted because he claimed that the sun was a “mass of red-hot metal and therefore, not a divine celestial object” (Grant, 2004, p. 15). Likewise, Prodicus of Ceos (ca. 395 BC) was put to death by the Athenians on the charge of “corrupting their youth” (Anthon, 1841, p. 1130).

Thales of Miletus, money-making and Aristotle’s Politics. In the *Politics* Aristotle provides an apocryphal tale about Thales of Miletus that takes place within the context of Aristotle’s discussion of the money-making aspect of business (Aristotle, 1993). It reads as follows:

All these methods are serviceable for those who value wealth-getting, for example the plan of Thales of Miletus, which is a device for the business of getting wealth, but which, though it is attributed to him because of this wisdom, is really of universal application. Thales, so the

story goes, because of his poverty was taunted (*oneidizōtōn*) with the uselessness (*anophelous*) of philosophy; but from his knowledge of astronomy he had observed while it was still winter that there was going to be a large crop of olives, so he raised a small sum of money and paid round deposits for the whole of the olive-presses in Miletus and Chios, which he hired at a low rent as nobody was running him up; and when the season arrived, there was a sudden demand for a number of presses at the same time, and by letting them out on what terms he liked he realized a large sum of money, so proving (*epideichai*) that it is easy for philosophers to be rich if they choose, but this is not what they care about (*spoudazousin*). Thales then is reported to have thus displayed (*epideichin*) his wisdom (*Politics* I.1259a5-20).

Some contemporary scholars recognize in the above the earliest articulation of futures and options from the perspective of trading (Taleb, 2012). For our purpose, however, the focus here is on the public perception of astronomy as “useless”. In the case of Thales, the public perceived him as useless and mocked him as such. A mocking, one would add, that is not much different than the laughing Thracian maid that one encounters in Plato—insofar as she was a woman, a slave, and a barbarian she was the lowest denominator in ancient Greece. It is only when Thales manages to translate his scientific knowledge into *tangible benefits* that the public ceases their ridicule.

Conclusion

Borrowing Pelling’s and Wyke’s (2014) phrase “ancient ideas for modern times”, multiple similarities exist between ancient Greek astronomers and NASA. Similar to the ancient Milesians who were pressuring Thales of Miletus to demonstrate the practicality of his science, American administrations—Republican and Democrat alike—have been pressuring NASA to justify its existence in terms of tangible, practical benefits. Failure to demonstrate practical benefits, it is argued, risks adding to the “myth” of wasted taxpayer dollars. NASA, the argument goes, must prove how it ultimately benefits the American citizen.

Moreover, this challenge is unlikely to be resolved in its entirety; it can only be mitigated by continuous efforts. In the case of Thales of Miletus it meant applying his scientific knowledge in an entrepreneurial setting. In the case of NASA it has meant the publication of spinoff reports. These reports are still one of the easiest and most effective methods by which NASA can demonstrate its “usefulness” to the American public. Similar to Thales of Miletus who demonstrated direct financial rewards (and hence the cessation of disparaging remarks by the general public), NASA should quantify the benefits of the spinoff technologies—especially the creation of American jobs—using a coherent, standardized analytic framework.

At the risk of repetition, changing geopolitical landscapes and economic realities are having a huge impact on NASA’s funding levels. This is something that von Braun realized after the end of the WWII when he half-joking said that at Peenemünde, Germany his research team was financially “coddled”, while during his early years in the USA they were counting pennies” (Brzezinski, 2007, p. 87). The end of the Cold War led to decreased funding levels for NASA. As mentioned earlier, in 1966 NASA’s funding stood at 4.5% of the federal budget but today it is a meager <0.5% of the federal budget (Heracleous et al., 2018). To paraphrase von Braun, the United States are now “counting pennies” in regard to NASA’s budget.

NASA has adapted to the new reality by, among other things, the publication of spinoff reports. While future geopolitical

realities remain uncertain what remains certain is that, in the absence of any future conflicts (and by implication generous funding), NASA must continue the publication of spinoff reports.

Moreover, increased funding could also come from partnerships with the private sector or increased self-reliance. After all NASA is behind some of the most significant, contemporary technological advances and as a result has amassed a huge collection of patents. Yet in 2015 NASA opened up hundreds of patents to private investors for free under its Technology Transfer Program. Additionally, NASA waived any royalty fees for the first 3 years, while applying only a “standard net royalty fee” for the years thereafter (Fung, 2015). Besides, in terms of the ensuing “standard net royalty fees” the money goes first to the inventor and then to “maintaining the agency’s technology transfer activities and technology advancement”. (NASA, 2015). Needless to say this financial arrangement is disadvantageous to NASA. To begin, it is far too generous towards the private investors. Second—and assuming the collection of the net royalty fees is unproblematic—financial priority should be given to NASA and not to the inventors.

The best example (that I am aware) of substantial missed financial benefits for NASA is the blended winglet technology. Granted that the winglet—which diminishes induced drag by close to 20 percent on airplanes—was not part of the 2015 free patents, nonetheless this technology is now found in airplanes around the world and it is estimated that it has saved over two billion gallons of jet fuel with monetary savings totaling over four billion dollars (NASA, 2010). Yet, it was Boeing and not NASA that reaped the lion’s share of financial benefits.

One possible objection to this recommendation is that NASA should be focusing on pursuits leading to the improvement of humanity. This is something that is stated in the Outer Space Treaty which states that the exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all mankind” (United Nations, 1966). Similar sentiments are found in Section 102 (a) of the National Aeronautics and Space Act of 1958 which reads: “The Congress hereby declares that it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind” (NASA, 2004).

I would argue that this a case of false dichotomy: increasing economic output and serving humanity are not mutually exclusive options. Furthermore, this view is reminiscent of the most influential philosopher of the Western tradition, Plato—he was of the mind that those who pursue knowledge do not pursue money. However, we should not forget that Plato came from a wealthy family whose inheritance enabled him to engage in his passion, namely political philosophy, without having to worry where his next meal would come from. In an ideal world NASA would have unlimited resources, however since we live in a real world a more pragmatic framework is needed.

Policy recommendations

If one was pressed to offer policy recommendations on the basis of what has been examined so far, a number of proposals could be put forth. First, NASA should continue publishing of spinoff reports, but the same reports should be more detailed. Second, the marketing strategy of spinoff reports should be more effective and with a greater outreach. This should include quantifying the benefits of the spinoff technologies using a coherent, standardized analytic framework with an emphasis on the creation of American jobs. Third, NASA could negotiate better financial terms for its patents.

Received: 15 November 2019; Accepted: 12 August 2020;

Published online: 27 August 2020

Notes

- 1 For those unfamiliar with these terms, an empirical approach (also referred to as “positivist” in some fields) attempts to explain how the world works, whereas a normative theory is value-laden and attempts to explain how the world ought to work.
- 2 The insightful reader would have noticed the irony of this approach. For instance, it could be argued that “without government influence, the free market would probably have taken a very long time to develop space technology of any kind, if it ever did at all. So simply being in a position to extol the possible benefits of space exploration would seem to presuppose the existence of enough space technology to know what’s out there” (with thanks to the anonymous reviewer).
- 3 There is no *one* version of Aesop’s fables because a multiplicity of versions exist as a result of textual transmission spanning millennia. The fable quoted here is from one of the more reputable sources, namely, the Loeb Classical Library.
- 4 For non-classicists, the term ‘doxography’ encompasses “those writings, or parts of writings, in which the author presents philosophical views of some... ancient philosophers or schools...with or without presentation of the argumentation or analysis through which they offered philosophical support or reasons in favor of their ‘tenets’.... In other words, these are works... taking as their subject matter the tenets or doctrines of the philosophers, rather than independent works of philosophy in which the author addresses in the first instance issues or topics of philosophy, with ancillary discussion along the way of the opinions of other philosophers” (Mansfeld, 2016).
- 5 For those not familiar with Socrates’ biography, there is a subtext here that is worth mentioning. Socrates was put on trial for, among other things, politically motivated charges. Those charges, however, were not acknowledged during his trial and were related to Socrates’ friendship with Critias, a violent oligarch. When the Athenian democrats eventually ousted Critias they appear to have neither forgotten nor forgiven Socrates for his friendly association with the Thirty Tyrants despite the fact that he never partook in any of their illegal activities. Seen from the historical perspective of 4th BC century Athens, the utterance by Socrates that “...because he [philosopher] knows no evil of any man, never having cared for such things (*Theaetetus* 174)” takes on a new significance. Namely, Plato would have his readers draw comparisons: lack of awareness of the political world (political struggles between oligarchs and democrats in 4th century Athens) is every bit as dangerous as lack of awareness of the physical world (falling down a water well). In terms of the star-gazing astronomer who falls into water wells, the message is an esoteric one and it is meant to convey the pitfalls of philosophical naturalism. Whether the tale is an Aesopian, Aristophanic or Platonic one, it carries a political warning. Insofar as astronomy can undermine theism—especially in young people—it is a serious threat not only to society but also to the philosopher himself who lacks awareness of the potential dangers.
- 6 Some authors have portrayed von Braun as a Nazi villain who escaped the wheels of justice (Piszkiwicz, 1998). By contrast, other authors have portrayed him as a passion-driven scientist who struck a “Faustian bargain” with the Third Reich in order to get access to needed resources (Neufeld, 2007). Judging from, among other things, von Braun’s chastising of Herbert Axster (his fellow co-patriot from Operation Paperclip) and his wife, Isle Axster a known Nazi sympathizer who von Braun accused of falling prey to “dangerous political ideas” (Crim, 2018, p. 175), I would disagree with Piszkiwicz’s assessment.
- 7 This is the same figure that we encountered earlier on § 3.
- 8 Namely, if roosters and other non-human animals do not respect their fathers, why should sons respect their fathers?
- 9 Conflicts that make no use of space are actually a hindrance to NASA. For example, in 1967 President Johnson was forced by Congress to divert \$500 million from NASA in order to deal with the growing deficit of the Vietnam War (Kay, 2005, p. 98).

References

- Aesop P, Babrius EB, Phaedrus (1965) Loeb Classical Library. Harvard University Press, Cambridge
- Anthon C (1841) A classical dictionary containing an account of the principal proper names mentioned in ancient authors and intended to elucidate all the important points connected with the geography, history, biography, mythology, and fine arts of the Greeks and Romans. Together with an account of coins, weights, and measures, with tabular values of the same. Harper & Bros, New York
- Aristotle (1993) *The Politics* (trans: Rackham H). W. Heinemann, London
- Brzezinski M (2007) Red Moon rising: Sputnik and the hidden rivalries that ignited the space age. Times Book, New York
- Bury H (2013) Eisenhower and the military-industrial complex: ‘Open Skies’ and the Cold War arms race. I.B. Tauris, London
- Clark S (2014) NASA would get funding hike under congressional budgets. *Spaceflight Now*. <http://spaceflightnow.com/news/n1406/05appropriation/#.VXJEoSzBjJo>. Accessed 7 Dec 2019
- Crim B (2018) *Our Germans: project paperclip and the national security state*. Johns Hopkins University Press, Baltimore
- Dance A (2012) NASA scientists fight budget cuts with cupcakes: planetary researchers bake cakes and shine shoes to raise awareness of declining budget. *Nature*. <http://www.nature.com/news/nasa-scientists-fight-budget-cuts-with-cupcakes-1.10805>. Accessed 7 Dec 2017
- DeGroot J (2009) The space race is a pointless waste of money. *Telegraph*. http://www.telegraph.co.uk/comment/personal-view/4807506/The-space-race-is-a-pointless-waste-of-money.html#disqus_thread. Accessed 15 Jan 2019
- Delgado ML (2016) When inspiration fails to inspire: a change of strategy for the US space program. *Space Policy* 37:190–194. <https://doi.org/10.1016/j.spacepol.2016.11.007>
- Fung B (2015) NASA is opening up hundreds of patents to investors, for free. *The Washington Post*. https://www.washingtonpost.com/news/the-switch/wp/2015/10/07/nasais-opening-up-hundreds-of-patents-to-investors-for-free/?utm_term=.07464ef8eef1. Accessed 15 Jan 2019
- Giannopoulos Z (2013) *Plato’s Theaetetus as a second apology*. Oxford University Press, Oxford
- Gibbs (2002) Aesop’s fables. Oxford University Press, Oxford
- Grant E (2004) *Science and religion, 400 B.C. to A.D. 1550: from Aristotle to Copernicus*. Greenwood Press, Westport
- Heath T (2002) *The works of Archimedes*. Dover Publications, New York
- Heracleous L, Douglas T, Gonzalez S (2018) The reinvention of NASA. *Harvard Bus Rev*. <https://hbr.org/2018/04/the-reinvention-of-nasa>
- Hudgins E (n.d.) Time to Privatize NASA CATO Institute. <https://www.cato.org/publications/commentary/time-privatize-nasa>. Accessed 22 Dec 2018
- Kay W (2005) *Defining Nasa: the historical debate over the Agency’s Mission*. State University of New York Press, Albany
- Logsdon J (2007) Space in the post-cold war environment. In: Dick S, Launius RD (eds) *Societal impact of spaceflight*. NASA History Division, Office of External Relation, Washington, pp. 90–102
- Mansfeld J (2016) Doxography of ancient philosophy. *Stanford Encycl Philos*. <https://plato.stanford.edu/entries/doxography-ancient/>. Accessed 15 Jan 2019
- Mieczkowski Y (2013) Eisenhower’s Sputnik moment: the race for space and world prestige. Cornell University Press, Ithaca
- Nadeau F (2013) Explaining public support for space exploration funding in America: a multivariate analysis. *Acta Astronaut* 86:158–166. <https://doi.org/10.1016/j.actaastro.2013.01.004>
- NASA (2004) *National Aeronautics and Space Act of 1958 (Unamended)*. <https://history.nasa.gov/spaceact.html>. Accessed 15 Jan 2020
- NASA (2010) https://spinoff.nasa.gov/Spinoff2010/t_5.html. Accessed 15 Jan 2020
- NASA (2012) Office of the Chief Technologist. https://www.nasa.gov/offices/oct/communications/about_comm_mission.html. Accessed 14 May 2019
- NASA (2015) NASA Technology Transfer Program: bringing NASA Technology Down to Earth. <https://technology.nasa.gov/startup>. Accessed 15 May 2019
- NASA (2017) NASA spinoff: technology transfer program. <https://spinoff.nasa.gov/>. Accessed 14 May 2019
- NASA (2018) Jet Propulsion Laboratory. <https://www.jpl.nasa.gov/about/>. Accessed 15 May 2019
- Nehamas A (1999) *Virtues of authenticity: essays on Plato and Socrates*. Princeton University Press, Princeton
- Nelson LP, Walter B (2018) *Space capitalism: how humans will colonize planets, Moons and asteroids*. Palgrave studies in classical liberalism. Palgrave Macmillan, New York
- Neufeld JM (2007) *Von Braun: dreamer of space, engineer of war*. A.A. Knopf, New York
- O’Grady P (2002) *Thales of Miletus: the beginnings of western science and philosophy*. Ashgate, Aldershot
- Panagiotarakou E (2019) Agonal conflict and space exploration. In: Milligan T, Schwartz J (eds) *The ethics of space: exploration, colonization and justification*. Springer International Publishing, London, pp. 47–60
- Pelling C, Wyke M (2014) *Twelve Voices from Greece and Rome: Ancient Ideas for Modern Times*. Oxford University Press, Oxford
- Pigliucci M (2010) *Nonsense on stilts: how to tell science from bunk*. University of Chicago Press, Chicago
- Piszkiwicz D (1998) *Wernher Von Braun: the man who sold the Moon*. Praeger, Westport
- Plato (1921) *Phaedo* (trans: Fowler HN, Lamb WRM & Shorey P). Loeb Classical Library, William Heinemann, London
- Rowett C (2004) *Presocratic philosophy: a very short introduction*. Oxford University Press, Oxford
- Shammas LV, Hohen BT (2019) One giant leap for capitalist kind: private enterprise in outer space. *Palgrave Commun* 5(10). <https://doi.org/10.1057/s41599-019-0218-9>

- Steinberg A (2011) Space policy responsiveness: the relationship between public opinion and NASA funding. *Space Policy* 27:240–246. <https://doi.org/10.1016/j.spacepol.2011.07.003>
- Strauss L (1966) *Socrates and Aristophanes*. University of Chicago Press, Chicago
- Taleb NN (2012) *Antifragile: things that gain from disorder*. Random House, New York
- Thibodeau P (2017) Anaximander's Spartan Sundial. *Class Q* 374–379. <https://doi.org/10.1017/S0009838817000507>
- United Nations (1966) Outer Space Treaty, RES 2222 (XXI). <https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html>. Accessed 28 Jun 2020
- Whitman C (2011) Who's supporting space activities? An 'issue public' for US space policy. *Space Policy* 27(4): 234–239. <https://doi.org/10.1016/j.spacepol.2011.09.007>

Acknowledgements

With thanks to Anthony Milligan, James Schwartz, Demetra-Amalia Kargakos, Richard Baron, Maia Gemmill, Lori Kent, Luke Trusso, Horst Hutter, Francine Prevost, Emanuel Lowi, and CUPFA for the financial support.

Competing interests

The author declares no competing interests.

Additional information

Correspondence and requests for materials should be addressed to E.P.

Reprints and permission information is available at <http://www.nature.com/reprints>

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/>.

© The Author(s) 2020