A Brief Note on the Economic History of Space Exploration in America

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For the majority of its history, space exploration in America has been funded privately. The trend of wealthy individuals, such as Paul Allen, Jeff Bezos, Robert Bigelow, and Elon Musk, devoting some of their resources to the exploration of space is not an emerging one, it is the long-run, dominant trend which is now *re*-emerging. This note provides a brief synopsis of the evidence and argument for these statements.

For hundreds of years prior to the Space Age, we explored space through the telescopes of ground-based astronomical observatories. If we consider discoveries made through observations by robotic spacecraft to be space exploration, then we should consider discoveries made through ground-based astronomical observatories to be space exploration as well. In both cases the experience of the human observer is fundamentally the same – that of having vision extended into space through advanced technology. By using a consistent metric to compare the cost of that technology, whether spacecraft or telescope, we can examine the economic history of space exploration in America as a continuum extending from the mid-19th century to the present day and identity long-run trends in funding.

There are a number of ways to convert historical costs into present day equivalent values. The most commonly used method is adjustment for inflation. This method calculates current equivalent values of historical costs according to the change in the price of basic consumer goods, like bread and clothing, over the intervening time. If we are interested in the share of total resources that a given project of space exploration represents, however, we need to adjust according to the change in the size of the American economy. To do this, we take the then-year expenditure of a given project and divide it by the estimated Gross Domestic Product (GDP) of the U.S. economy for that year. To convert this ratio into an equivalent present day value, the percentage is multiplied by the current GDP. The result is the equivalent GDP ratio value of space exploration expenditures, and if we are interested in how the American economy has allocated its resources towards space exploration over time, this is the appropriate metric to examine.

Project	Year	Cost	2008 GDP Ratio Equivalent Value
University of North Carolina Observatory	**1831**	**$6,430**[1]	**$89,000,000**
Williams College Observatory	**1836**	**$6,100**[2]	**$60,000,000**
West Point Academy Observatory	1842	$5,000[3]	$45,000,000
U.S. Naval Observatory	1842	$25,000[4]	$225,000,000
Cincinnati Observatory	**1843**	**$16,000**[5]	**$149,000,000**
Harvard College Observatory	**1843**	**$25,000**[6]	**$233,000,000**
-Edward Phillips Endowment	**1848**	**$100,000**[7]	**$601,000,000**
Georgetown Observatory	**1844**	**$18,000**[8]	**$154,000,000**
Detroit Observatory	**1852**	**$17,000**[9]	**$81,000,000**
Shattuck Observatory	**1852**	**$11,000**[10]	**$52,000,000**
Hamilton College Observatory	**1852**	**$15,000**[11]	**$71,000,000**
Dudley Observatory	**1852**	**$119,000**[12]	**$566,000,000**
Dearborn Observatory	**1865**	**$25,000**[13]	**$37,000,000**
Transit of Venus Expedition	1872	$177,000[14]	$310,000,000
Lick Observatory	**1876**	**$700,000**[15]	**$1,220,000,000**
Warner Observatory	**1880**	**$100,000**[16]	**$139,000,000**
Transit of Venus Expedition	1882	$85,000[17]	$101,000,000
McCormick Observatory	**1881**	**$135,000**[18]	**$168,000,000**
Yerkes Observatory	**1892**	**$500,000**[19]	**$441,000,000**
Mt. Wilson Observatory	**1910**	**$945,000**[20]	**$408,000,000**
Mt. Palomar Observatory	**1928**	**$6,550,000**[21]	**$972,000,000**
McDonald Observatory	**1939**	**$840,000**[22]	**$132,000,000**

Space Exploration Projects in the 19th and early 20th Century
(Source: MacDonald, A., *The Remote Space Age: An Economic History of Space Exploration from Galileo to Gagarin* forthcoming doctoral dissertation at the University of Oxford; conversions using GDP time series from Johnston, L.D., and Williamson, S.H., "The Annual Real and Nominal GDP for the United States, 1790 - Present" MeasuringWorth, 2008)

Examining the equivalent GDP ratio value of early American observatories makes it clear that space exploration has been funded at economically significant levels for over 150 years. The table above provides the 2008 GDP ratio equivalent values for a number of American observatories and space exploration projects in the 19th and early 20th centuries. Projects at relative scales equivalent to $100 million to $1 billion were relatively common. It is worth emphasizing that the modern equivalent values calculated here should be taken only to indicate the order of magnitude of expenditure, given that other appropriate equivalent resource share values can be calculated; for example, rather than scaling the expenditure as a share of the total resources of the U.S. economy, the expenditure can be scaled as a share of the resources of the individuals who undertook the projects. James Lick was the richest man in California and the Lick Observatory expenditure represented 17.5% of his entire estate. The equivalent share of the wealth of the richest man in California today, Larry Ellison, is $3.9 billion dollars, approximately four times higher than the GDP equivalent share.

This alternate resource-share metric highlights the dominant role that private sources played in the funding of early American space exploration projects. The projects that were funded privately are shown in the table in bold. Although this is hardly a complete record of American observatories built during this time, most large observatories are included and, with the exception of the West Point Academy Observatory and the U.S. Naval Observatory, all were privately funded, discovery-focused observatories with large optical telescopes. Significantly, the motivations for the private funding of these observatories were principally non-market in nature. The primary source of funds was wealthy individuals who were either indulging a personal interest in astronomy, or who were interested in leaving to the world a personal legacy and monument. Examples of this type of patronage are the observatories built by Andrew Carnegie, James Lick, Leander McCormick, Charles Yerkes, and John Rockefeller's General Education Board. A second motivating force was the desire of urban communities for civic monuments and a way to explore the heavens. In the cities of Albany, Boston, Cincinnati and Detroit, significant observatories were built with funds raised through public subscription. Although there were numerous successful funding models for private observatories, in all cases, non-market motives, principally personal interest and desire for a monument, were the dominant factors.

As government sources of funding for astronomy increased in the mid-20th century, with the formation of NASA and the NSF, private funds for space exploration decreased; no significant, privately funded observatories were built in America between the McDonald Observatory in 1939 and the W.M. Keck Observatory in 1992. However, in much the same way that private individuals have recently shown an increased willingness to fund the development of human spaceflight technology, private funding is re-emerging as a significant source for astronomical observatories; the $200 million dollar commitment from the Gordon and Betty Moore Foundation for the 30-Meter Telescope being one example.

Two significant observations can be drawn from the calculations above. First, even before the mid-twentieth century, space exploration projects of comparative relative magnitude to small-to-mid-sized robotic spacecraft were relatively common. Second, for most of its history, space exploration in America has been principally funded by private sources. The re-emergence of this trend, in both astronomy and space exploration more generally, may be robust and long-lasting. Plans for the development of space exploration infrastructure should consider that economically significant space exploration projects undertaken by private entities for non-market, as well as for-profit reasons, may become a relatively common phenomenon in the near future.

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