**Unveiling the Trends: Effects of Privatization on Space Missions**

**Introduction:**

The exploration of space has long been an endeavor pursued by governments worldwide, representing a symbol of human curiosity, ambition, and technological prowess. Historically dominated by government space agencies, space missions have recently witnessed a significant shift with the emergence of private space companies. The rise of privatization in the space industry has opened new possibilities, challenges, and debates surrounding the future of space exploration.

Privatization in the space sector refers to the increasing involvement of privately owned companies in the development, funding, and execution of space missions. While government space agencies like NASA (National Aeronautics and Space Administration) and ESA (European Space Agency) have been the traditional pioneers of space exploration, private companies like SpaceX, Blue Origin, and Virgin Galactic have emerged as formidable players, driven by entrepreneurs with ambitious visions for the cosmos.

This shift towards privatization has triggered widespread discussions on the potential implications it may have on space missions worldwide. Supporters of this argue that private companies bring innovative approaches, efficiency, and cost-effectiveness, potentially accelerating space exploration and opening opportunities for commercial ventures beyond Earth.

As we navigate the ever-evolving landscape of space exploration, it becomes a priority to analyze the influence of privatization on our understanding of the cosmos and its significance for future generations. This study aims to shed light on the complexities surrounding the interplay between public and private interests in space missions, ultimately contributing to a comprehensive understanding of the modern era of space exploration.

**Methodology:**

The datasets of the astronauts and the rockets is obtained from The Center for Strategic and International Studies. The details of the budget, success and reasons, different kinds of launch weights, etc. were obtained by mailing one of the most reputed organizations, NASA. All the data that I have acquired is public information, but not accessible without certain permissions. So, I have requested NASA to use this information for academic purposes which is granted immediately.

**Tables:**

1. **Space Missions Detailed** – This table contains detailed data on each of the space missions that ever happened. This includes details like Year, place of ascend, if the mission was a success or a failure, etc.
2. **Annual Space Visits** – This table shows us the total number of space visits that occurred in a particular year irrespective of the country responsible for its success.
3. **Budgets** – This is the table with the overall budget information. It has been divided into years and it shows the overall spending in that year throughout the world.
4. **Launch Pads** – The data on all the launch pads available in the world (Functional and Non-functional) is given in this table. This table also covers information like Headquarters, Orbit Altitude, Launch Class, etc.
5. **Astronauts** – This is a details-oriented table on all the astronauts that have ever been to space. This includes pilots, engineers, tourists, etc. The number of missions each member is a part of is also included in this table.
6. **Total Space Launches** – This table has the total number of missions that occurred in a particular year. This includes the space visits and each launch that has ever taken place for any reason.
7. **Cost of Space Launches** – This is a table detailing the cost that has been incurred per kilogram to send to space over the years divided into weight classes.
8. **Space objects by orbits** – This shows the number of objects/remains in orbits over years. This includes entities like debris, rocket bodies, etc.

**Sources:**

1. Center for Strategic and International Studies.
2. NASA.
3. Data World
4. The Planetary Society

**References:**

1. <https://data.world/datasets/astronaut/>
2. <https://data.nasa.gov/>
3. <https://aerospace.csis.org/data/>
4. <https://www.planetary.org/>

**Research Question:**

1. This is aimed to study 2 very prominent periods in time related to Space Exploration. The first private space launch took place in 2004. What is the overall success rate of space launches over the years, and how has it evolved over time?
2. How does the number of space launches vary with the allocated budget each year, and is there any correlation between the budget and the number of space launches?
3. Which countries have the highest number of astronauts participating in space missions?
4. Which countries have spaceports capable of launching space missions?

**Analysis**

I have used tableau, which is a very powerful visualization tool to represent all the data very effectively. I have used bar graphs, line graphs, multi-line graphs, Maps, Dashboards to compare the Ascend and Descend Shuttle, etc.

**Visualization – 1: Success Vs Failures by Year**

This is the graph indicating the number of successes and failures of overall missions that ever took place categorized via each year. We can see that the percentage of failure was high when space exploration first started. Slowly the rate of success kept increasing, but from 2004, the number of failed missions in comparison with the count of overall missions is very less. There are only a single number, usually 2-3 failed missions per year of about 58 missions that happened. The filter on the top right corner has 3 options. In is the period when private sector did not enter the market of space exploration, i.e., before 2004. Out is the period after private companies took a considerable position in the market, i.e., beginning from 2004.

A green and red graph

Description automatically generated

**Visualization – 2: Total Space launches vs Budget by Year**

This visualization shows us the number of space launches that took place each year. We can see there is a very little increase in the number of missions happening each year from 1960 to 2003. From 2004, The number of missions per year kept increasing and started shooting up tremendously from 2016. The number kept multiplying and this trend is only going to continue soon.

Also, we can see that privatization has developed efficiency. This conclusion can be drawn if we look at the graph. The budget release in the years 2004 and 2022 are similar, but there is a huge increase in the number of missions that were possible in the same budget. The filter on the top right corner has 3 options. In is the period when private sector did not enter the market of space exploration, i.e., before 2004. Out is the period after private companies took a considerable position in the market, i.e., beginning from 2004.

A graph with orange and blue lines

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**Visualization – 3: Number of objects in space**

This is a visualization, using an area graph showing us the number of different kinds of objects in space. We know that once a rocket is launched, it goes through multiple stages of separation and those separated parts stay in space forever. If we analyze the graph, we can clearly see that the number of entities in space is growing year by year as the number of space launches are increasing year by year. But, if we observe the number of rocket bodies in space, it is not increasing at the same rate as others. This is because of the technique of reusable rockets that is put in motion by a private company named SpaceX.

The filter on the top right corner has 3 options. In is the period when private sector did not enter the market of space exploration, i.e., before 2004. Out is the period after private companies took a considerable position in the market, i.e., beginning from 2004.

A graph of a graph

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**Visualization – 4 & 5: Ascend Shuttles & Descend Shuttles**

These graphs show us the number of times a specific shuttle has been used to fly astronauts or satellites to space (Ascend) and number of times shuttle has been used to transport astronauts to earth from space (Descend). We can clearly see that a different kind of shuttle has been used since 2004. STS-42 is the shuttle most used for both ascend and descend before 2004. But after 2004, STS-131 is the most frequent shuttle that is being used because of its economic advantage over its competitors.

The filter on the top right corner has 3 options. In is the period when private sector did not enter the market of space exploration, i.e., before 2004. Out is the period after private companies took a considerable position in the market, i.e., beginning from 2004.

A graph with blue lines

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A graph of a bar chart

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**Visualization – 6: Average Cost of different Launch models**

We are using a multi-line graph, each line to represent a class of payload and their respective costs (per kilogram) that is spent by industry to send machinery or people to space. We can see a very distinct difference here in the graph before and after 2004. There is a clear decrease in the cost incurred per kg in each class of payload (Heavy, Medium, and Small).

The filter on the top right corner has 3 options. In is the period when private sector did not enter the market of space exploration, i.e., before 2004. Out is the period after private companies took a considerable position in the market, i.e., beginning from 2004.

A graph of different colored lines

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**Visualization – 7: Countries with Spaceports**

This graph shows a clear image of the countries which have launchpads in them. This graph also shows the headquarters of each region. Apart from the giants in the Industry, USA and Russia, only a few countries have the luxury of launching their own satellites/ rockets to space. A few European and Asian countries have been proactive in the recent years but most of Africa is still to do good in this sector.

If we hover on any specific country, we can see the Headquarters of that region too.

The filter on the top right corner has 3 options. In is the period when private sector did not enter the market of space exploration, i.e., before 2004. Out is the period after private companies took a considerable position in the market, i.e., beginning from 2004.

A map of the world

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**Visualization – 8: Average number of hours by astronauts in space**

This is a bar graph showing the average number of hours spent by astronauts in space over years. Clearly there has been an increase in the number of hours spent by astronauts since 2004. This is because of the increase in the number of space missions, better technical facilities that we are able to provide due to advancements in industry, etc.

The filter on the top right corner has 3 options. In is the period when private sector did not enter the market of space exploration, i.e., before 2004. Out is the period after private companies took a considerable position in the market, i.e., beginning from 2004.

A graph of a graph

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**Visualization – 9: Number of Astronauts by Nationality**

This is a simple bar graph, each bar indicating the number of astronauts that have been to space with that country as their origin. Clearly, USA and Russia/USSR are industry experts here as they have sent about 850 and 250 astronauts to space respectively and the next best is France with 18 astronauts.

A graph with blue lines

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**Visualization – 10: Number of Men & Women in space by Year**

This Visualization is the comparison of Men (represented in blue) vs Women (represented in pink) that have been to space by each year after starting the very first space missions in 1957. I have used a bar graph to clearly depict the differences and reversed the axis of one of the plots so that it will be easy for comparison. The filter on the top right corner has 3 options. In is the period when private sector did not enter the market of space exploration, i.e., before 2004. Out is the period after private companies took a considerable position in the market, i.e., beginning from 2004.

The scales of the graphs are kept common so that we can clearly analyze the sharp differences in the numbers. It is also to maintain the relativity between the data and to avoid portraying the wrong picture.

A graph of a graph

Description automatically generated

**Dashboard – 1: Ascend vs Descend Shuttle**

This is a dashboard where Ascend Shuttles and Descent Shuttles are put together separately, to compare the names and their frequency of use.

**A screenshot of a computer screen

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**Dashboard – 2: Budgets Vs Average Number of Hours spent in Space.**

This dashboard is designed to compare the budgets of the space missions over years with the number of hours humans spend in space. Evidently, we can see that even with higher spending, humans did not spend a lot of time in the initial days. But as time progressed, we developed efficient methods to stay for longer periods in space. Now, after privatization, we are also looking at the possibility of colonizing space and any other habitable planets with the technology we have. We are now going towards a phase where technology is going to be even more efficient in its ways of delivering success.

A graph of a number of hours

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**Conclusion:**

Overall impact of privatization is on the positive side of things as there has been a huge increase in number of launches, with almost the same budget, more visits, more reusability of rockets, a greater number of astronauts spending good amounts of time in space, etc. There is also an argument where there is an increased number of entities in space as privatization kept creeping into the industry.

**Other Research Questions:**

1. How did Privatization influence technological advancements?
2. How has privatization influenced the diversity and scope of space missions? Are private companies targeting different objectives than traditional space agencies?
3. What role does competition between private space companies play in fostering innovation and driving progress in the space industry?
4. How has the entry of private companies affected international collaborations in space exploration? Are there challenges in coordinating efforts between private entities and government agencies from different countries?
5. What are the risks and challenges associated with privatization in space missions, particularly in terms of safety, regulation, and space debris management?