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Artigo

Falling-Behind: India's space sector and Brazil's attempts to develop its own

Ficando para atrás? O setor espacial Indiano e as tentativas brasileiras

Quedando Atrás: El sector espacial de la India y los intentos de Brasil de desarrollar el suyo propio

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Resumen:
Este breve artículo cuestiona por qué la India ha logrado un desarrollo tan exitoso en el sector espacial. A partir de esta pregunta, se indaga: ¿Por qué Brasil no lo ha conseguido? Se observa que la India mantuvo una inversión sólida a largo plazo en su programa espacial, mientras que Brasil solo invirtió de manera volátil y no sistemática. El artículo utiliza el método comparativo, teniendo como principales parámetros de comparación el desempeño de la industria espacial en ambos países, medido en términos de inversión, etapas del desarrollo tecnológico y resultados. Con esto, se busca analizar cuáles son los factores que llevaron a la India a destacarse en el sector, a pesar de que Brasil también ha tenido grandes avances. Se observa que la India mantuvo una inversión sólida a largo plazo en su programa espacial, mientras que Brasil solo invirtió de manera volátil y no sistemática. Lograr el éxito de un proyecto a gran escala y a largo plazo requiere la priorización de este en un escenario en el que varios gobiernos e incluso regímenes cambiarán. La amenaza externa que siente la India sin duda es un impulsor del desarrollo. Brasil, con un entorno más tranquilo, no tiene este incentivo. Sin embargo, si aspira a proyectarse como un jugador clave y ser líder regional, no podrá dejar de seguir invirtiendo.
Palabras chave: Espacio; Defensa; India; Brasil; Inversión.

Abstract:
This brief article questions why India has achieved such successful development in the space sector. From this inquiry, the question arises: Why hasn't Brazil managed to do the same? The article employs a comparative method, using the performance of the space industry in both countries as the main parameters of comparison, measured in terms of investment, stages of technological development, and results. The aim is to analyze the factors that have led India to excel in the sector, even though Brazil has made significant progress. Achieving success in a large-scale, long-term project requires prioritizing it in a scenario where

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various governments and even regimes will change. It is observed that India maintained a solid long-term investment in its space program, while Brazil only invested in a volatile and unsystematic manner The external threat that India faces is certainly a driving force behind its development. Brazil, in a more peaceful region, does not have this motivator. However, if it aims to project itself as a key player and become a regional leader, it cannot afford to stop investing.
Key-words: *Space; Defense; India; Brazil; Investment.*

Resumo:
Este breve artigo questiona o porquê de a Índia lograr um desenvolvimento tão bem-sucedido no setor espacial. A partir desse questionamento indaga-se: Por que o Brasil não conseguiu fazer o mesmo? Vê-se que a Índia manteve um investimento sólido a longo prazo em seu programa espacial e o Brasil só investiu de maneira volátil e não esquemática. O artigo parte do método comparativo tendo como principais parâmetros de comparação o desempenho da indústria espacial, nos dois países, medidas em termos de investimento, etapas do desenvolvimento tecnológico e resultados. Objetiva-se, com isso, analisar quais os fatores que levaram a Índia a se destacar no setor, muito embora o Brasil tenha tido grandes avanços. Lograr o sucesso de um projeto de larga-escala e longo prazo requer a priorização deste em um cenário em que diversos governos e até regimes mudarão. A ameaça externa que a Índia sente com certeza é um propulsor do desenvolvimento. O Brasil, com uma vizinhança mais tranquila, não tem esse indutor. No entanto, se almeja se projetar como player e ser líder regional, não poderá ficar deixar de seguir investindo.
Palvras-Chave: *Espaço; Defesa; India; Brazil; Investimento.*

Introduction

This paper addresses the cases of India and Brazil and their respective space sectors. While India has a well-established and successful program with good prospects, Brazil has lagged, despite its historical investments in the field. The aim of this paper is to address the reasons for this difference. India was the fourth-largest military spender globally in 2023. At $83.6 billion, its military expenditure was 4.2% higher than in 2022. I argue here that sustained and long-term investment, priority management, and external threat factors put India's program ahead of the Brazilians. As a rule, military investment is closely tied to aerospace development and its objectives. Figures, particularly those related to investment, demonstrate priorities assumed by a country and have a clear impact on its Defense Industrial Base. It is important to state that while the main objective of the present paper is to analyze and compare investment in the space programs this does not mean that India is ahead in all defense sectors. It is *important to highlight too that this paper focuses mainly on comparisons among space programs with military ends*. That said, civil programs usually also have military objectives. Middle-range powers such as India, Turkey, and Brazil have special importance in a multipolar world in which alliances will become increasingly important. Nonetheless, this is mainly a defense economics paper. It is based on parameters for comparison put forward by Hartley (2011; 2019), such as those mentioned above. Transforming resources into a well-established program is the core issue. Thus, I address the problem from a mobilizing resources and personnel point of view. Certainly, tactical and strategic considerations will not be disregarded when needed. The comparative reconstruction of the history of both countries' space programs has the objective of determining causality among the variables highlighted, such as the country's initiatives and external threat impacts and the main object of this study: the causes of success of space programs in developing countries. The comparative method allows the researcher to infer causality among phenomena (Bennet; Elman, 2010; Elman 2008). However, a rigorous comparison is a challenge, due to fundamental historical differences.

1.Space Capabilities and Engagement

What are the main capabilities a state can maintain in space and how much do they cost? If considered just in terms of efficiency, going to the moon might not be a good choice. However, defense economics is also about power. Effectiveness and deterrence are more important than short-term expenditures. In order to illustrate space capabilities and their role in 2024, I present some of the main features of the U.S. Space Command:

> "The space force's record budget – including a 16% increase in RDT&E funding – and end strength to 9,400 personnel (up from around 8,600) reflect the growing importance of space to current and future DoD operations. The service's main procurement priority was to increase the number of annual launches to 15 from ten. The FY24 missions cover ten for the National Security Space Launch program, placing spacecraft in geostationary and medium orbit, and five launches for the Space Development Agency's Low Earth Orbit constellation. Key RDT&E programs include resilient missile warning and missile tracking, space-technology development and prototyping, and next-generation overhead persistent infrared satellites (IISS, 2024).

It is clear that RDT&E is the major investment which correlates with an increasing development of space forces. Missile warning and tracking, alongside satellites, are *sine qua non* conditions in the present scenario of great power competitions. Certainly, India does not yet compete with the United States. However, it´s development shows a fast pace, and its space program has been promising since the 1990s (Mistry, 1998). Innovation requires risk taking; nonetheless, it is the most solid way of turning the distribution of resources to your favor. Alliances are unstable, and a state must ultimately count on its own efforts (Santos, 2008)

2-The Case of India

The Indian space program was established on November 21, 1963, with the launch of Nike-Apache, an American sounding rocket from the shores of Themba near Thiruvananthapuram on the west coast of India (Vasant, 2009; Mistry, 2009). Since then, India's launch vehicles advanced through the SLV-3 and Augmented Satellite Launch Vehicle (ASLV) towards numerous accomplishments. India launched its first satellite from the Satish Dhawan Space Center in 1980. Since then, it has successfully developed launch vehicles, imaging and communications capabilities and other critical satellites. It has begun to develop counterspace capabilities. The country has several bureaus dedicated to the space domain both in the military and civil sectors, each with supporting policies. It does not have a comprehensive space force yet. The India Space Research Organization (ISRO) maintains the country's SLVs and spaceports. It is necessary to point out, however, that despite its successful space program, India is import dependent on most of its weapon systems (e.g., 40% in 2018). So, it is not unreasonable to state that India's space program evolved conjointly with its nuclear program, primarily taking into account the threats presented by its neighbors: China and Pakistan.

By 2020 India had two operational orbital launch vehicles, the Polar Satellite Launch Vehicle (PSLV) and the Geosynchronous Satellite Launch Vehicle (GSLV). Since 1980, there have been 67 total Indian launches from the Satish Dhawan Space Center. In 2017, India broke records launching 104 satellites with one PSLV.

The document entitled "Technology Perspective and Capability Roadmap" highlighted detailed investments for the second phase of the program and intended to play an "anti-satellite" role from ground & aerial problem". Regarding Mission Shakti, DRDO Chief Sthat Reddy stated that India was in the process of developing different ASAT (Anti-Satellite Weapons) technologies, including directed-energy weapons, lasers, and electromagnetic pulses. However, beyond these general statements and reports, the government of India has not publicized any details of these activities. India could use Nuclear Electromagnetic Pulse weapons for nuclear detonation and to disable satellites, although, as yet, there have been no public statements of intent to pursue such a program.

India's 2018 Technology Perspective Capability Roadmap also declared an interest in "detect, monitor, and jam enemy cellular receivers and satellite communication receivers, or an integrated system to "carry out jamming & spoofing of satellite-based positioning systems". In terms of cybercommunication, by 2019, the government of India had set up the Defence Cyber Agency, the DCA, that is intended to "control and coordinate joint cyber operations". Cyber deterrence against enemy satellites both in space and on their land-based systems is another option.

Indian lunar lander Chandrayaan-3 successfully touched down on the lunar surface on August 23, 2023, making India the fourth nation to successfully land on the moon and the first to land in the south pole region. At a time of heightened international competition, this accomplishment cannot be ignored. According to the CSIS "ISRO's space exploration program is part of a broad government strategy to realize the scientific, economic, and security benefits of space capabilities. India's space program is also seen as a pathway for attracting young Indians into high-technology fields and for ushering in a more technically advanced society" (CSIS, 2020). Communication satellites orbiting the Earth can improve connectivity among rural areas, navigation systems, mariners, and imagery satellites. India can also monitor Chinese developments in the area.

Since 2020, the Modi government has encouraged private-public partnerships in space explorations and has as its main objectives the first human spaceflight mission (Gaganyaan). The south pole region of the moon is believed to have frozen water that could be critical to support human life on the satellite. Other mineral stores, used in electronics, and helium, are capacities being explored. India's accomplishment cannot be understated since Russia failed to land on the South pole of the moon just months earlier.

India developed kinetic physical weapons after China's successful 2007 ASAT developments, calling it ~~the~~ Mission Shakti (strength in Hindi). "It suddenly reminded them that their diverse space assets were now at risk" (CSIS, 2020). While India still does not have the capabilities to co-orbit ASAT capabilities, it is developing the technical requirements with France to build an RPO (Rendezvous and Proximity Operations). Regarding Mission Shakti: On March 27 2019, India successfully launched a Prithvi Delivery Vehicle Mark-II (PDV MK-II) missile defense interceptor at one of its own satellites. Non-kinetic physical weapons are in the plans of the Indian administration, with a focus on electronic weapons, specifically miniaturization of EW elements as payloads on satellites.

3-The Case of Brazil

The main difference in success between Brazil and other nations in space exploration may lie in the historical context and political will that shaped Brazil's approach to long-term projects like a space program. Brazil has experienced periods characterized by volatile elite leadership, where investments in ambitious, long-term projects have fluctuated based on prevailing political ideologies.

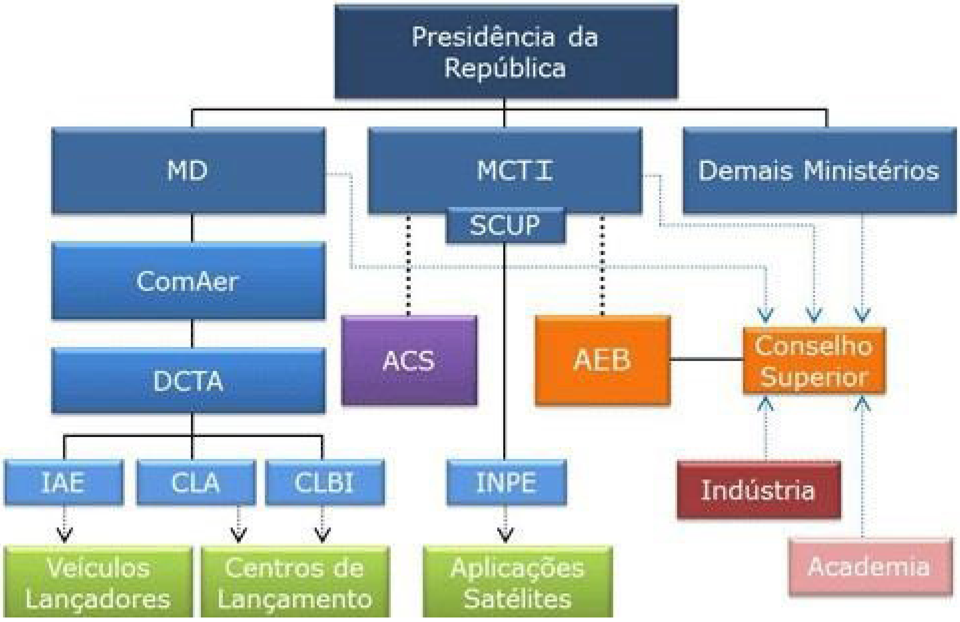
Building a robust space program requires sustained investment and consensus within the government to sponsor such endeavors. Historically, mercantilist views, which prioritize the accumulation of power and wealth even at the expense of short-term economic gains—have correlated with the high points of Brazil's space program. During liberal periods, however, Brazil's capabilities as a middle power aiming for industrialization and self-sufficiency have deteriorated.

After the 1930s revolution, Brazil's geopolitical position and policy direction leaned towards a mercantilist approach. Investments in defense were viewed as key to industrialization, growth, and the pursuit of national wealth and power (Mattos, 2021). This perspective was influenced by figures like Góes Monteiro, considered the "father of geopolitical thought in Brazil."

By the 1950s, Brazil had established the Instituto Tecnológico Aerospacial (ITA) in conjunction with the Centro Tecnológico Espacial (CTA) and the Instituto Militar de Engenharia (IME), recognizing the critical importance of research and development for an autonomous space program. During military governments, institutions for the Defense Industrial Base were created, aiming to reduce dependency through strategic industrial policies such as the PND I and PND II.

In the 1960s, Brazil continued to advance in the space sector with the construction of the Centro de Lançamento de Barreira do Inferno in Natal-RN. Brazil successfully launched four sounding rockets at sub-orbital levels, leading to the creation of the Missão Espacial Completa Brasileira (MECB), which aimed to develop national satellites and launch vehicles for launch from Brazilian soil.

Figure 1- The Brazilian Space Program



Source: Antunes, Erich Vieira. 2016, p. 72.

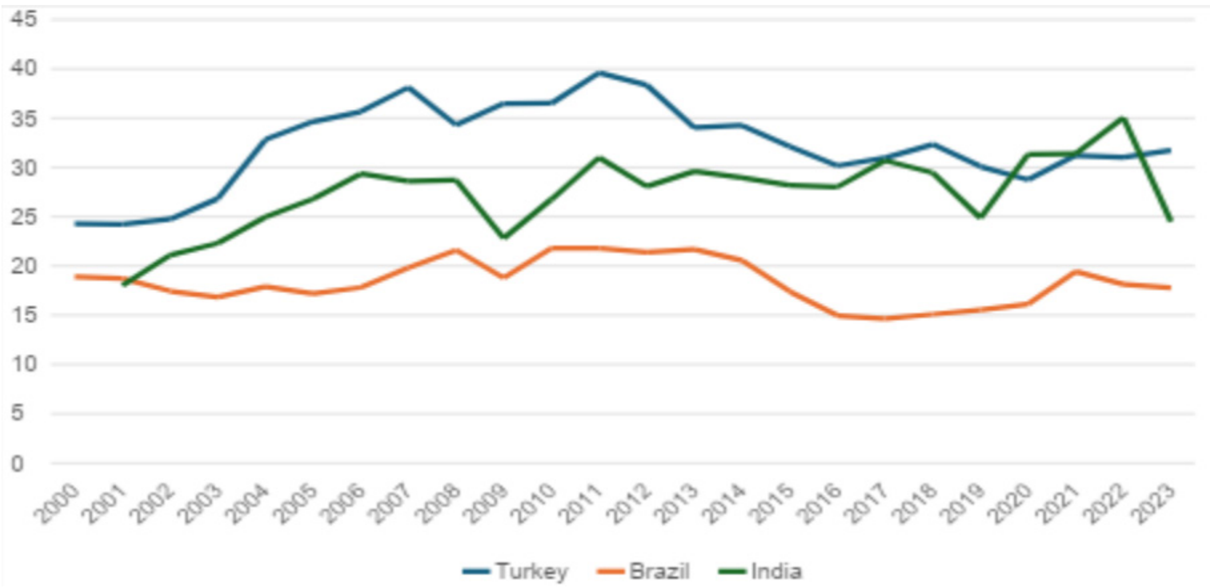
Brazil achieved success in constructing functioning satellites such as SCD-1, SCD-2, and SCD-3, launched from Cape Canaveral in collaboration with China's Taiyuan base. However, one of the notable setbacks to Brazil's space program was the failure to develop a functional space rocket capable of independently launching satellites. The VLS-1 project, initiated in 1984, aimed to achieve this autonomy but faced significant challenges, including mission failures in 1997 and 1999, and a tragic incident in 2003 resulting in the loss of lives.

After the 1990s, Brazil's space program faced significant changes. The country's democratization process led to a lack of consistency in addressing national defense issues, with civil society calling for limits to military power and political protagonism. Brazil renounced key capabilities under Fernando Henrique Cardoso's government, embracing a cosmopolitan, globalized, liberal worldview reflected in treaties banning missiles and nuclear weapons (NPT), for example. Budget cuts further impacted the ability of the space program-to procure necessary components for launching systems (Vieira, 2016).

In recent years, Brazil has faced resource constraints for investments in science and technology, opting for a secondary role in global space economy chains. This insertion model reflects a shift towards renouncing strategic autonomy, exemplified by the signing of the Technological Safeguards Agreement (AST) with the United States (BRASIL, 2024). These shifts highlight the challenges and transformations faced by Brazil's space program amidst evolving political and economic landscapes.

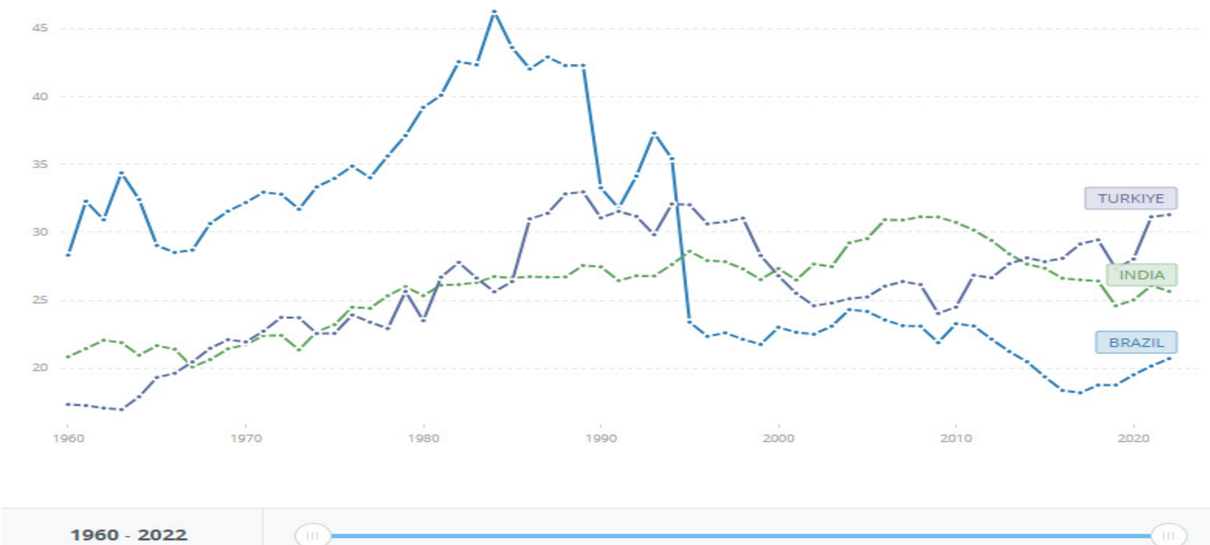
2 It was decided to leave the figure in Portuguese as it is a very specific government structure.

Graph 1- Investment as a share of the GDP %



Source: The Author. IRBD.

Graph 2- Industry Contribution to GDP%



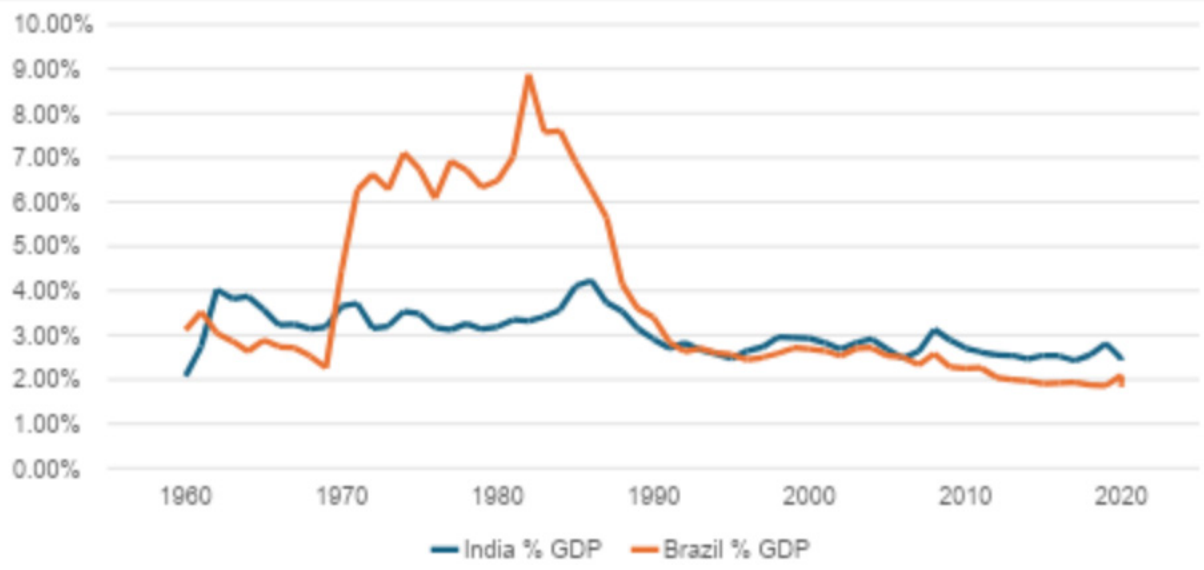
Source: IRBD. The Author

Investment is the fundamental variable, especially through a long-time span, or in the long term, to make a project successful. Space programs require investment, especially in the form of R&D. Governments can change, but a program such as the space program has to be funded and administered, or it will fade as was the case with Brazil. I added Turkey to the graph-to make a point: economists claim that industry downsizing in proportion to GDP is only natural because of productivity. But as illustrated in Graph 2, middle powers may not follow this rule. They are not developed countries with highly specialized and aggregated value services. Industry is still a path for development[3].

3 For a critical and normative analysis of the Brazilian space program, see: Ceballos, Durão, 2010.

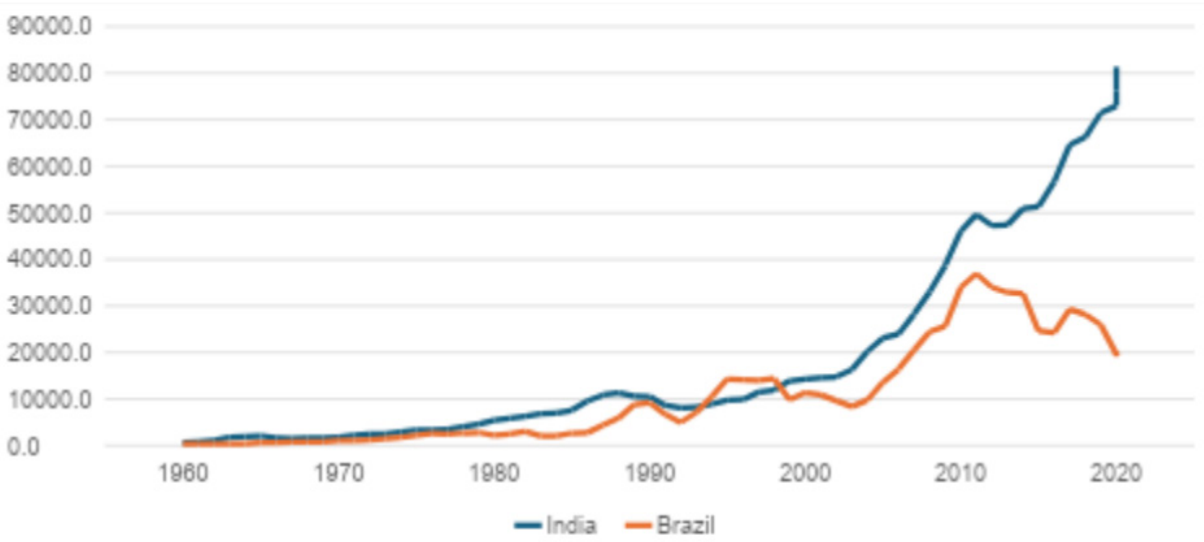
I include this graph not only to show the abrupt fall of Brazil's industry but also to reinforce that what economists propose as natural/ prevailing development – services representing more than industry in GDP – must be analyzed carefully. Medium powers, which are not leaders in cutting-edge technology service provision, can benefit significantly from industrial investment.

Graph 3- Military spending as a % of the GDP



Periods of high growth and investment when Brazil was the fastest growing country in the world led to rising military expenditures. But investment in large-scale projects must be solid, without interference from budget and administrative fluctuations. These projects have to be a state priority, regardless of who wins the election. Space programs are long-term investments, and the downsizing of resources will certainly affect them.

Graph 4- Defense Spending (U$ 2021 dollars)



Source: The Author. SIPRI

While Brazil clearly has a volatile defense budget, which may represent periods of doubt in terms of the discussion about the importance of the defense industry, especially since the levels of external threat are low, India has a steady ~~a~~ growing project to expand its influence and be a regional power. Space, space defense, shipbuilding and cybertechnology are India's strengths. However, Table 1 demonstrates that it needs R&D and development in a number of other technologies. The country already has the fourth highest military expenditure figure in the world and, facing Pakistan and China as possible enemies is the main motivator behind India's space program. However, some problems in the country's industrial base still remain ~~for India~~.

Table 1- Procurement (National and International) in India

Year	*Domestic source (current $ billion)*	*Import (current $ billion)*	*Total (current $ billion)*	*Share of domestic source (%)*	*Share of imports (%)*
2015–16	6.0	3.5	9.5	63	37
2016–17	6.2	4.1	10.3	61	39
2017–18	6.8	4.5	11.3	60	40

Source: Behera, 2019

India is highly dependent on arms imports which, from the point of view adopted here, is problematic considering its potential threat scenarios. To produce major components of all forces domestically, and innovate or emulate, however, would be a massive endeavor, one it seems that India's DRDO is already undertaking. It is interesting that in table 2, space industry requirements are considered, whereas that is not always the case with Brazilian investment in technologies.

Table 2- DRDO's Developed Systems (2017)

Systems	*Inducted* (current $ billion)*	*Under induction # (current $ billion)*
Missile Systems	3.6	11.2
Electronic and Radar Systems	2.0	3.2
Advanced Materials and Composites	0.7	0.3
Armament Systems	1.3	3.0
Aeronautical Systems	0.2	12.1
Combat Vehicles & Engineering Systems	0.8	1.8
Life Science Systems	0.1	0.0
Naval Systems	0.2	0.6
Micro Electronics Devices and Computational Systems	0.04	0.0
Total	8.9	32.2
Grand Total	41.1	

Source: Behera, 2019, p. 519

Table 2 shows that the top technologies for Indian investment are space-linked: Missiles, Radar Systems, and so on. India has chosen to specialize in some strategic areas. That seems to be their plan. Brazil has ~~a~~ relative success in the aerospace sector with Embraer and the São José dos Campos Cluster, although it is more civilian oriented.

Although the data collected is more general, highlighting investments and defense expenditures, for example, I argue here that they have a direct effect on the country's space programs, which are conducted by the Air Force with most of the investments by the public sector. Furthermore, there is a problem with data availability, especially when regarding past programs. This poses a limitation to this study, regarding both countries.

Concluding Remarks

Even if Brazil has an ambition of becoming a regional power *per se*, or a global player, fluctuations in budgets and priorities cannot happen in this way. Brazil's area of ~~possible~~ potential influence is large and has to count on building capabilities, because even if you are at peace, you prepare for war, and even if you don't want to develop new capabilities, it is a good reminder that they are relative and not absolute.

In this paper I have conducted a comparative analysis between the space programs of India and Brazil. Brazil has made some advances, although India is far ahead. Some of the explanations reside in steady investment and budget, alongside maintaining a strategy. Additional factors are the external threat to India by China and Pakistan and the immense volatility of Brazil's space program, both budgetary and administrative. Brazil's pursuit of a development program, emulating some aspects of India, would not be a bad idea. Nowadays there are startups and private companies operating in space, although the State remains the main actor. Partnerships should be sought cautiously, but not disregarded.

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