Pontifícia Universidade Católica
do Rio de Janeiro

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The perception of political risk in the Brazilian Space Industry: A probing exercise into the sectorial understanding of the geopolitical environment of the CBERS cooperation

DISSERTAÇÃO DE MESTRADO

Dissertation presented to the Programa de Pós-Graduação em Análise e Gestão de Políticas Internacionais da PUC-Rio, in partial fulfilment of the requirements for the degree of Mestre (Opção Profissional)

Advisor: Prof. Carlos Frederico de Souza Coelho

Rio de Janeiro
Novembro de 2023

Pontifícia Universidade Católica
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Ficha Catalográfica

Roland, Vinicius de Moraes

The perception of political risk in the Brazilian space industry : a probing exercise into the sectorial understanding of the geopolitical environment of the CBERS cooperation / Vinicius de Moraes Roland ; advisor: Carlos Frederico de Souza Coelho. – 2023.
51 f. : il. ; 30 cm

Dissertação (mestrado)–Pontifícia Universidade Católica do Rio de Janeiro, Instituto de Relações Internacionais, 2023.
Inclui bibliografia

1. Relações Internacionais – Teses. 2. Risco político. 3. China. 4. Nearshoring. 5. Friendshoring. 6. Indústria aeroespacial. I. Coelho, Carlos Frederico de Souza. II. Pontifícia Universidade Católica do Rio de Janeiro. Instituto de Relações Internacionais. III. Título.

CDD: 327

To my professors and instructors, for their commitment,
diligence and competence.

Acknowledgements

I would like to thank my family for the example and love. As soon, brother, partner and friend, my words could never describe my appreciation for every act of critical thinking, ethical diligence and kindness.

To my professors, advisors and instructors, for the guidance. Specially, I would like to thank for the opportunity to participate in the Barrometro da Política Externa Brasileira research, for it was a great opportunity to learn more about survey methodology, which proved to be paramount for the method of this article. Furthermore, I would like to thank professor Carlos Frederico Coelho for guiding me in this endeavor and Simone Rocha for her help building the literature review for this work.

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

Abstract

Roland, Vinicius de Moraes; Coelho, Carlos Frederico de Souza (Advisor). **The perception of political risk in the Brazilian space industry: a probing exercise into the sectorial understanding of the geopolitical environment of the CBERS cooperation.** Rio de Janeiro, 2023. 51f. Dissertação de Mestrado – Instituto de Relações Internacionais, Pontifícia Universidade Católica do Rio de Janeiro.

The expansion of satellites as a critical infrastructure for efforts to mitigate and reverse climate change, as well as the relevance of these space devices for expanding social connectivity, calls for the formation of stable supply chains capable of ensuring that the national industry has the conditions to succeed in developing projects in the satellite sector. What is more, Brazil can exploit its geopolitical position to link itself more effectively to global value chains in the aerospace sector. Given this context, the aim of this work is to understand the Brazilian aerospace sector's perspective on the possible political risks arising from the Sino-Brazilian cooperation on satellites (CBERS), in order to identify possible behaviors of the national industry in the face of future international conjunctures as well as to generate data that will contribute to publicizing the advantages of carrying out special projects with Brazil. The methodology used was the establishment of a survey with entrepreneurs and employees in the Brazilian aerospace industry and interviews with leaders in this sector. The results point to a risk environment characterized by uncertainty, although the discontinuation of cooperation is not seen as likely. The perceived impact of a possible end to the cooperation would affect notably the infrastructure of the Brazilian satellite industry, but would also possibly make new international partnerships in the North-South cooperation axis viable. This research is limited to analyzing the industry's perception of risk, refraining from a factual assessment of the real probability, impact and uncertainty of an end to the CBERS program. Also, this study was exploratory, working with a small sample of data, so the conclusions found here still need to be strengthened by further research

Key words

Political Risk; Aerospace; CBERS; China.

Resumo

Roland, Vinicius de Moraes; Coelho, Carlos Frederico de Souza (Orientador). **A percepção de risco politico na indústria aeroespacial brasileira: Um exercício exploratória sobre o entendimento do ambiente geopolítico da cooperação CBERS.** Rio de Janeiro, 2023. 51f. Dissertação de Mestrado – Instituto de Relações Internacionais, Pontifícia Universidade Católica do Rio de Janeiro.

A expansão dos satélites como infraestrutura crítica para esforços de mitigação e reversão de mudanças climáticas, assim como a relevância desses engenhos espaciais para a expansão da conectividade social, impele a formação de cadeias de suprimentos estáveis capazes de assegurar a indústria nacional as condições de sucesso no desenvolvimento de projetos no setor de satélites. Mais ainda, o Brasil pode explorar sua posição geopolítica para ligar-se de forma mais proveitosa às cadeias globais de valor do setor aeroespacial. Diante desse contexto, o objetivo deste trabalho é entender a perspectiva do setor aeroespacial brasileiro face aos eventuais riscos políticos advindos da cooperação Sino-Brasileira em matéria de satélites (CBERS). Visa-se, dessa forma, identificar possíveis comportamentos da indústria nacional diante de futuras conjunturas internacionais assim como gerar dados que contribuam para a divulgação das vantagens de realizar projetos espaciais com o Brasil. A metodologia utilizada foi a elaboração de uma sondagem por meio de formulário com empresários e funcionários da indústria aeroespacial brasileira, além de entrevistas com lideranças desse setor. Os resultados encontrados apontam que a percepção do ambiente de riscos da cooperação é marcada por incerteza, embora a descontinuação do projeto CBERS não seja vista como provável. O impacto percebido pela indústria é de que um eventual fim da cooperação afetaria principalmente a infraestrutura da indústria de satélites brasileira negativamente, mas também possivelmente viabilizaria novas parcerias internacionais no eixo de cooperação Norte-Sul. A presente pesquisa limita-se a analisar a percepção de risco do setor, abstendo-se de uma avaliação factual sobre a real probabilidade, impacto e incerteza de um fim do programa CBERS. Também, o presente estudo foi feito de forma exploratória com pequena amostra de dados, por isso as conclusões aqui encontradas ainda precisam ser fortalecidas por novas investigações.

Palavras-chave

Risco politico; Aeroespacial; CBERS; China.

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BSI – Brazilian Space Industry

1. Introduction

Research scope

The main object of this study is Brazilian space industry's perception of political risks related to the Sino-Brazilian aerospace cooperation. Considering this object, the main question of research is: "how does Brazilian aerospace industry located in Rio de Janeiro and São Paulo perceive the political risk of a termination of the CBERS project due to geopolitical reasons, until 2024?". This study aims to achieve results in the quantification of probability, impact and uncertainty associated to this hypothetical risk event. By doing this, we hope to provide further considerations on the resilience of the supply chain to external geopolitical chocs. In this sense, the present work is a probing exercise to gather data for future inquiry into the response of the Brazilian Space Industry (BSI) when facing political events associated with the CBERS project.

The present study does not intend to provide a risk assessment of the national industry for space operations. Moreover, its methodology, albeit using the PRISMA framework for systematic review, does not intend to develop a meta analysis of the publications on political risk, the CBERS project nor the Brazilian Aerospace Industry.

In order to answer this question, the following specific objectives were pursued:

- What are the risk referential objects for the Brazilian Space Industry?
- What are the assigned probabilities, impacts and degrees of certainty of specific risks events for the Brazilian Space Industry?

Current state of the Brazilian Aerospace Sector and Chronology of the Sino-Brazilian space cooperation (CBERS)

The CBERS project is an international cooperation between Brazil and China established in 1988 in order to provide satellite imagery of both countries territories and to help develop national capabilities in the space sector. When established, the project aimed to make use of the high complementarity of supply chain between Brazilian and Chinese space programs, considering both the satellite sectors and launching capabilities. The program has been renewed several times and is now currently in its sixth edition.

To circumvent technological restrictions imposed by developed countries through the Missile Technology Control Regime (MTCR), Brazil sought an aerospace partnership with China (Brito, 2013). Cooperation with the Chinese was particularly important after the unsuccessful launch of the first Brazilian data collection satellite, SCD1 (Furtado & Costa Filho, 2003, apud Fernandes, 2013). In 1982, in the context of strengthening of the Sino-Brazilian broad diplomatic relation, the two countries signed the Scientific and Technological Cooperation Agreement. This is the normative basis for other bilateral acts of the two countries in the space area.

The presidential visit of João Figueiredo to Beijing in 1984 provided the impetus for furthering the cooperation and culminated with the signing of the Complementary Adjustment to the Agreement for Scientific and Technological Cooperation. Taking advantage of the previous agreements, the CBERS Program was created in August 1988, with the National Institute for Space Research (INPE) responsible for the cooperation on the Brazilian side and the Chinese Academy of Space Technology (CAST) in China. The main missions of CBERS are: i) to inventory, develop, manage and monitor the terrestrial resources of China and Brazil, through remote sensing space techniques and ii) to develop Brazilian and Chinese remote sensing techniques (BECARD, 2008).

Right at the beginning of the program's operations, the cooperation project went through a crisis, when the Collor government considered ending the partnership with China (Brito, 2013). Despite the instability, CBERS-1 was launched.

In 2003, the success of the program led to the signing of an agreement to renew the endeavor, which resulted in the successful launch of the CBERS 2 satellite. Both satellites were sent by the Long March 4B launch vehicle (INPE, 2020). 2003 was also the year of the fateful explosion at the Alcântara Base and the consequent delay in the Brazilian launch vehicle program (INPE, 2020 and Fernandes, 2013).

In 2006, during the Committee on the Peaceful Use of Outer Space (COPUS), Brazil presented a draft resolution in favor of treating space data as an international public good. This position and the fact that Brazil could release

CBERS images for free, undermining US and European market position, pressured the European Sentinel program and the North American Landsat to open their image sets without cost. The latter was even added to the Group on Earth Observation (GEO), which is an inter-governmental partnership in favor of the free distribution of geospatial data (Brito, 2013).

Chinese and Brazilians declared, in 2007, the free distribution of satellite images to South American countries and China's Asian neighbors. In the same year, the "CBERS for Africa" initiative was announced. It made possible the distribution of satellite images to the entire African continent through the installation of reception centers in South Africa, Egypt and the Canary Islands (Brito, 2013). Still in 2007, CBERS-2B was launched (INPE, 2020).

In 2010, the policy of free data dissemination reached its peak, through the unrestricted global distribution of data from the Sino-Brazilian satellites. In 2013, due to a failure of the Long March, the launch of CBERS 3 was unsuccessful (INPE, 2020). Note that CBERS 1 and 2 divided the responsibilities between INPE and CAST in a proportion of 30% for the Brazilians and 70% for the Chinese; however, in the following editions, the National Space Research Institute, INPE, contributed with 50% of the systems (Fernandes, 2013).

This division, however, maintained Chinese control of main subsystems, such as orbit and attitude control, as well as propulsion and on-board supervision. After the third launch, the project was once again extended to enable CBERS 4 in 2014 and CBERS 4A in 2019. These two satellites and their data are used in projects such as PRODES and DETER. Both artifacts are still operational (INPE, 2020).

Regarding CBERS 05 and 06 the cooperation is as follows. The 10-year plan for the cooperation between China and Brazil stipulated the creation of new satellites in the context of the CBERS project (Brasil, 2017). Bringing this objective to technical consideration, the 17th meeting of the Joint Projects Committee, which acts as the technical body for coordination of the cooperation between CAST and INPE, announced the interest to consider the requirements for the developing a new cycle of satellite cooperation through CBERS 05 and CBERS 06. (INPE, 2021). In the National Program of Space Activities for 2022

until 2031, effected by the government decree number 247 of 31 December 2021, the Brazilian government officialized its intent to develop CBERS 5 and 6. (Imprensa Nacional, 2021), by including it in its policy framework for development of the space program. According to this document, CBERS 05 would have a resolution of 1 until 30 meters and CBERS 06 would innovate by including a Synthetic Aperture Radar technology (SAR) instead of a camera like the former editions of the CBERS satelites. (Brasil, 2022).

In February 2023, the Brazilian Ministry of Science and Technology announced that CBERS 06 would start being constructed in 2023, inverting the order of operation by launch this satellite before CBERS 05. (Hora do povo, 2023). In March 2023, Brazil and China signed the Protocol to the Framework Agreement Regarding the Peaceful use of Science and Technology in Outer Space. This protocol established the terms for the development of CBERS-06, determining the following points: i) the budget division will remain 50% for Brazil and China; ii) the responsible for their respective module of the space artifact; iii) the lunch will be done by the Long March Rocket and the orbital payload delivery cost will also be split in half; iv) the responsible will be the Ministry of Science and Technology (MCTI) as well as the Brazilian Space Agency (AEB), from the Brazilian side, and the National Space Administration (CNSA), from China; v) both parts will have equal use of the satellite and the use of the device by a third party will require mutual consent from Brazil and China (Brasil, 2023). In April 2023, in the Joint Declaration of The Brazilian and Chinese Government after president's Lula visit to China, Brazil and China expressed their interest to expand the satellite cooperation by accelerating the research and development of CBER-6 and to further evaluate the implementation of CBERS-5 (Brasil, 2023).

In sum, currently, the CBERS assets are as such: There are two operational satellites, CBERS 04 and CBERS 04 A, as well as two new artifacts under consideration, CBERS 05 and CBERS 06. The former will be released in a future date, but the latter is already under construction and has political as well as technical support from institutions in Brazil and China.

Framing of the CBERS project in International Cooperation for Development

On the one hand, CBERS should be considered a typical South-South Cooperation (SSC) project, since it seeks to build mutual capabilities through a perspective of collective self-reliance, especially through Technical Cooperation, following the cooperative bases proposed at the Buenos Aires Conference (UN, 1979). Moreover, it maintains principles of the Bandung Conference, by offering a reaction to the conditioning of northern aid to the political-strategic agenda of developed nations, as presented by Figeredo's Government decision to establish the Sino-Brazilian cooperation in reaction to limitations in the context of the Missile Technology Control Regime (MTCR) (Brito, 2013).

On the other hand, the technological disparity between China and Brazil drives cooperation away from the supposed horizontality desired in the SSC. The disparity between the two countries is evidenced by the Chinese control of critical activities for satellite launching. Although INPE has achieved a budget equitable division of responsibilities, which would bring the cooperation closer to a SSC model (Fernandes, 2013), the Chinese government distances itself from core technical cooperation behavior, which often structures SSC initiatives, by restricting the transfer of its technology to Brazil. Thus, the Asian country conditions cooperation to strategic objectives, similarly to what occurs in the North-South cooperation axis (Fernandes 2013 and Brito, 2013).

Justification

The importance of the Brazilian Aerospace Industry

The justification for this paper is grounded in a twofold argument. First, what is important to be expressed is that geopolitical instabilities in core markets in Europe and South East Asia increase political risks for industries with high fixed costs, such as the aerospace sector.

In 2022, for example, supply chain and talent issues were among the biggest risks perceived by actors in the aerospace sector globally. Such concerns were enhanced by the War in Ukrainian and the subsequent global disruption of supply chains, especially for critical metals and rare earth elements. Fuel price volatility were also a major destabilizing factor. Consequences of these chocks drive incentives to reduce supply chain risks as expressed by the fact that 90% of

surveyed manufacturing executives by Deloitte claimed to experience an increased frequency of disruptions. In response, firms are investing in resilient supply chains to mitigate risk, through the acceleration of the shift from global to regional sourcing for raw material, parts and finished goods (Deloitte, 2022).

Building such resilience is a challenge. A company from the United States has on average over 12,000 tier-2 suppliers, hindering awareness of possible chocs through the supply chain. Since approximately 80% of the world's space equipment has some U.S. made component, this nationalized complexity has global sectoral effects (Deloitte, 2022 and Brasil, 2021).

Therefore, there is a market incentive to shift supply chains to more stable regions. South America, notwithstanding its many internal security issues, has low levels of interstate confrontation (Our World in Data, 2023). As a consequence, this perceived geopolitical stability makes Brazil an attractive investment location for space projects.

This possibility is further enhanced by two factors: First, Brazil is physically close to growing consumer markets for aerospace products. Its proximity to areas with repressed demand for telecommunications connectivity in sub-Saharan Africa, the Amazon and the Andes could drive its relevancy for near shoring of supply chains in important segments of satellite and other aerospace operations. Furthermore, Brazil's unique universalist foreign policy which congregates links to OECD, G77, BRICS expands its possibilities for friend shoring. Moreover, it can work as a redundant supply chain path to access markets in the global south through shipping liens through the Atlantic Ocean.

The second possibility that amplifies this tendency to allocate investment is the Alcântara Spaceport. The signing of the Technological Safeguard Agreement (TSA) allows for the use of equipment manufactured in the United States to be deployed in Space Operations launched from the Alcântara base, by providing guarantees that patents will be protected from unauthorized use or copying. It is a common agreement among countries that operate space launch centers, as supported by the fact that The United States has signed similar treaties with Russia, China, India, Ukraine, and New Zealand. In essence, the text of the convention provides that the United States authorizes Brazil to launch rockets and

spacecraft, domestic or foreign, that contain American technological parts. In return, Brazil guarantees the protection of the American technology contained in these artifacts. (Brasil, 2021).

Alcântara has the potential to become a core site in the circuit of space operations. This base is distant from major flight paths, population centers, security instabilities, while being close to the equator, and, thus, bridging the atmospheric distance to get from Eart's surface until orbit. Also, it is under booked, therefore reducing the lead time between establishing a contract and conduct a space operation. (Space BR, 2022).

Meanwhile, space has opened several greenfield opportunities for civilian activities. In 2022, 72 rockets were launched, delivering 1,022 spacecrafts. For 2023, 88% of surveyed senior executives by Deloitte believed the prospect for the industry was “somewhat to very positive”, thus indicating a maintenance of this uptake in space business, 94% of which consists of commercial operations (Deloitte, 2022). From all the activities in the sector, 11% is on upstream parts of the supply chain such as manufacturing launch services and ground control, whereas 89% is on satellite operations and satellite service. Most of the revenue is concentrated in satellite navigation and telecommunications. (SpaceBR, 2022).

Also, military contracts are projected to increase. It is expected that by 2029, there will be a 69% increase in defense budgets, with a projection of 850 satellites launched and a doubling of space military projects. These satellites will provide connectivity, provide situational awareness and other applications for military or dual use. (SpaceBR, 2022).

There is, therefore, an increasing demand for space services and, possibly, a very relevant part of these activities could be redirected towards Brazil, providing a greater insertion in global trade and advanced technologies value chains. Such interactions would help further develop present technology hubs, such as the Polo Tecnológico de São José dos Campos, but also create new sites. To provide a figure on the possible revenue. Brazil's space market could reach 10 billion US$ yearly by 2040, even if it provides only 1% of total global space business (SpaceBR, 2022).

Stronger Brazilian presence in this sector, through the further development of the national industry, would have important fiscal benefits. In 2020, most of the exports of Spacecraft, satellites, and spacecraft launch vehicles were concentrated in five countries, with the United States accounting for the largest part of the industry. Furthermore, in the same year, Brazil was the sixth-largest importers and the fifth-fastest growing import markets for spacecraft, satellites, and spacecraft launch machines. The development of a Brazilian space industry could account for part of the national demand for these goods, further improving the balance of payment position (OEC, 2023).

Not only opportunities determine the importance of this question but also the strategic nature of space operations for national sustainable development drive this research endeavor, for the space industry is paramount for climate change mitigation and adaptation as well as to guarantee self-determination through democratic institutions.

As shown by the critical importance of the Starlink constellation in Ukraine to maintain connection between institutions, even under political crisis, cyberspace has become a critical component for social interaction (The Economist, 2023). It so happens that recent technological developments in constellation satellites network allows for the use of space telecommunications for internet connection, thus making this a significant network for the manifestation of political will (Deloite, 2022). It is paramount, therefore, to assure continuity and influence over these networks to assure legality and that Brazilian networks are compliant with our values and institutions.

Satellites are critical to assess causes and consequences of climate change in the national territory. Data provided by programs such as CBERS are essential to measure which areas are being more drastically affected by rising sea levels and other effects of changing ecological structure. It is also fundamental for large strategic national projects, such as PRODES and DETER, to evaluate deforestation and CANASAT, which monitors sugarcane growing areas. (INPE, 2023)

On the one hand, the opportunities, and the preeminence of space related projects argue for studies regarding the Brazilian Space Program. Analyzing this

through a political risk perceptive, on the other hand, is due to the lack of integration of this variable into project planning and evaluations in many projects, consequently undermining the broadcasting of national assets.

The importance of political risk

De la Torre posits that while political risks have always been present in trade and investment, the scale of exposure and notable losses brought political risks to the forefront of business and academic discussions. The sheer magnitude of potential challenges underscores the importance of addressing political risks in the management of international operations (De la torre, 1988). Such tendency has neither subsided in the first decade of the XXI century, as stated by Jakobsen in analysis of the bauxite and aluminum industry, nor in the most recent years according to Allianz (Allianz, 2023).

Normally, as suggested by Howell, political risk includes factors like government stability, socioeconomic conditions, investment profile, internal and external conflicts, corruption, military involvement in politics, religious tensions, law and order, ethnic tensions, democratic accountability, and the quality of bureaucracy. These elements are crucial in assessing the overall political risk associated with a particular region or country (Howell, 2011). Such risks can come from state as well as non-state social agents (Simon, 1984).

Investing abroad involves higher risks due to cultural and political differences and the analysis of such risk is concentrated in the hands of few. To help circumvent political adverse events, rating agencies such as Fitch Ratings, Standard & Poor's and Moody's constantly monitor risk indices. These yields great power to such corporations, leading to criticism from leaders such as Angela Merkel and Barack Obama (Nostti, 2020). Similarly, the ISO 31000: "Guidelines on Principles and Implementation of Risk Management"; Geneva: ISO, 2009 provides a framework, centralizing the power to monitor and understand risks (GESI, 2017). Furthermore, exporter agencies like Export Development Canada tend to develop their own methodologies to account for political variables (EDC, 2023).

Often, the industry uses adjacent methods to cover the need for political risk analysis, such as country risk. However, as pointed out by Nossti, a country risk indicator frequently overestimates economic and financial factors to the detriment of political risk. While some believe that it covers economic, financial and political aspects, in reality it often gives excessive weight to the first two. This is because the main purpose of country risk is to assess a country's ability to meet international financial commitments, even under political risk, therefore limiting research scope to the effects of political events on economic variables underestimating how this political events could be impactful independently of financial concerns. Moreover, many analysts confuse country risk with political analysis, although the latter involves factors such as ideology and authority, while the former is based on economic metrics. Political risk is much more unpredictable, unlike country risk, which follows predictable patterns (Nostti, 2020). Even when political risk is included in decision-making, its application is also limited to political forecasting. There is a tendency to side-line analysis from the strategic planning process, due to the complexity of political variables. (Sauers, 1992).

Therefore, three factors highlight the current state of political risk analysis. First, it is indeed a variable that affects international investment, trade and cooperation, both because of the actions of non-state and state actors. Second, the power to perform risk analysis is highly concentrated. Third, analysis of political variables are often done using adjacent methodologies, downplaying the relevancy of political risk.

These three factors can curb efforts to broadcast Brazilian political stability as a major attractor of investments. In a time when political risks are growing in relevancy, the attractive effect of our distance from geopolitical confrontation is dependent on few foreign companies and in an industry that typically downplays precisely our strengths as a low political risk environment. As such, it is paramount to create, improve and standardize political risk frameworks that provide for accurate analysis of the national potential.

2. Methodology

Concept gathering literature review

To provide the concepts for the questions included in the survey as well as in the interview script, this author chose to use the PRISMA flow diagram (Liberati et ali, 2009). In order to assure that the question in the survey and in the interview are scientifically grounded, it was important to assure the tracking of information to allow peer review of the concepts used to formulate the survey as well as the interview questions.

The methodology does not, however, provide an ontological argument regarding the validity of specific concepts. This author does not endeavor here to establish a risk analysis model, nor does he aim to rank different perspectives in the field. In sum, the PRISMA framework is above all an exercise of intellectual honesty through systematic review of literature used for the data acquisition phase, inasmuch it allows readers to see the origin, the arrangement, and the scope of the concepts used to ground the survey and the interview questions.

Search

The identification of the risk concepts for the survey and the interview was done in seven phases, divided in three steps: search, eligibility and exploitation

First, the author applied these terms “political risk” and "political risk analysis", in English as well as Portuguese, in the following search engines: Google and General research from PUC-Rio database (Pesquisa Integrada), including periodic CAPES. This process was done repeatedly over the space of two weeks and using different computers and accounts to avoid limitation by algorithms. It is important to reinforce that at no point the objective was to search for all the results for these terms in any of the platforms. To exhaust such search results would require more time and resources available to the research.

Second, revision of the references used by José Hernández in his 2018 article called The Political Risk Analysis.

Third, revision of the references listed in the syllabus from courses specialized in Political Risk from Pontifícia Universidade Católica do Rio de Janeira and Fordham University, taught respectively by Mariana Rondon and Dr. John P. Entelis.

Fourth, all the references were captured using Evernote's tag system and organized for further review using a software called Obsidian. This search process resulted in 104 sources.

Eligibility

Fifth, the selected texts were further scrutinized using the title as well as the abstract, to assess the relevance for the study. References that did not have the word political and risk either in the title or in the abstract were excluded from the review. However, if these concepts were considered to be implicit, this author chose to include the references in the review, providing a larger conceptual body for the study. Also, any references that did not have any consideration on at least one of the components were also excluded. In total 47 articles were eligible for the exploitation phase, described below.

Use

Sixth, the texts that were considered pertinent were included in an Excel table. Then, the texts were revised looking for these components: risk definition, definition of politics and operational environments, considerations regarding uncertainty, risk referential objects, types of political risk, models of political risk analysis. The reasons to include these components were as follows, respectively.

Risk definition. Political risk is no different from any other type of risk as pointed out by Bremmer in 2010, therefore it was worth looking for the concepts of risk in general.

There is a second distinction regarding the auspicious or malicious nature of risk (Rice, 2019). Commonly, risk is characterized as a harmful development that can jeopardize or halt the pursuit of a goal. However, some authors point out that the concept of risk can also include positive events that facilitate or enhance organizational assets' capability to achieve an objective. In this sense, risk can either be a threat or an opportunity. Once more, this author looked for conceptualizations that included both positive and negative definitions.

Definition of politics. Albeit political risk analysis does not especially endeavor in deep political theory conceptualization, it is nonetheless paramount to have a clear, even if simplified, definition of what political events are, to differentiate political risk from other types of risk. This conceptualization is made

evident by the recurrence of attempts to define political actions in the works of McKeller (2010), Bremmer (2010), Rice (2019) and Hernandez (2018).

Characterization and considerations regarding uncertainty. Uncertainty is a core component of risk and critical to distinguish the two definitions of it. Thus, it was important to see how the literature approached this topic.

Risk referential object. The risk referential object is the component, be it abstract or concrete, that is exposed to a risk event (McKeller, 2010). This category varies depending on the organization that is exposed to the specific risk (Rice, 2019). It was critical to form a shortlist of risk referential objects, otherwise the answers would be an endless description of assets and concern points. For this, it was paramount to revise different conceptualization of risk referential objects in the literature.

Types of political risk. Looking for an enumeration of political risks had the potential to aid the conceptualization of politics, in general, and political risk, in particular.

Models of political risk analysis. Searching for analytical models in previous publications, allowed this author to convert these frameworks into questions for the survey and interview script. In a sense, looking for these components allowed for a reverse engineering of the approaches. It is important to highlight here that risk mitigation models were not included, for the focus of this study is precisely in the process of spotting and understanding political risk and not on the steps to deal with it.

The systematic review was done for political risk literature, to assure the construction of a framework capable of optimizing the time of the respondents, while gathering data needed to characterize the Brazilian space industry perception's of risks associates with the CEBRS project. In the table where the literature was organized, there are two segments corresponding to the political risk literature review, done with the PRISMA frame work, and another for the aerospace industry, which followed recommendations from specialists. The review of this material resulted in the following terms and definitions.

Terms and definitions

In this section, the terms and definitions of this research will be detailed. They will refer to the image below to provide visual clarification.

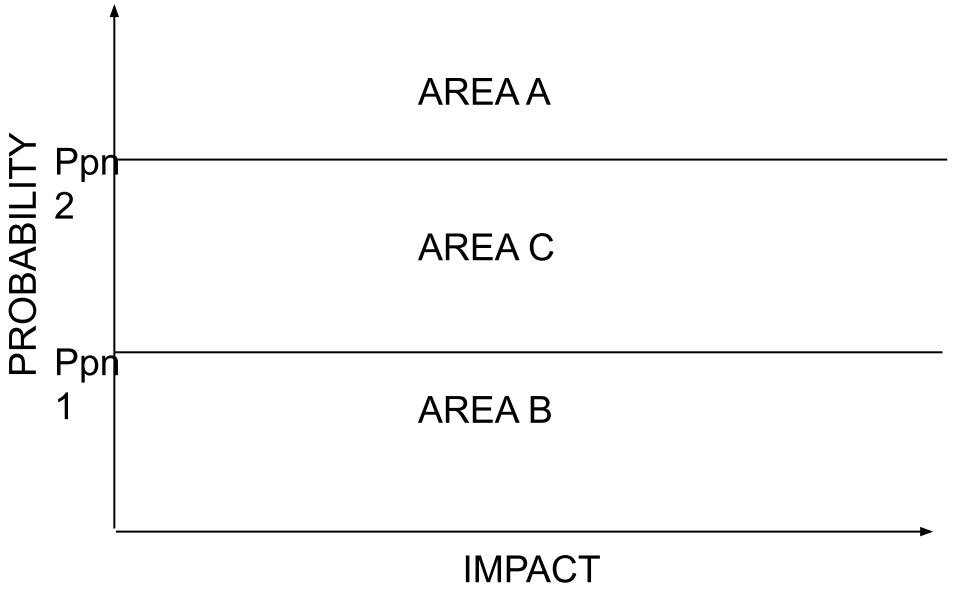

Figure 1: Title: Compound risk perception framework

Possible future. Here, possible future events are considered as developments that are perceived as possible to take place in the future, regardless of their probability (Garvin, 2006).

Uncertainty. Based on the works from Tripa Dias (2014) and Brennglass (1983) uncertainty is considered the feeling of doubt associated to the future. It is a perception of the future, therefore disconnected from the material dynamics and probabilities that shape concrete realities and, thus, of the real probability of the risk events. Moreover, uncertainty is often described as being mathematically close to a 50% figure of probability, where any value lower to that is progressively more certain not to happen and any value higher is more certain to happen, because of greater probability (Garvin, 2006).

Probability and Impact. Making use of the works from Simon (1998), Alon and Martin (1998) as well as Robock (1971) probability was defined as the

perceived likelihood of a risk event associated with the Sino-Brazilian satellite cooperation materializing. Impact is the effects that a risk event will have on the risk referential objects**.** As is the case with uncertainty and probability, impact is considered a perception for the effects of this work. As a consequence, when monitoring the risk perceptions of the space industry, this research did not endeavor to assess the real impact of possible risk events.

Risk event. Risk event is any future event that is perceived as uncertain and the product of probability and impact (Jackobsen, 2010) (Demison, 1996, apud Hernandez, 2018). Since the future is in essence beyond verification, any future development is to some degree an uncertainty. However, to conceptualize a future event this way means that everything is a risk, reducing the explanatory value of this definition. Therefore, it is important to measure the degree of uncertainty associated with a risk event, to make sure it is an actual risk and not just an event perceived as an established part of the future.

Political event. Using the concept of Entelis (2020) to characterize the definition of political risk in capital markets, a political event is a legal and social occurrence that can change the "rules of the game" under which an organization made its calculations of risk and return. This concept is aligned with the works from Grath (2008), Theodorou (1993); Kobrim (1982); DeLa Fuente (2011); Haner, (1979); Simon (1982) and Alon (1996), apud Hernandéz (2014).

Political risk referential objects. Political risk referential objects were considered parts of the supply chain that could be affected by the materialization of future uncertain political events, regardless of the probability of such events actually occurring. Due to the great complexity of the aerospace supply chain, it was critical to establish a short list of referential objects. Otherwise, it would not be possible to consider all the affected assets that could be impacted. In a way, this research had to limit the range of perceptions of the individuals interviewed and surveyed, by offering a defined set of political risk referential objects. This was done, in particle therms, by offering check boxes on question 13 with the options “personal”, “infrastructure”, “reputation” and “information availability”. These categories were based on the list of typical risk referential objects provided in McKeller (2010), by merging some categories provided by him.

Political Risk. In conclusion, political risk was defined as any future event caused by human decisions to favor one course of action towards a goal in detriment of the other approach(s) consequently changing the rules of the game by which actors made calculations of risk and return, if such future event is perceived as uncertain and the product of perceived probability and perceived impact. Thus, mathematically, I considered political risk as follows: $Y(\alpha) = pP(B)\, x\, pI(B),\ if\ pPn1 < pP(B) > pPn2$. Where:

- $Y(\alpha)$ is Political risk to referential object α;
- α is a part of the BSI supply chain;
- B is a human decision to favor one course of action towards a goal in detriment of the other approach(s), thus changing the rules of the game by which the organization's calculations of risk and return were made. In essence, this is the political risk event;
- $pP(B)$ is the perceived probability of a political risk event B occurring;
- $pI(B)$ is the perceived impact of political risk event B, if it occurred;
- $pPn1$ is the point of perceived probability below which future events are considered to be absurd;
- $pPn2$ is the point of perceived probability after which future events are considered to be unquestionably part of the future.

This definition has the elements from two conceptualizations of political risk. On the one hand, some posit that political risk is the product of probability and impact (Bremmen, 2010) (McKeller, 2010). On the other hand, there are authors that posit that future scenarios need to be charted considering uncertainty, in order to define which future events should be regarded as risks (Garvin, 2006). The former has the benefit of expanding the explanatory value of risk, by distinguishing it from established perceived future occurrences; the latter establishes an operational formula for analysis. The conceptualization provided here integrate booths these perceptions.

The Space Sector. The UN International Standard Industrial Classification (ISIC) defines Aerospace activities, including everything from hang

gliders to space shuttles. Notwithstanding the rage of the definition, it does not include space-related services such as telecommunications (OECD, 2007). With another approach, The Fédération Aéronautique Internationale uses the Kármán line to define space. The Kármán line is an atmospheric mark 100 km above ground that indicates the beginning of space. At this mark, air pressure is too low for a flying body to generate lift force without exceeding orbital velocity, thus driving objects naturally into orbit. I considered any company associated with operations to deliver, control, repair and retrieve data and materials from machines above this line to be part of the space sector (Spaceflight, 2022).

List of surveyed and interviewed individuals

There were four approaches to gather contacts for the survey and interview.

First, using the Classif website from the federal government, this author identified the NCM codes for the aerospace sector. The NCM is a classification system that specifies the globally used Harmonized System and provides a taxonomy for every imported and exported product in MERCOSUL. With this information, the researched applied this NCM codes in the Catálogo dos Importadores Brasileiros (CIB), a public database of importers and exporters, to learn which companies worked in this industry. It is important to note that there were no results for "Veículos espaciais (incluídos os satélites) e seus veículos de lançamento e veículos suborbitais" (NCM 880260, which was the best correspondence to space operations inside chapter 88, "Aeronaves e aparelhos espaciais e suas partes"). Thus, this research opted to include all other available NCMs for chapter 88, for often companies that deal with space operations also endeavor in other subsectors of the aerospace industry such as aviation manufacturing. After applying this larger query, the survey question number 1 allowed for a verification if the company was actually part of the space sector. Here it is significant to consider that this research wanted to gather data from 2023 until 2024, thus it was valid to include companies that were not part of the space industry now, but intended to join the industry until December 2024.

Second. Visiting the website of the associations and fair organizers of the sector, this author formed a new list of possible agents. After checking for

redundancies with the first list, the author verified if the selected respondent were based in Rio de Janeiro or São Paulo and if they had operations in the aerospace sector. In this sense, the researcher used the associate list of the Associação das indústrias Aeroespaciais do Brasil and the Space BR show exhibitors list. The letter is the main trade fair for the sector. Here, the same consideration made for the NCM is also valid. Many of the associated companies do not deal with the space sector, however, operational proximity could facilitate their entrance in the future as well as account for lateral supply chain integrations, such as when aviation engineers also work in space projects. The verification if a subject was indeed involved in the space operations was done in question 1 of the survey through self declaration.

Third. Using the firms listed in the Catálogo das Empresas Espaciais Brasileiras it was possible to find more agents involved with the supply chain.

Fourth. Word of mouth and snowball. The survey had a question asking for recommendations of further contacts interested in answering the research. Also, the survey was made available through link, to facilitate sharing.

The acquired contacts were plotted in a spreed sheet using Excel. One should note that the localization of headquarters was provided by the websites of the organizations, without any further verification. A second layer of verification in this regard was the self statement of localization using the answer to question 1. This information was not further verified.

3. Results

Survey results

The survey question intend to assess how the Brazilian Aerospace sector perceives the risks related to the Sino-Brazilian cooperation. It does not, as stated before, endeavor to establish the actual risk level of sector vis-a-vis this diplomatic relationship, but rather to understand how firms involved in this industry perceive China.

The survey was sent to 108 entrepreneurs in the Brazilian Space Industry, resulting in 14 respondents. One should note that the name of the respondent as well as company is kept anonymous to decrease the concerns of illegal use of this data.

Question 1: "Does your firm posses an office or installation in Rio de Janeiro or in São Paulo?" The objective of this question was to assess if the respondent was inside the geographical research scope. From the 14 people that responded the survey, 71,43% indicated they had operations or offices in Rio de Janeiro and 50 % indicated they had physical locations in São Paulo.

Question 2: "Since when is your company part of the Brazilian aerospace sector?". This question provided four close ended answers, "less than one year"; between "1 and 5 years; "between 5 and 10 years"; "more than 10 years". Most 53,85% of respondents had established operations in the industry for over a decade, whereas 15,38% had been working in this sector between 5 and 10 years. No respondent answered the option "between 1 and 5" and 30,77% answered that they were working with aerospace activities for less than one year.

Question 3: "Would you like your firm to participate in aerospace projects in the next 16 years?" All respondents answered "yes".

Question 4: "How do you consider to be the CBERS contribution to the Brazilian Space Industry?" The objective of this question is to grasp the general perception of the impact of the CBERS project for the Brazilian Aerospace industry, aiming to gather insights if risk events in this cooperation would be perceived as having a negative or positive impact to risk referential objects. If the CBERS cooperation would be perceived as generally positive by the industry, risk to the project could be perceived as negative events that could jeopardize a

positive contribution to the industry. However, were this project to be perceived as negative, then events that could destabilize the cooperation could be understood as being positive, for they would undermine a negatively perceived bilateral undertaking. The question was constructed to allow respondents to provide a grade from zero to 100 to the bilateral cooperation. The result was a grade of 56 points.

Question 5 to 9 consisted in stream approach to the aerospace supply chain, providing data on different stages of the Brazilian Space Industry product cycle. The answers to this question were close-ended and consisted in a grading of the CBERS contribution from 0 to 100. The aerospace industry value chain is divided into five components: 1) Manufacturing of satellites; 2) launch operations; 3) ground operations; 4) satellite operations 5) provider of services using space acquired data (Space BR, 2022). Social agents can have different perspective of the impact of the CBERS project through this value chain, thus the analysis accounted for segmentation in different stages of the aerospace industry. As far as policy is concerned, this allows for detailed risk perceptions in specific parts of the BSI, as well as targeted confidence building and risk mitigation endeavors.

Question 5: "How do you consider the contribution of the CBERS program for satellite construction, endeavors?" The first section of the supply chain industry stream is satellite construction. Here, respondents gave 61 points to the Sino Brazilian satellite cooperation to Brazilian satellite building efforts.

Question 6: "How do you consider the CBERS contribution to launch operations?" The grade result to this question was 60 points.

Question 7: " How do you consider the CBERS contribution to satellite control operations based on the ground? " The grade to this question was 76 points.

Question 8: "How do you consider the CBERS program contribution to satellite maintenance operations?". Once more, the grade to this question was 60 points.

Question 9: "How do you consider the CBERS contribution to the availability of services with satellite data? ". Respondents grades this contribution with 71 points.

Question 10: "Do you consider the following scenario likely? Until 2024 geopolitical pressures will end the CBERS cooperation?". Once more, this question asked the respondents to provide a grade on the likelihood of the scenario. This question has two goals: The primary goal is to assess how decision makers in the aerospace sector perceive the CBERS projects cooperation effects in specific components of the Brazilian space industry. The secondary objective of this question is to gather insight about how this social agents consider the exposition of the CBERS project to the general global political environment. Here we were measuring the perception that risk is the result of the multiplication of probability and impact. The average result was 47 points.

Question 11: Referring to the previous scenario, this question asked: "How sure are you about the likelihood described in question 10?" The result was a grade of 47 points. In this question, we are trying to assess the risk as a byproduct of impact times uncertainty. According to this perspective, as previously stated, it is the high level of uncertainty that increases the factor of risk. If respondents answer that they are not sure about their assessment on the continuity of the CBERS initiative, project continuity is perceived as uncertain.

Question 12: "What would be the impact if the CBERS project ended?" Respondents graded this question as 56 points.

Question 13: "What assets would be affected the most in the Brazilian Space Industry, in case the CBERS program ended?" The following table describes the results.

Answer choices	Responses
Employees and human resources	25%
Reputations	16,67%
Infrastructure	33,33%
Availability of information	25%

Table 1: Title: Results for the risk referential objects in the Brazilian Aerospace Supply Chain

Question 14 Through an open-ended question, this part of the survey inquired if respondents had anything else to add. To provide context for the respondent's answers, I included some technical definitions in the responses outside the brackets. These are some noteworthy answers:

1. "CBERS has extremely obsolescent satellites, artificially expensive and heavy for what it delivers, could easily be replaced by another 50kg satellite (e.g. Satellogic)". Satellogic is an earth observation data company, which invest in low-cost access to satellite images (Satellogic, 2023).

2. "We have the following types of market: 1) Competitive (easy to enter the market and easy to leave the market; the consumer sets the price of the product, i.e. the lowest price wins); oligopoly (few companies in the market, difficult to enter the market, because the producer sets the price of the product, demand is greater than supply) and monopoly (the producer sets the price of the product, demand is greater than supply). When a company enters the technology sector, i.e. it has no or few competitors, the price of the product is set by the producer, i.e. it has added value. This is why there is a big difference in price between a steel plate and a satellite. Satellite technology has very high added value and few competitors. It is therefore important for Brazil to develop its own technology, as other countries will make it difficult for Brazil to enter this market and gain knowledge. No country is going to hand over its knowledge to another country that could become its competitor. In other words, technological development depends only on us, because the return on investment is very high."

3. "It's very unlikely and CBERS 6, being SAR, will bring new lessons and benefits to national industries." Synthetic aperture radar (SAR) is a technique to provide higher quality image resolution through a more rudimentary radar system. (NASA, 2020).

4. "Availability of information: certainly not. There are free alternatives, such as Landsat and Sentinel-2. There is no alternative to WPM, but it has been little used. Reputation: not either. In the past, the shortcomings of the CBERS program led to a loss of human resources in the industry.The

infrastructure would be relatively affected" The WPM camera is one of CBERS 04A payloads and is manufactured by China. It provides 2m panoramic resolution and 8m multispectral resolution images inside the satellite's orbit (INPE, 2019).

Interview results

The interview was conducted online with two senior or C level employees from the Brazilian Aerospace Industry. During the interview, the questions used in the survey and the interview referred to each question independently, asking for further comments. Thus, the process was conducted in open-ended format question, resulting in a semi-strucutred interview (Harvard, 2023). This approach aimed to provide data that could be used to put the results from the survey into context, and not to extrapolate conclusions to a larger population (Marash, 2010). The entire process was done preserving anonymity and the only identification data that will be provided here is if the interviewed person works in a Brazilian or foreign firm.

Interviewed person number one. Works for a foreign firm.

- Highlighted that every time that his company wants to establish a foreign contract, even in topics unrelated to satellite projects, they have to answer questions related to the trustworthiness of the Brazilian space program because of the links between the Instituto Nacional de Pesquisas Espaciais (INPE) and China National Space Administration (CNSA). Here, the underlining assumption is that, because Brazil and China cooperate in this area, there is a risk that China will have access to sensitive knowledge and equipment produced in the United States or in European countries. He highlighted that explaining the structure, mission and values of INPE helps mitigate these doubts.
- He stressed that his companies is very dependent on goods listed in the International Traffic in Arms Regulations (ITAR). The ITAR are a group of regulations administered by the U.S. Department of State’s Directorate of Defense Trade Controls (DDTC). These regulations control the export

of defense articles and defense services, such as software and technical data included on the United States Munitions List. (United States, 2023). In light of this, there is a concern that US policy aimed at isolating China from dual use supply chains, that can contribute to civilian and military projects, could restrict availability of components to Brazilian based operations, due to concerns that such services and goods could reach China's program. Further expanding of this concern, he added that it seems that the core risk is how much the United States would allow Brazil to remain equidistant or neutral upon great power competition between China and the US, before restricting availability of means through trade restrictions in strategic industries, such as the aerospace.

- Further, he added that other non-western collaboration with Brazil, such as Glosnass alignment station located in Brazil, contribute to this perception that the country could suffer trade restrictions in case of a higher US-China power dispute. Like the US GPS system, the Global Navigational Satellite System (Glonass) is a Russian-established project that provides navigation data, including in polar regions and low earth atmosphere (Embrapa, 2023). In order to maintain precision of orbital flight, there is a Glonass base in Brazilian territory, in the Universidade de Brasília, dedicated for realignment of space artifacts (Brasil, 2013).
- Also, considered that CBERS contribution for Brazilian capacity building in satellite manufacturing, launch operations, maintenance of space artifacts is very low. For ground control endeavors, CBERS has a great contribution.
- He considered the scenario of discontinuation of the cooperation due to geopolitical tensions very unlikely, even under a reorganization of supply chains due to political factors. He backed his statement with a high degree of certainty. If the program was discontinued, there would be a limited impact. Availability of data for mining projects would be the hardest hit, due to lack of satellite provided data, however, since the 1980s there has been a policy of data source diversification in many sectors, therefore there would be resilience. Regarding reputation, it would depend on specific agents. For the Chinese the discontinuity would hurt the

reputation of our space industry, but for western partners in the North Atlantic, this would increase the trustworthiness of the BSI. Human resources would be quickly reallocated to other Brazilian space cooperations such as with Russia, Europe and Argentina, thus the impact would be small in this regard.

Interviewed person number two. Works for a Brazilian firm.

- Highlighted that the product cycle is excessively centered in putting space artifacts into orbit and not so much in making use of satellite data.
- Regarding the CBERS project, he highlighted that CBERS project has created a path dependency, leading the Brazilian Space Industry into depending on large products.
- Shared that with the United States there was a very strong exchange of ideas, but with the Chinese there is little knowledge sharing.
- Shared that, even if the CBERS project is restricted to satellite cooperation, partners such as the European Space Agency (ESA) and the National Aeronautics and Space Administration (NASA) restrict their cooperation with Brazilian space organizations.
- Pointed that CBERS has negligible contribution to launch operations and that only with the lunch of Amazonia 1 Brazil developed experience in certification and development of orbital space load delivery. Regarding ground operation, CBERS had an important and positive effect in this part of the product cycle, since Brazil is responsible for satellite control and navigation every 6 months. Also, after the lunch of Amazonia 1, Brazilian ground stations had to be able to deal with connection overlap from data coming from CBERS 4A and Amazonia 1, thus forcing the ground team to learn how to circumvent such connection saturation. Moreover, CBERS staff does a good job in satellite maintenance.
- The interviewed person coincides the discontinuation of CBERS project very unlikely, because the Chinese appear to be invested in maintaining a good partnership with Brazil to balance the US presence in Latin America.

The person affirmed this with great certainty. In the view of this person, the greatest risk to the project are the constant delays from the Brazilian side due to financial limitations. Also, there is a concern due to the aging of the professionals dealing with the CBERS cooperation from Brazil's side: China has a larger, more diverse and constantly renewing team whereas Brazilian counterparts have been working with the project since its beginning and are all former employees from INPE. Especially, China has increased the number of people dedicated to software development in the CBERS project.

- An end to the CBERS project, the person added, would have a great impact for the sector. The Brazilian Space Industry depends on contracts from Finaciadora de Estudos e Projetos (FINEP), which is a public fund dedicated to provide financial support for innovations projects in the country. The persons further explained that Brazilian space projects are often not self-funded, therefore, once the financing from FINEP is finalized, the company has no capacity to keep developing its projects. Support from FINEP, on the other hand, depends on the establishment of large space cooperations such as CBERS. The end of this project could make many national companies bankrupt, opening space to acquisition by foreign companies from China and Israel, for example.
- In terms of specific points of impact, the person highlighted that information availability would not be jeopardized, because other programs such a Landsat offer similar images for free. The expectation to this are images with under 2 meters resolution that are currently provided by CBERS 4 and are not available freely by other platforms. Human resources would be dramatically affected. Reputation would also be impacted, since Brazil is losing market share and visibility to other southern space programs, such as the ones from Argentina and South African. To mitigate the risk to the industry due to the end of the CBERS project, the person highlighted the importance of FINEP diversifying initiatives and including new models of space activities, such as INPE`s constellation project. Also, the person highlighted that investing in software development that could help establish new income sources from

available satellite data could help establish self-financing projects that would be independent of FINEP resources.

- The persons added that CBERS has not contributed greatly to expanding the technological frontiers of the Brazilian Space Industry. Although, indeed, Brazil has progressively expanded its budgetary contribution to the CBERS project, the components that are nationally introduced to the Sino-Brazilian satellites were already used in other projects, hindering the contribution to expanding the country's space technological capabilities. One example is the utilization of the Plataforma Multimissão (PMM) that was developed for the Amazonia 1 satellite and will be introduced in the CBERS 6. In conclusion, the person added that the CBERS project keeps the Brazilian Space Industry alive, but does not help it advance.

Operational results

Material	Link to source
Research flyer	https://drive.google.com/file/d/1LB0wfMKh11CfgPzzvqZ4rhqPMQGRkFRH/view?usp=sharing
Survey and interview contacts	https://docs.google.com/spreadsheets/d/1IryH9Ht02p0jk85rrItXMF7SIcN_NND5/edit?usp=sharing&ouid=110757758515983875574&rtpof=true&sd=true
Concept literature review (political risk)	https://docs.google.com/spreadsheets/d/1B2Rd7E3aAW6ZD81WTLZkhx5BIvSi5bZu/edit?usp=sharing&ouid=110757758515983875574&rtpof=true&sd=true

Table 2: Title: Operational results

The table above contains all the material created in order to develop the empirical part of this study, as well as the theoretical framework used.

4. Conclusions and policy recommendations

Conclusion

The results can be divided into 9 specific points and one cross-cutting conclusions that answers the main research question for this work. Also, there are some valid policy indications that can be inferred from the results of this research, notwithstanding the fact that more solid assessments depends on an expansion of the sample.

1. **Overlap between São Paulo and Rio de Janeiro**. The answer to the question number 1 of the survey indicated that 71,43% of the respondents lived in Rio de Janerio and 50% in São Paulo. There is, thus, a mathematical overlap of 21,43%. This indicates that the Brazilian Space Industry is significantly integrated between the two states, rather than independently in these federal units. This might be a tendency established due to new remote working options.
2. **Growing for the long term**. Over 50% of the respondents have operations in the space sector for over a decade, suggesting that firms that enter this market tend to stay in operations for the long term. 30,77%, the second-largest response group in terms of time operating in the space sector, have been working with space related activities for less than one year. Therefore, one could conclude that investment in the sector is expanding with a tendency to stay in the long run.
3. **Dividing opinions**. The average grade of the respondents to the survey was 56, affirming that the CBERS had a positive contribution to the Brazilian Space Industry. Considering the interview with person number two, this relatively low score could be attributes to the sense that the project does not contribute to expanding the technological frontier of the national space program, albeit it has an important role in keeping project cycles that support the BSI alive through contracts by FINEP.

Segment of the supply chain	Grade
Satellite construction	61 points
Launch operations	60 points
Satellite control operations	76 points
Satellite maintenance operations	60 points
Availability of services with satellite data	71 points

Table 3: Title: Results regarding the contribution of CBERS to different segments of the project life-cycle

4. **Homogeneous supply chain perception**. The table number 3 consolidates the point given by survey respondents to the contribution of the CBERS project to each part of the supply chain. This table shows that there is a 15 perceptual point variation between the smallest contribution, satellite construction, and the highest mark, satellite control operations. Therefore, it is reasonable to conclude that the supply chain has a reasonable cross-cutting perception of the CBERS contribution to BSI along the stream of satellite production.
5. **Difference between segmented and complete perception.** Moreover, one should note that when asked about specific contributions of the Sino-Brazilian Satellite cooperation to segments of the supply chain, such as launch operations, the results were higher than the grade given to the contribution of the project as a whole to the Brazilian Space industry. This change in perception could be relevant in case future risk events impact specific parts of the project or the initiative in its integrity.
6. **Up and downstream awareness.** It is also remarkable that the grades follow the scope of the CBERS project as discovered during this work's documentation review. Indeed, the project has very little to do with launch operations, since this is done by the Long March Chinese launching vehicle, corroborating the lowest grade in the previous table (60 points).

Satellite control operations and availability of data, differently, are a core part of the bilateral cooperations, reinforcing the high scores in the previous table (76 and 71 points, respectively). The coherence of the grades with the actual activities of the cooperation indicate that agents throw the project stream have a reasonable understanding of the full project cycle.

7. **Uncertainty is high; probability is low.** There are two formulas to calculate risk, as previous mentioned: 1) $risk = probability\ x\ impact$ and 2) $risk = uncertainty\ x\ impact$. In question number 10, respondents gave an average 41 points to the consideration that the CBERS project could be discontinued due to geopolitical reasons until 2024. In question 11, when asked how certain they were of their assessment, the average grade was 41 points. Considering that these points are represented in a 0 to 100, they can be mathematically translated to percentage, meaning that both questions resulted in identical 41% level of probability and certainty of probability. This number provides insight into the risk presence in the vision of future of the industry. Considering the 41% level of probability, one could argue that the probability of this risk event happening is perceived as low; however, it is precisely this middle stand in the probability continuum that makes this scenario a high uncertainty risk event. This happens because of the fact that this event is not seen as very likely to happen, thus a perceived establish part of the sector's vision of future, nor perceived as a highly unlikely to happen, which would exclude this scenario from the BSI vision of future. Therefore, this research concludes that the scenario "Until 2024 geopolitical pressures will end the CBERS cooperation " is a high uncertainty risk event.

8. **Impact is great, because infrastructure is under jeopardy.** 33,33% of respondents of the survey considered that the most vulnerable asset to the scenario was the infrastructure of the Brazilian Space Industry, indicating that this is perceived as the most vulnerable part of the industry. This number by itself has little meaning, however, in context of what was presented in the interviews, one could argue that infrastructure disruption

could undermine financial sustainability of firms, thus jeopardizing the existence of many companies and possibly the sector itself. Therefore, the risk factor of a termination of the cooperation is perceived as relevant even under the risk peer probability definition, because the impact factor is great.

9. **Opportunity**. The interviewed person number one and number two both highlighted that the discontinuation of the CBERS project could open opportunities for further improving cooperation with OECD countries, especially the United States. Therefore, the materialization of the risk event could bring opportunities in terms of North-South cooperation avenues.

Cross-cutting conclusion. This research's main question is "how does Brazilian aerospace industry perceive the political risk of a termination of the CBERS project due to geopolitical reasons, until 2024?". Based on conclusions 7, 8 and 9, it can be affirmed that this risk is perceived as a middle probability and high uncertainty event, which would greatly impact the national industry, negatively, by undermining financial sustainability. The negative impact of this scenario would hit the industry in a moment when new companies are entering the market, as identified in conclusion number two.

Moreover, there is anecdotal evidence that the industry perceives this risk event as having a positive reputation impact, because it could open channels for deeper North-South collaboration. Such perception was mentioned by interview person number one and the fact that reputation was considered the least impacted part of the supply chain points to this understanding. However, one cannot infer that the reason behind this low score was the possibility to enhance South-North collaboration, since respondents did not give reasons for their answers. Therefore, one should not consider this perception of new avenues for cooperation as part of the conclusion, but decision makers could consider this as anecdotal reference in their planning to provide further context regarding the BSI behavior when facing such geopolitical risks.

Policy recommendations

The following points are policy recommendations that could help reduce the Brazilian Space Industry exposure to political risk coming from the CBERS project. These recommendations, therefore, intend to assure the continuity and stability of this industry.

1. **Monitoring**. It is paramount to establish higher certainty levels regarding the continuity of the CBERS cooperation. As presented in conclusion number 8, the industry does not confidently state if the cooperation will continue or not until the end of 2024. This uncertainty undermines investment in the supply chain, curbing space firms ability to use the cooperation as a technological leverage. Thus, decision makers must endeavor in establishing strong political risk monitoring capabilities that will bring greater certainty about the future of the cooperation. To be successful, this monitoring must account for strong analysis that are widely distributed national and internationally. This strategy would allow for a greater sense of predictability. Also, Brazil could capitalize in the reputation gains vis-a-vis the West in case the probability of a termination of the cooperation becomes more likely, by fostering cooperation with NASA and ESA, for example.
2. **Mitigation.** Another strategy is to start mitigating the impact of an eventual end of the CBERS project, through two avenues. First, invest in smaller projects with higher frequency of launch. The establishment and operation of the Brazilian Microsatellite Launch Vehicle (VLM) dedicated to small satellite orbital delivery will be paramount for increasing the space project cycle turnover rate. Second, invest in downstream data use, by developing software that can exploit the images already available, because these downstream endeavors account for the largest revenue share of space activity. This investment should consider interstate relations between Rio de Janeiro and São Paulo, since a large part of the industry seems to be simultaneously located in both parts of the Brazilian southeast.

5. Final considerations

As final considerations, it is important to present research limitations and next steps of inquiry.

I believe that the definitions of risk, risk event, uncertainty, probability, and impact suffice for the goals of this research. However, I would like to see if more complex definitions of these terms could open new variable frameworks to analyze political events related to international cooperators and trade relations. In particular, I would like to research how Nicholas Taleb's suggestion to divide decisions in four quadrants considering complexity and impact on outcome can be merged into the political risk mathematical entity used in this paper (Taleb, 2010). It could be possible that this research did not account for every variable necessary to monitor the aerospace risk culture, for it is unclear how much the concept of complexity can be derived from the variables measured in the survey.

Another good lead to further improve the risk model used here would be to follow the works of Frank H. Knight. In Risk, Uncertainty, and Profit he suggests that risk is a conceptual consequence of randomness with knowable probabilities and uncertainty is randomness with unknown probabilities. Indeed, the notion of uncertainty used in this work was different from that of Knight, for, here, uncertainty is an event perceived as having a probability close to 50 %. (Knight, 2021). Such difference of conceptualization, however, does not alter the validity of the current model, because an event that has an equal chance of happening or not happening can also be described as uncertain. It seems to be the case that Knight's conceptualization refers to a more radical situation of uncertainty, when it is impossible to define the probability of an event, thus hindering the possibility of allocating the occurrence of such event close to the 50% line of a risk chart. Therefore, it would be interesting to see how Knight's conceptualization of uncertainty can allow for the inclusion of new types of risk events in the risk model, further expanding the approach to include cases of events that are so radically unpredictable that they might not be possible to plot in the probability Y axis.

In order to do this, however, it will be important to understand if Knight's approach can work with the idea of probability as a perceived variable. In the present model the notion of probability, as well as impact, were not derived from

the statistical analysis of previous events, but from the perception of the social agents regarding the risk event in question. Knight's approach favors a characterization of risk and uncertainty depending on the objective probabilistic chance of an event occurring and the model used here considers the probability and the impact according to the intersubjective value for these variables attributed by the social agents that were part of this study, regardless of the actual probability of such an event occurring.

In next editions of this study, this research could consider using the CNAE cods for Brazilian companies to identify every company in the Brazilian space sector. Doing so would increase the sample number, which is indeed a limitation of the present work. It will be important to expand the geographical scope outside of the Rio de Janeiro - São Paulo region, but since the industry is largely concentrated in these states, such limitation did not hinder the results. Differently, the lack of independent verification of geographical positioning of the subjects' headquarters. However, it will be hard to bypass this problem without exposing the identity of respondents. This researcher also excluded academics, government institutions and enthusiasts from the research to narrow the scope of this work. However, in next editions of this study it would be interesting to include such agents. One approach could be to identify enthusiasts of the sector, using LinkedIn search system, querying for the words "aerospace", "space", "aeroespacial" and "espaço". By using the Lattes CV, it would be possible to identify relevant academics in engineering and other fields

Moreover, investment in confidence building with possible respondents will be paramount to increase the number of social agents that respond to the survey. This research had to deal with a sense of insecurity of some of the respondents that did not fell comfortable answering the questions. Also, the fear that the information in this research would be used for commercial gain also hindered the response levels. To counter this, this research followed strict ethical guidelines from PUC. Future measure to improve trust could include: i) write a legally biding contract with a lawyer specialized in the Brazilian Law for Data Protection (LGPD) to assure public compliance to data protection; ii) Visit the Space BR and other trade fairs in the area, to establish a personal contact with the respondents; iii) Share a video explaining this research project together with the

email; iv) Continue doing this research yearly in the hope to gain trust from the sector.

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