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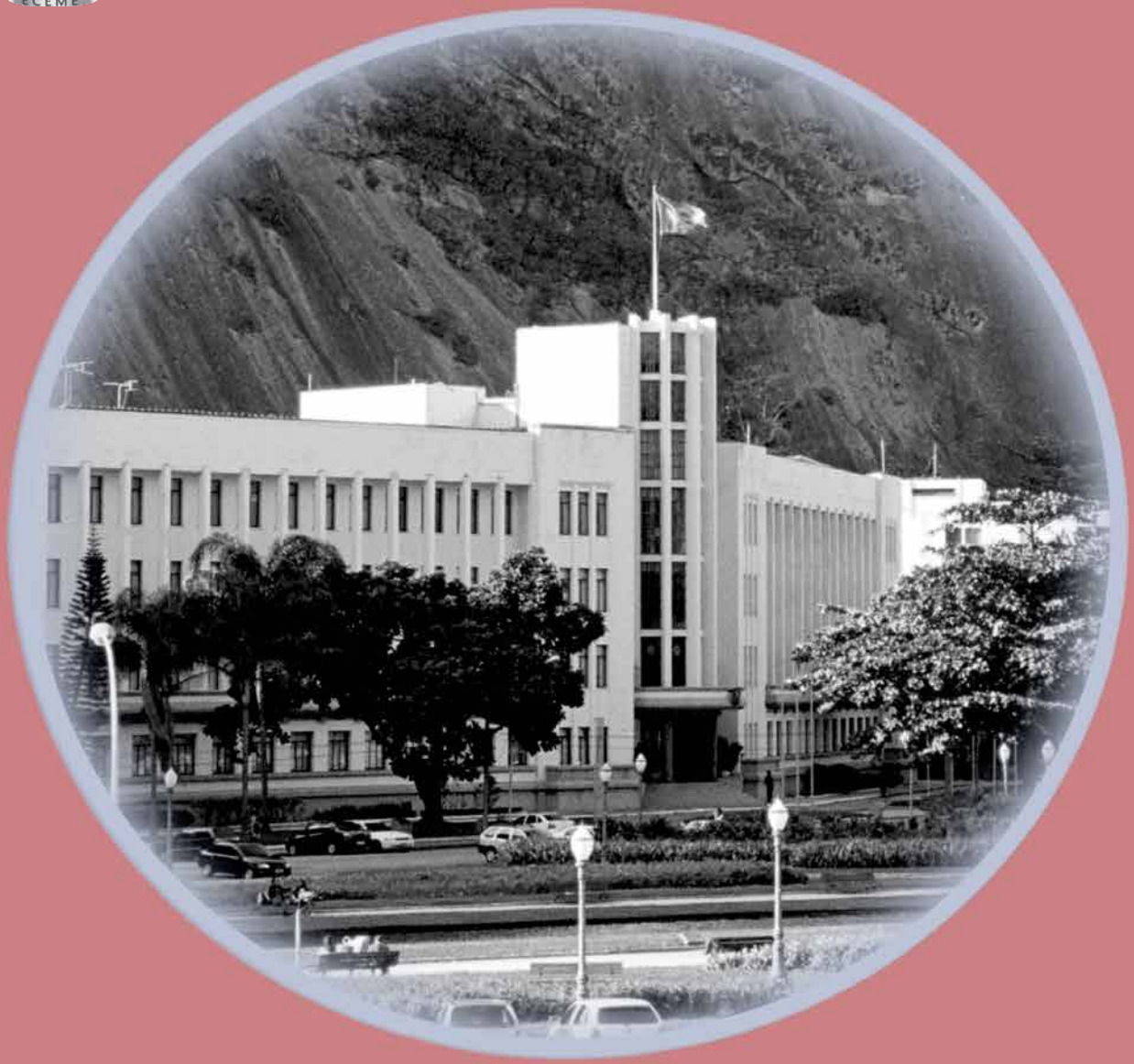

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PROFESSIONAL ANALYSIS

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The War in Ukraine and beyond: some contributions from the Meira Mattos Collection to the reflection on the current conflict and other topics.

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On February 24th the world witnessed the Russian invasion of Ukraine. In a matter of days the Russian Army reached the vicinity of the capital Kyiv, while other fronts were advancing towards their objectives in southern Ukraine and the Donbass region. The Ukrainian Army offered all possible resistance to the Russian advance. In parallel with the military campaign, the use of non-kinetic means was present from the very beginning of the conflict. Campaigns in the media sought to disseminate their arguments and versions, seeking to consolidate the constructed narratives and to seek support from allies. A few weeks later, member countries of the North Atlantic Treaty Organization (NATO) began to provide support in terms of resources and equipment. The material and political support of NATO countries has been growing successively – at all times – creating a real 'proxy war'. The conduct of the war has gone beyond the limits of the Theater of War in Ukraine and the strategies of employing military means, showing the world the use of other expressions of national power (economy, diplomacy, communication and others) to achieve the goals set by each of the sides involved.

The use of other expressions of national power in the conflict, while at the same time broadening the limits of the Theater of War, is not new to scholars of war.

The Meira Mattos Collection, over the past few years, has published studies that collaborate to understand these dynamics, whether Russian or Western. Articles such as "Russian Reflexive Control: military theory and applications" (CROCE, 2021), explain in detail the use of information instruments to induce enemy decisions. Also presenting the phasing of the nation's engagement in a war, prepared by Army General Valeri Vassilievitch Gerassimov, current commander of the Russian Armed Forces, and his staff, as a way of translating the Russian national objectives outlined and matured since the period of the First Minister Yevgeniy Maksimovich Primakov (1989-1999). Other articles have also discussed the geopolitical aspects of the National Strategy of the Russian Federation (DE FREITAS COUTINHO, 2020). In order to think about the non-kinetic characteristics of war and its impacts, the text "The Two Dimensions of Financial Warfare" brings some reflections (SILVA AZEVEDO, 2021). The use of mercenaries and/or volunteers from other countries who are not regular soldiers of

the Russian or Ukrainian armies is nothing new, as they have been employed in different conflicts and scenarios throughout history. In this sense, the article "The Impact of Private Military Companies in Military Operations" (NYATI, 2021) can help a reader to reflect on the topic. Two interesting reflections on the understanding of war and the characteristics and limitations of the employment strategies by the western armed forces can be found in the articles: "The art of war in the 21st century: advancing to the Multi-Domain Battle" (SANTOS et al., 2019) and "Winning in multi-domains is not enough: thoughts on the new doctrine and the gray zone conflicts" (VISACRO, 2020).

Leaving the war in Ukraine, the current issue brings a series of articles that present other important topics for thinking about National Defense in its various dimensions. Observing issues related to areas affected by Science, Technology and Innovation: "Anomaly Detection in the Global Innovation Index's Indicators" (GALDINO; FRANÇA, 2022). An analysis of the strategic projects of the Brazilian Air Force (FAB) can be found in: "FAB Dimension 22 in terms of defense and integrated security: analysis of the FX2 Gripen and KC 390 Millenium strategic projects" (SANTOS, 2022). Bringing contributions to think the theme of victory, from a point of view of military history, we have the article "Victory Beyond Superiority: How the Allies won the World War II in Europe" (MACEDO et. al. 2022). Still in dialogue with the theme of the recently released dossier on borders and integrated security (ESPÓSITO NETO, et. al., 2022), we have the article: "Coordination and planning: central categories in interagency relationships" (FIGUEIREDO; MOREIRA, 2022). The article "Knowledge creation in the Armed Forces: an analysis of the lessons learned systems in the light of the SECI model" (BARROS, 2022) presents internal reflections on the Forces, pertinent to their continuous improvement. Closing the articles section, Barcellos (2022) emphasizes the importance of the military-industrial complex for the economic development process and for the geopolitical strategy of the countries with analysis of the cases USA and China. The edition also brings an interesting article that proposes a dialogue between Machiavelli's work with the area of Science, Technology & Innovation, and the consequences of this evolution in the military expression of national power (GALDINO; SCHONS, 2022).

We hope that readers can benefit from the articles published in the Meira Mattos Collection, either to seek to understand a little better some of the dynamics and strategies related to the current War in Ukraine; or to dive into current topics to think about National Defense in its different facets.

Have a pleasant reading!

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Anomalies Detection in the Global Innovation Index's Indicators

Detección de anomalías en los indicadores del Índice Global de Innovación

Abstract: The measurement of a country's innovation capacity is essential for studies of trends and the identification of bottlenecks in a National Innovation System (NIs). In this context, the indicators utilized by the Global Innovation Index (GII) are crucial, since they support various researches and strategic decisions by investors, entrepreneurs and public agents. However, GII indicators are impacted by methodological changes and suffer from several types of practical problems such as measurement errors or missing data, generating anomalies in analyzes. Based on the premise of innovation incrementalism, the concept of anomaly was defined and a method was developed to automatically detect them, while classifying those resulting from methodological changes in opposition to those resulted from practical problems. The proposed method was applied to the indicators from the innovation outputs of Brazil, from 2013 to 2019, released by the GII.

Keywords: Innovation Index; Incrementalism; Global Innovation Index GII; National Innovation Systems.

Resumen: Medir la capacidad de innovación de un país es fundamental para realizar estudios de tendencias e identificar cuellos de botella en un Sistema Nacional de Innovación (SNI). En esta línea, se destacan los indicadores utilizados por el Índice Global de Innovación (GII), que sustentan diversas encuestas y respaldan las decisiones estratégicas de inversores, emprendedores y agentes públicos. Sin embargo, a lo largo del tiempo, los diversos indicadores de GII sufren cambios metodológicos y adolecen de diversos tipos de problemas prácticos, como falta de datos, lo que dificulta el análisis de tendencias. Partiendo de la premisa del incrementalismo de la innovación, se definió el concepto de anomalías y se diseñó un método para detectarlas automáticamente, además de clasificarlas como resultantes de cambios metodológicos, frente a inconsistencias, que involucran problemas de orden práctica. El método propuesto fue aplicado a los indicadores de los Productos de Innovación de Brasil, de 2013 a 2019, publicados por el GII.

Palabras clave: Indicadores de innovación; Incrementalismo; Índice Global de Innovación GII; Sistemas Nacionales de Innovación.

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1 Introduction

The efficiency of the National Innovation System (NIS) is essential for economic growth (LUNDVALL, 2010) and the development of important technologies to ensure a country's sovereignty (GALDINO, 2019; SCHONS; PRADO FILHO; GALDINO, 2020). Therefore, having reliable indicators capable of evaluating the performance of a country's NIS is fundamental to subsidies studies and analyses aimed at identifying bottlenecks and trends in the NIS (AVELLAR; BRITO, 2015), gathering information to establish policies and strategic actions aimed at increasing innovation capability both nationally and sectorally (SANTOS, 2014; SCHONS; PRADO FILHO; GALDINO, 2021), and evaluating the effectiveness of policies and strategic actions in place (KHEDHAOURIA; THURIK, 2017).

Among the main innovation indicators at the national level, the *Global Innovation Index* (GII) (DUTTA, S. et al. 2018; KOSE; TOPÇU, 2016), which infers the capability of a NIS from an aggregate of about 80 variables, here called baseline variables (BV), stands out.

Innovation indicators, such as those produced by the GII, attract the attention of specialists, public agents, entrepreneurs, and investors. To exemplify the effects that these indicators can produce in the public sphere, we bring up a recent case that occurred in Brazil. Motivated by Brazil's poor results disclosed by the GII indicators, the Brazilian Federal Audit Court (Tribunal de Contas da União – TCU) audited public policies related to the area of innovation and concluded that there was a need for studies to be coordinated by the President's Office and by the Ministry of Science, Technology, Innovation and Communications (BRASIL, 2019) aimed at creating an efficient and effective National Innovation Policy that would be able to improve the country's position in the innovation *ranking* (SCHONS; PRADO FILHO; GALDINO, 2020). The TCU is an example of a public organ that has been expanding its field of action, starting to evaluate not only the formal aspects of the legality of procedures, but also the performance and results achieved by other organs and public entities (GOMES, 2006).

Released annually since 2007, the GII indicators treat innovation broadly, considering in their metrics variables that measure investments in research and development (R&D), invention patents and scientific articles, as well as others that capture information about institutions, infrastructure, human resources and research, market, aspects linked to the business sector and innovation products (DUTTA et al., 2018). The large number of countries evaluated and the availability of a voluminous database make these indices even more attractive for the analysis of a country's innovation capability (KOSE; TOPÇU, 2016), particularly since 2013, when the architecture of the indicators consisting of indices, sub-indices, pillars and sub-pillars was inaugurated.

Despite the maintenance of this architecture, the calculation of the indexes, sub-indexes, pillars, and sub-pillars of the GII depends on base variables that are prone to methodological changes, given the incessant search for improvement in the understanding of the innovation phenomenon and its measurement forms (JANGER et al., 2017). These sometimes

expressive changes, such as the inclusion or deletion of baseline variables (DUTTA et al., 2018), generate anomalies in the temporal evolution of indicators (indexes, sub-indexes, pillars, and sub-pillars of GII) that can lead to erroneous conclusions about NIS.

In addition to GII methodological changes, other anomaly-generating factors can compromise the accuracy of trend analyses and capability bottlenecks of an NIS (DUTTA et al., 2018), making it critical to develop procedures capable of gauging on the reliability of baseline variables. An important step in this intent is to detect and classify these anomalies.

Another fundamental aspect in the contextualization of this article comes from the premise that national scope policies tend to provoke incremental effects (FAGERBERG; MOWERY; VERSPAGEN, 2009; GROENEWEGEN; STEEN, 2006; MICALE, 1990; SOGNER, 2009), specifically producing in the NIS long-term effects with slow and gradual changes (NELSON; WINTER, 1982). This premise highlights the importance of analyses that consider indicators from successive years (hereafter called evolutionary analysis) as opposed to those that adopt only indicators from a single year (here defined as static analysis), because they facilitate the study of trends and analysis of the results of innovation policies (FAGERBERG; MOWERY; VERSPAGEN, 2009; GROENEWEGEN; STEEN, 2006; SOGNER, 2009), assisting in the diagnosis of the benefits of innovation strategies on the competitiveness and economic growth of a nation (LUNDVALL, 2007).

Additionally, this premise suggests that there is a "pattern of normality" whereby "reliable indicators" that capture the results of these public policies do not tend to change abruptly over time. In this paper, anomalies refer to abrupt changes in the behavior of innovation indicators in the short term, such as within a year. Under normal conditions, abrupt changes in a country's indicators are unlikely, as they violate the expectation of incremental changes of a NIS over time (NIOSI et al., 1993). The existence of this normality pattern enables the use of time series analysis tools to identify inconsistencies in the innovation indicators, particularly in those of GII.

However, to the best of the authors' knowledge, the studies using GII indicators to analyze trends, bottlenecks, and capability of a NIS disregard or pay little attention to possible problems caused by anomalies in the data used in the analysis. Here, it is argued that these abnormalities can cause erroneous conclusions about the results of policies and strategic actions directed to the area of innovation, harming both analyses and investments and strategic planning. It is necessary to develop procedures capable of making inferences about the reliability of the data before they are used in trend studies. An important step in this intent is to detect and classify the anomalies of the indicators.

In this context, this work aims to conceptualize anomalies, classify their types, and propose a procedure to identify them in an automated way, considering the measurements of the BV of GII. The proposed method is evaluated for Brazil's Innovation Products from 2013 to 2019.

The remainder of this article is organized as follows. Section 2 provides a literature review of studies using GII indicators in static and evolutionary analyses, as well as discusses the existence of anomalies in these indicators and the difficulty they impose on analyses. Section 3 briefly discusses the concept of anomaly in the literature of statistics. Section 4 discusses the premise of incrementalism in National Innovation Systems. Section 5 discusses the methodology adopted in this work. Section 6 presents the case study for the application of the proposed method. Finally, discussions of the results achieved are presented in Section 7 and main conclusions of the work are presented in Section 8.

2 The use of the gii in the analysis of national innovation systems

The performance of a NIS expresses the national innovation capability, defined as the ability of a country to manage its resources to produce new knowledge, transforming it into technologies and products for the benefit of the entire economic system (FAGERBERG; SRHOLEC, 2008). The national innovation capability is assessed not only by the innovation outputs produced by the system itself, but also through the innovation inputs, often resulting from public policies, which are indispensable to create a favorable environment for the generation of innovations (KHEDHAOURIA; THURIK, 2017).

Several studies that rely on the GII indicators are conducted with the aim of analyzing the impact of innovation policies and comparing the innovation capability of countries. For example, from the 2015 GII database, Jankowska, Matysek-Jędrych e Mroczek-Dąbrowska (2017) analyzed the correlation between innovation inputs and outputs and found that 23 countries do not exhibit the expected positive correlation between these factors, among them Poland and Bulgaria. While Poland had high innovation efforts and unsatisfactory products, Bulgaria had the opposite situation.

Considering the 2015 GII data, Crespo e Crespo (2016) identified combinations of indicators that can deliver excellent innovation performance, which differ for high-income versus low-income countries. This study is in line with others that indicate that the public policies necessary to promote innovation should be particularized according to the country's level of development (KONDO, 2001).

Other static analyses are presented in the GII reports. For example, in the 2018 report (DUTTA et al., 2018), it is discussed and compared leading countries in the high- and middle-income economy groups. Based on the data in this report, Saisana, Domínguez-Torreiro, and Vértesy (2018) seek to establish statistical consistency among country inputs, outputs, and classifications, making inferences about anomalies and measurement errors in the data. Similarly, Famalika e Sihombing (2021), based on the GII 2018 data, compared two cluster analysis techniques to group different countries with similar performances.

However, while static analysis can make inferences about a country's innovation capability at a given point in time, it is especially limited for trend studies. In order to overcome these difficulties, it is necessary to use analyses that consider time series of indicators. Regardless of the benefits, evolutionary analyses are quite complex because of the anomalies.

Using the approach known as *Fuzzy*-set Qualitative Comparative Analysis (fsQCA) methodology (RAGIN, 2008), Khedhaouria and Thurik (2017) arrived at different combinations of innovation inputs that provide the greatest impact on national innovation capability. To do this, they analyzed the GII database between 2012 and 2015. However, they mentioned that the lack of some indicators and the occurrence of anomalies made it impossible to conduct a more comprehensive survey.

Milenkovic et al. (2019) analyzed the correlation between GII and SSI (Social Sustainability Index) indicators for the period from 2010 to 2016. The authors reported difficulties in conducting the study because of changes in GII variables and methodologies after 2010.

Based on the GII indicators from 2008 to 2013, Franco e Oliveira (2017) analyzed the NIS performance of the countries that make up the so-called BRICS (Brazil, Russia, India, China, and South Africa). In this study, the authors used a regression analysis to determine the correlation between innovation inputs and innovation outputs and inferred the impact of each indicator on the country's *ranking* in the GII. However, the authors encountered methodological changes and other anomalies present in the GII reports from 2008 to 2013.

Using the GII indicators from 2013 to 2017, Galdino (2018) performed trend analysis of NIS by grouping countries into quartiles according to the value of innovation indicators. Despite the important findings, this work did not detect, classify, or treat the anomalies. Employing the same indicators, Galdino (2019a) identified bottlenecks and trends in the Innovation Inputs of Brazil's NIS. In this study, the author was faced with missing data, methodological changes from GII, and variables with abnormal values. To try to overcome the effects of these problems in identifying bottlenecks and trends, counterfactual exercises were performed. However, he did not generalize the procedure adopted, nor did he propose a technique to identify anomalies and treat the problems identified automatically; an empirical procedure was adopted.

Drawing on data from China's *World Economic Forum* from 1996 to 2012, Wang, Zhao e Zhang (2016) analyzed China's NIS with a focus on the time lag between investments in innovation input and outputs in terms of innovation outputs. In this study, the authors found missing data in the variable that measures the collaboration between industry and academia for the period 1996 to 2006 and filled in the time series considering 2007 data as missing values, without discussing the effects and justifications as to the relevance of this procedure.

The GII itself recognizes, in its Annex 2, the existence of the factors that generate anomalies in its base variables and therefore recommends caution in the evolutionary analyses (DUTTA; LAVIN; WUNSCH-VICENT, 2017). For example, in the 2017 report, an evolutionary analysis of the performance of the top ten countries over the previous five years is conducted. In this analysis, significant changes in the Netherlands' *ranking* are observed, particularly, between the years 2015 and 2017, and it is commented that this may have occurred as a result of methodology changes or lack of data, suggesting that the abrupt change in the Netherlands' position in the world *ranking*s would not be reliable. However, GII does not delve into the analysis of this issue, nor does it discuss how to solve any anomaly problems (DUTTA et al., 2018).

Finally, in an attempt to avoid anomaly problems, some studies, such as the one conducted by Porto e Memória (2019), restrict the analysis period by suppressing the years that contain anomalies. Others use simple procedures in an attempt to mitigate anomalies, such as repeating data or using averages to replace non-existent data. There are also those works that are silent on this issue. The importance of identifying and treating anomalies in time series is emphasized by Refaat e Hadi (2018) as an essential mechanism to increase the reliability of the analysis and to describe more accurately the phenomenon under study.

Therefore, in general, the analysis of time series of innovation indicators of a NIS can generate misleading conclusions about the behavior of a country, if an efficient and effective method of identifying and correcting anomalies is not adopted.

3 Anomalies in time series

In statistics, an anomaly, or *outlier*, , can be defined as an observation that deviates greatly from the others, causing suspicion as to how it was generated (HAWKINS, 1980). In other words, an anomaly represents a nonconformity with respect to an expected behavior, and is considered an exception (CHANDOLA; BANERJEE; KUMAR, 2009). Anomaly detection has been studied in a variety of applications, such as intrusion detection in *cyber* defense, credit card fraud detection, or fraudulent accounting in industry (BLÁZQUEZ-GARCÍA et al., 2021; GUPTA et al., 2014). Many of these studies are based on time series analysis (GUPTA et al., 2014).

Some methods for anomaly analysis in time series have been proposed, aiming, for example, at model training according to anomaly class, threshold optimization to improve anomaly detection, or time series prediction based on *deep-learning* – (BUDA; CAGLAYAN; ASSEM, 2018). However, the techniques, their parameters, and performances obtained depend essentially on the application, and are therefore difficult to generalize to a diverse range of problems (BLÁZQUEZ-GARCÍA et al., 2021).

4 Public policies and the incrementalism of innovation

Given the large number of unknown variables that influence or are influenced by public policy, policy makers often take conservative positions when making decisions about spending, budgeting, taxes, and other social factors (AINSWORTH; HALL, 2011; CARDOSO JÚNIOR; CASTRO, 2016; WILDAVSKY, 1966). As a consequence, public policies hardly make abrupt changes in the national reality (MICALE, 1990). They usually produce effects or results slowly and gradually, as suggested by the theory of incrementalism (LINDBLOM, 1959). Incrementalism, in

this context, is equivalent to marginal changes that occur in small steps, continuing the patterns of thought and modus operandi already accepted by society (BRAYBROOKE; LINDBLOM, 1970; TEIXEIRA; MISSIO, 2011; WILDAVSKY, 1966).

In the field of technological innovation, incremental innovations, which in essence produce small changes, are more frequent than radical and disruptive ones (DOSI, 1982; FREEMAN; SOETE, 1997; JANGER et al., 2017; LUNDVALL, 2010). In many cases, radical innovations can jeopardize the return on investment of technologies that are widespread and accepted in the market, causing large companies to adopt conservative stances, to the detriment of the launching of novelties that might harm the products or services being comercialized. This trend, therefore, has led to a greater occurrence of incremental rather than radical innovations in various industries (JANGER et al., 2017).

Additionally, the incremental condition of innovation tends to be more intense in emerging countries, whose technology-based companies usually start their business from technologies acquired from foreign companies (HOBDAY, 1997; KIM, 2005). In these countries, these companies often adopt innovation techniques by imitation, do not master critical technologies, and engage in a gradual and increasing process of learning and accumulation of technological capabilities (FIGUEIREDO, 2004; KIM, 2005).

It is worth noting that even when radical innovations occur in the business environment, their signs manifest themselves early and progressively, and can be captured by the various variables of a NIS, such as those related to the indication of investments in R&D, scientific publications, patents, creation of startups, etc (MAZZUCATO, 2014).

Therefore, radical innovations are the result of actions that take place over time, from the emergence of ideas and inventions that develop, traveling a long way until they become successful products and services (TROTT, 2008). The "radical" effect is perceived from the market's point of view, where both the end user and the companies promoting these innovations are faced with changes in habits, competencies, capabilities and procedures (AFUAH; BAHRAM, 1995). Every innovation considered radical to an entity that receives it, such as the final consumer or a large integrating company, results from a laborious process of incremental innovation undertaken by the entity that provided it, such as component supplier companies (AFUAH; BAHRAM, 1995). Innovation, therefore, can be considered as a phenomenon that occurs in modern society, whose processes happen gradually and cumulatively, and may even arise from combinations of pre-existing possibilities and components, that is, future innovations are always dependent on the past (LUNDVALL, 2010).

In this conjuncture, radical innovations, important in the business context for its reflexes on the increase of productivity and competitiveness of the companies (AFUAH; BAHRAM, 1995; MAINE; THOMAS; UTTERBACK, 2014; SCHUMPETER, 1961), do not necessarily cause abrupt changes in a NIS (NIOSI et al., 1993). According to evolutionary theory (NELSON; WINTER, 1982), dominant design and technological regimes evolve in incremental cycles, causing nationwide systemic changes to occur slowly.

Given all the above, it is reasonable to admit that reliable NIS indicators do not experience abrupt changes over time. In this paper, the **Incrementalism of Innovation** is a concept that refers to the process in which the signals or effects of incremental and radical innovations are captured progressively by innovation indicators implemented at the national level, such as those of the GII.

5 Methodology

Initially, from an exploratory approach, and based on the incrementalism of a country's innovation capability, the concept of anomalies was formalized. It is worth pointing out that exploratory studies are adequate when there is little known about the reality in question and the intention is to open a path for new research (YIN, 1994).

Secondly, based on bibliographic research, using scientific articles, and documentary research, using GII reports, an attempt was made to identify the frequency of occurrence of anomalies in GII data and the effects of these anomalies on NIS analyses. All these anomaly-generating factors were triangulated across the various documents collected, thus enhancing the internal validity of the research (RIEGE, 2003).

Third, adopting incrementalism and Gaussian modeling of GII's BVs as assumptions, and using statistical inference tools, a method for automatic anomaly detection was developed. It is worth mentioning that, at first glance, one might think that the simplest way to detect anomalies is to consult the GII reports themselves. However, this approach is laborious, inefficient, and ineffective. The GII works with a very large set of variables (on the order of 80) and collects data from about 200 countries, so manually analyzing all this data in detail to identify problems takes a lot of time. Additionally, data collection or processing problems are not often pointed out in the reports. Moreover, the mere identification of anomalies is not enough to infer about possible problems in the NIS analyses, because in some cases they have little influence on the BV values. The key point is to identify the main anomalies, in the sense of their impact on the countries' assessment, and to classify them according to specific categories in order to deal with them appropriately.

Fourth, the classification of anomalies is performed, with the support of the GII reports, according to two categories: methodological and inconsistencies. As methodological changes are considered changes in the calculation of the baseline variables, as well as the inclusion and exclusion of BV. It should be noted that despite improving the quality of the indicators and accommodating the improvements in the understanding of the innovation phenomenon, it was found that these modifications often cause disturbances in the time series, constituting sources of anomalies, from the perspective of incrementalism. Inconsistencies, on the other hand, include practical issues such as missing data and problems in data generation, collection, and processing.

Finally, analysis of the functioning of the proposed procedure was performed discussing its use in Brazil's Innovation Product indicators for the period from 2013 to 2019.

5.1 Método propuesto para detectar y clasificar anomalías

The time series of the GII baseline indicators, as previously discussed, may contain several anomalies capable of impairing the reliability of studies on a country's NIS. The concept of the incrementalism of innovation, explored in Section 4, suggests that mild variations of GII indicators occur in consecutive years. In this work, a methodology is proposed to identify data that deviate from this normal pattern, a condition understood as very significant variations in a short interval of time for phenomena that manifest themselves nationwide. To reduce subjectivism regarding the employment of incrementalism and to avoid a fruitless discussion aimed at quantifying the meaning of "very significant variations," the methodology employs hypothesis testing to identify the supposedly anomalous situations. In summary, in this paper, it is proposed to adopt probabilistic modeling to describe GII's BVs, and from this modeling, a statistical test is constructed to infer about the "normality" of the data disclosed in GII's reports.

The GII background variables infer about complex phenomena that result from the influence of many unknown factors. Considering that these factors are probabilistically modeled and that they combine to generate the physical phenomenon measured by the BV, one can resort to the classical Central Limit Theorem and admit as valid the assumption that these variables can be described by Gaussian distributions, whose statistical parameters (mean and variance) remain practically constant over time, due to the assumption of incrementalism. Therefore, the time series of the GII baseline variables can be defined as a sample function of a Gaussian stochastic process.

Considerando que existen N_{VB} baseline variables over J ayears, which are represented by X_{ij} , para i = 1,2, ..., N_{VB} e j = 1,2, ..., J, where j = 1, is the index specifying the first year of the time series and y $j = J$ the last year. Let μ_{ij} and σ_{ij} , be, respectively, the mean and standard deviation of X_{ij} .

Therefore, the random variable Z_i for i = 1,2, ..., N_{VB} is defined as follows:

$$Z_i = \sum_{j=1}^{J} X_{ij}^2 \quad \text{Eq. 1}$$

has a chi-square distribution with $GL = J-1$ degree of freedom.

The test variable S_i, associated with the i-th GII baseline variable X_i is defined as follows:

$$S_i = \sum_{j=1}^{J} \left[\frac{\left(X_{ij} - \mu_{ij} \right)^2}{\mu_{ij}} \right] \quad \text{para} \quad i = 1, 2, \cdots, N_{VB}. \quad \text{Eq. 2}$$

Adopting the premise of incrementalism, one can admit as insignificant eventual changes in the statistical parameters of the random variables that model the baseline indicators, especially when considering a time interval of a few years. Therefore, one can approximate the random variable S_i by:

$$S_i = \sum_{j=1}^{J} \left[\frac{\left(X_{ij} - \mu_i\right)^2}{\mu_i} \right] \quad \text{para } i = 1, 2, \cdots, N_{VB}. \quad \text{Eq. 3}$$

Estimating the mean from the time series data of the baseline indicators, Eq.3 can be obtained, in practice, as follows:

$$S_i = \sum_{j=1}^{J} \left[\frac{\left(X_{ij} - \hat{\mu}_i\right)^2}{\hat{\mu}_i} \right] \quad \text{para } i = 1, 2, \cdots, N_{VB}. \quad \text{Eq. 4}$$

Where $\hat{\mu}_i$ is an unbiased estimator of the mean of X_i, , obtained from the data made available in the GII reports for the years under analysis. In this context, S_i eexpressed by Equation 4, it can be well approximated by a chi-squared random variable.

Taking S_i cas the test statistic, a hypothesis test can be defined to verify if the observations of the i–th indicator follow a Chi-square distribution, a fact that can serve to infer about the normality of the data disclosed by GII, since this statistical modeling was obtained considering restrictions imposed by the incrementalism premise.

The following definition of the null hypothesis of the Hypothesis Test is proposed: "there is no evidence of anomalies in the data". This means that the data are well behaved, oscillating around the arithmetic mean of the values obtained for the years considered $\hat{\mu}_i$, sfollowing a Gaussian distribution, in which the test variable, under the assumption of normality, has a Chi-square distribution. Abrupt changes would be taken as an indication of the occurrence of the alternative hypothesis defined as "there is evidence of abnormality in the data disclosed by GII". This hypothesis test is supported by the perspective that it is unreasonable for innovation indicators at the national level to present abrupt variations. Again, this does not mean that the BV should not change over time, but that it should behave like a Gaussian random variable whose statistical parameters change incrementally over time.

Therefore, if the null hypothesis is true, S_i, the test statistic, follows a Chi-square distribution. The risk of this hypothesis being rejected erroneously (Type I error) is called the significance level, α, usually a value much smaller than 1. That is, when the hypothesis test indicates as being true the normality of the data, according to the definition presented here for this condition, there will be a $1-\alpha$ probability that this assertion represents the truth of the facts, with this value being as close to 100% as desirable, assigning an appropriate α.

Confirmation of the null hypothesis will occur when the observation is within the region of acceptance, or, similarly, outside the region of rejection. Since this is a one-sided test, these regions are delimited by a single critical value (cV) which serves as a reference for comparison purposes for the test variable. That is, the null hypothesis will be true when: $P(\chi^2_{GL} < cV) = 1-\alpha$, being χ^2_{GL} a chi-square variable with degree of freedom DF, in which cV is defined as the value of α. In the concrete case, the test is as follows: if $S_i < cV$, it is decided for the normality of the data; otherwise, for the occurrence of anomalies.

The hypothesis test presented here separates the baseline variables for a given country into two sets, those that show some kind of abnormality in the data for the years considered in the study and those that follow the normality pattern.

The next step in the method is to classify the type of anomaly from the baseline variables that are supposed to have abnormalities. This is done by reapplying the hypothesis test and using the GII reports.

Initially, the same statistical test is used to identify the years that caused the violation of normality, progressively suppressing data from the time series that presented abnormality and repeating the hypothesis test for the series with suppressed data until the null hypothesis is observed, indicating that the remaining time series data behave according to the expected pattern.

Subsequently, it is verified for the baseline variables and years considered anomalous the occurrence of methodological changes from the GII reports. If no methodological changes are identified, it is decided that there is inconsistency in the data.

Summarizing, the proposed method consists of the following steps:

1. Perform a hypothesis test to determine whether the baseline variables behave in a manner consistent with the theory of incrementalism.

2. Create the $\mathbb{A}$ set of baseline variables that have anomalous data.

3. For each baseline variable in the $\mathbb{A}$, set perform hypothesis testing to identify the years that made the baseline variable anomalous.

4. Create the $\mathbb{B}$ set, formed by the data of the base variables of the years considered anomalous.

5. For each element in the $\mathbb{B}$, set, classify the anomalies between methodological change or inconsistencies, with support from the GII reports.

6 Case study

To apply the proposed method, Brazil's Innovation Product indicators from 2013 to 2019 will be used as a case study. Composed of the sub-pillars "Knowledge Products" and "Technology and Creative Products", the Innovation Products of Brazil, for the period considered, represents a good choice of compromise between space limitation for discussion of the results of the application of the method proposed here and the need to consider a relevant set of GII indicators capable of providing richness of situations involving anomalies.

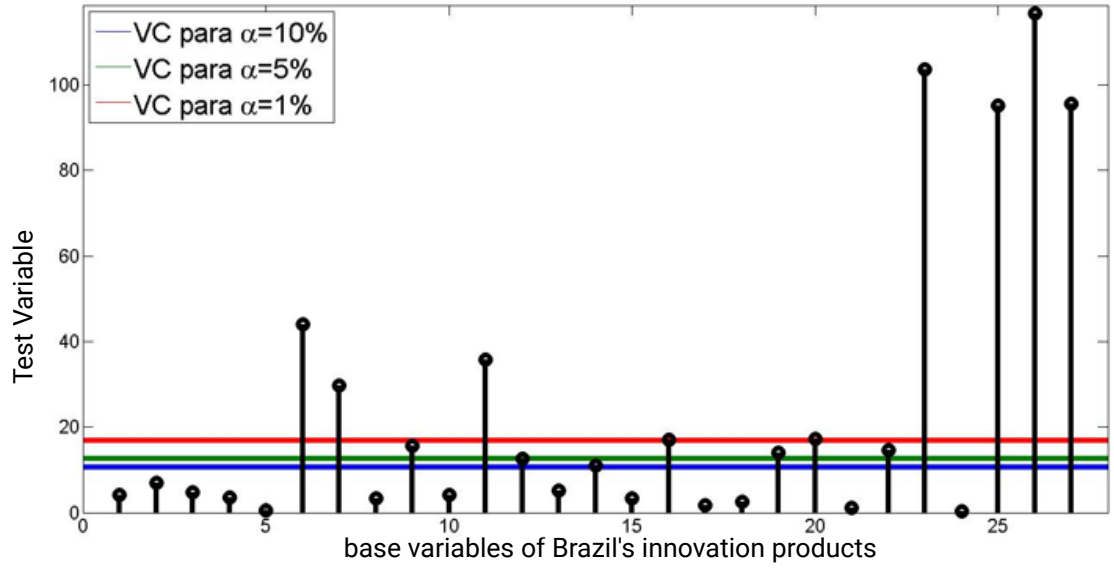
Since the time series contains seven years ($J=7$), the Chi-square variables that model the Hypothesis Tests (HT) have six degrees of freedom ($GL= 6$). Annexx A presents a table with the critical values (CV) to be used in the hypothesis tests, both for the identification of BV with anomalies and the years in which they manifest themselves, in this case the degree of freedom of the Chi-square variable will be less than 6. The results discussed here were obtained for α, significance levels of 1%, 5% and 10%, for these values of α, when the test indicates that the data do not present anomalies, if the proposed modeling adequately cap-

tures the normality pattern in the data, there is, respectively, a 99%, 95% and 90% chance that the data do not present anomalies. Therefore, the analyst can be more rigorous in identifying abnormal data by adopting a small value for α,so that the smaller the value of this parameter the more conservative the test will be, as the probability of false alarm is reduced (that of classifying normal data as anomalous), while at the same time the probability of loss is increased (that is, the probability of not identifying anomalous data). In this way, if the modeling proves to be adherent to the real phenomenon, the analyst can count on an objective criterion to identify anomalies.

To obtain its Innovation Products indicators, GII uses the pillars Knowledge and Technology Products and Creative Products. Each one results from the average of three sub-pillars, which, in turn, are formed by the aggregate of three to five baseline variables, listed in Annex B.

The results of HT are shown in Chart 1, where the colored horizontal lines are the critical values as a function of α and the vertical lines are the values of the test variables of the 27 BVs of the GII Innovation Products for Brazil, indexed by i, as reported in Annex B. When the value of the test variable of the base variable exceeds the critical value, the statistical test indicates that the data of the BV under study do not follow the established pattern, which occurred with 14 of the 27 base variables for α igual al 10%, esta cantidad cae a 13 VB cuando se usa el valor de α equal to 5% and to 9 with α equal to 1%. This behavior of the hypothesis test is objective evidence that the modeling is coherent.

Chart 1– Values of the test variables of Innovation Products and CV as a function α



Source: The authors (2021).

Table 1 presents the list of baseline variables for Brazil whose data are considered anomalous as a function of the value of α.

Table 1 – α Classification of the baseline variables according to the results of the statistical test.

α	i	Code	Variables de Base con Anomalías Conjunto $\mathbb{A}$
0,01	6	6.2.1	Growth rate of GDP per person engaged;
	7	6.2.2	New business density;
	11	6.3.1	Royalties and license fees receipts (% service exports);
	16	7.1.2	Madrid system trademark registrations by country of origin;
	20	7.2.2	National feature films produced;
	23	7.2.5	Creative goods exports
	25	7.3.2	Country-code top-level domains (ccTLDs)
	26	7.3.3	Wikipedia monthly edits
	27	7.3.4	Video uploads on YouTube
0,05	9	6.2.4	ISO 9001 quality certificates;
	12	6.3.2	High-tech exports;
	19	7.2.1	Audiovisual and related services exports;
	22	7.2.4	Printing and publishing output;
			e todas as obtidas com α=0.01.
0,10	14	6.3.4	Foreign direct investment net outflows;
			e todas as obtidas com α=0.05.

Source: The authors (2021).

The analysis that follows will be supported by the Annual Percentage Variation (APV) with respect to the average of the Baseline Variable i between years j e j+1 ($VPA_{i,j}$), defined as follows:

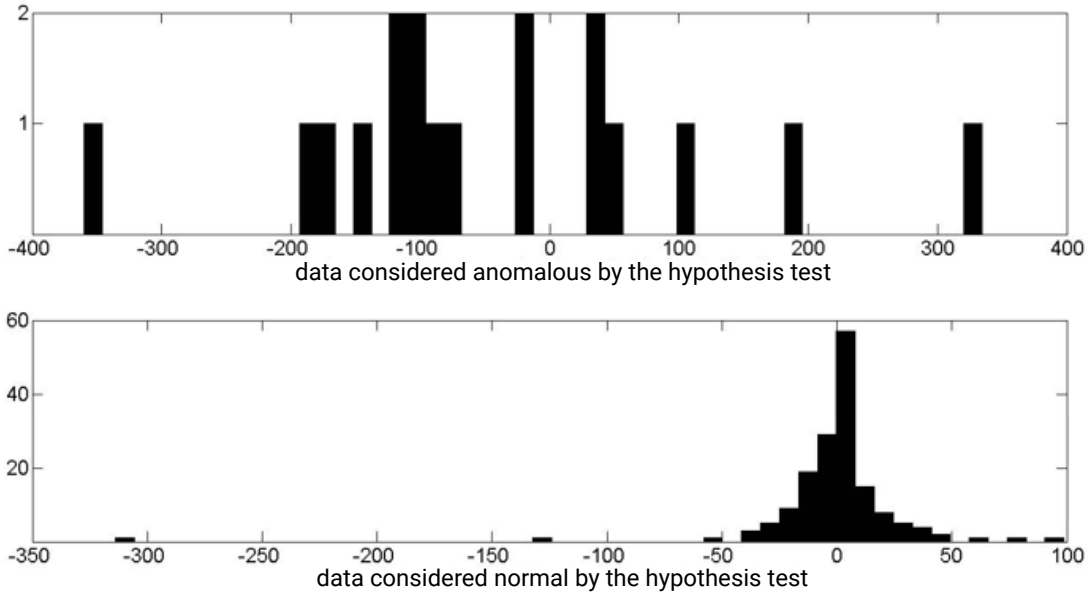
$$VPA_{i,j} = \frac{\left(X_{i,j+1} - X_{i,j}\right)}{\hat{\mu}_i} 100\% \quad \text{Eq. 5}$$

Chart 2 presents the histograms for the percentage variations from the mean of the base variables of the data considered anomalous and normal by the HT with α=0,10. It clearly shows that the Hypothesis Test correlates with the premise of incrementalism, since the aforementioned variations are small for the data considered normal and large for those detected as anomalous. Of the 189 data used to obtain this result (27 baseline variables from 2013 to 2017), 171 were found to be normal, of which in only 6 obtained a percentage variation from the mean of the baseline variable greater than or equal to 50%, which represents only 3.5% of the data. Whereas 14 of the 18 considered anomalous have a percentage variation greater than 50%, or 78% of the data.

Of course, detection procedures are subject to loss and false alarm errors. In this case, it is possible that some anomalies have been classified as normal and some normal data as anomalous, erroneously including both large percentage change values in the lower part of Chart 2 and small percentage change values in the upper part of Chart 2. However, regardless of the inevitable misconceptions of hypothesis testing (probability of loss and false alarm), it can certainly be said that the procedure separates the data into two groups according to the percentage variations from the means of the baseline variables in GII, with

those with smaller variations being considered normal. This is evidence that the proposed test is able to separate the BVs that have abrupt variations from those with mild variations. It is worth reaffirming the consistency of the results presented in Table1 with respect to the value of α. As the value of this parameter decreases, the test becomes more conservative and therefore more sensitive to detect anomalies.

Chart 2 – Histogram of APV for anomalous (top) and normal (bottom) data.



Source: The authors (2021).

Chart 2 presents information related to the baseline variables classified as containing anomalies by the procedure proposed in this paper. This information covers not only the results of the hypothesis test, but also the anomaly classification obtained with support from the GII reports.

To identify the methodological changes that occurred from 2013 to 2019, the GII reports that present the baseline variables of Innovation Products were consulted. Assuming, preliminarily, that the proposed procedure correctly classifies the anomalies, when there is no change in the aforementioned reports, it is concluded that there are measurement inconsistencies (arising, for example, from data generation, collection and processing errors, and lack of data), and this information is detailed in Chart 2.

Methodological changes were verified in six of the fourteen BV containing anomalies (6.3.1, 6.3.2, 7.2.1, 7.2.4, 7.3.3, and 7.3.4). Of these, four produced important percentage variations and were correctly identified by the proposed procedure, including the year in which the changes occurred. The other two BVs with methodological changes (6.3.2 and 7.3.4) were not identified by the proposed procedure. However, in the case of Brazil, as seen in Chart 3, in the years in which methodological changes occurred (2014 in BW 6.3.2 and 2018 in BW 7.3.4)

there were no significant changes in the BVs, so that there is no error in the method. On the contrary, it acted appropriately in pointing out the years in which the main changes occurred in these two BVs.

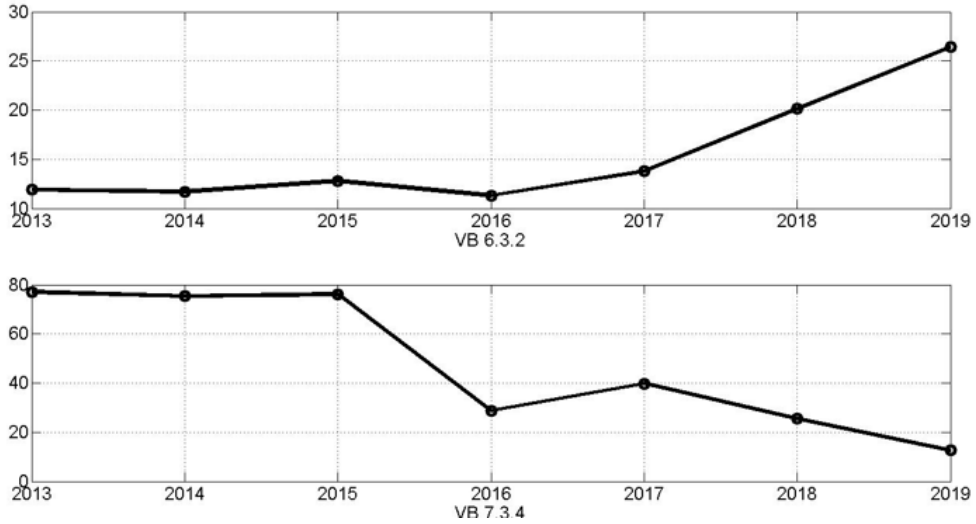
Table 2 – Baseline variables considered anomalous in the Hypothesis Test as a function of the value of α and classification of the anomaly according to the data from the GII reports.

α	Baseline Variable		Years		Type of anomaly Reports	$VPA_{i,j}$
	I	Code	TH	Reports		
0,01	6	6	2017	–	Inconsistency	101,1
	7	6.2.2	2017	–	Inconsistency	-142,8
0,05	9	6.2.4	2017	–	Inconsistency	-70,8*
0,01	11	6.3.1	–	2014	Methodological	0,6*
			2015	**2016**	**Methodological**	**-118,2***
			–	2019	Methodological	-13,1*
0,05	12	6.3.2	–	2014	Methodological	-1,3*
			2017	2017	Inconsistency	41,2
			2018	2018	Inconsistency	40,4
0,10	14	6.3.4	2014	–	Inconsistency	-25,1
0,01	16	7.1.2	2013-2015	–	Inconsistency	**
0,05	19	7.2.1	**2013**	**2014**	**Methodological**	**98,8***
0,01	20	7.2.2	2013	–	Inconsistency	-172,3
0,05	22	7.2.4	2013	–	Inconsistency	-112,7
			2017	**2018**	**Methodological**	**43,2***
0,01	23	7.2.5	2013	–	Inconsistency	-313,8
			2018	–	Inconsistency	-57,5
	25	7.3.2	2014	–	Inconsistency	-179,7
	26	7.3.3	**2016**	**2017**	**Methodological**	**334,28**
			2017	–	Inconsistency	-359,7
	27	7.3.4	2015	–	Inconsistency	-98,9
			–	2018	Methodological	-29,9*

Source: The authors (2021).

Notes:
* In methodological changes, the effect on the change in BV in principle manifests itself in the previous year's APV.
** Data were not provided for BV for the years 2013, 2014, and 2015. APV returned an infinite value.

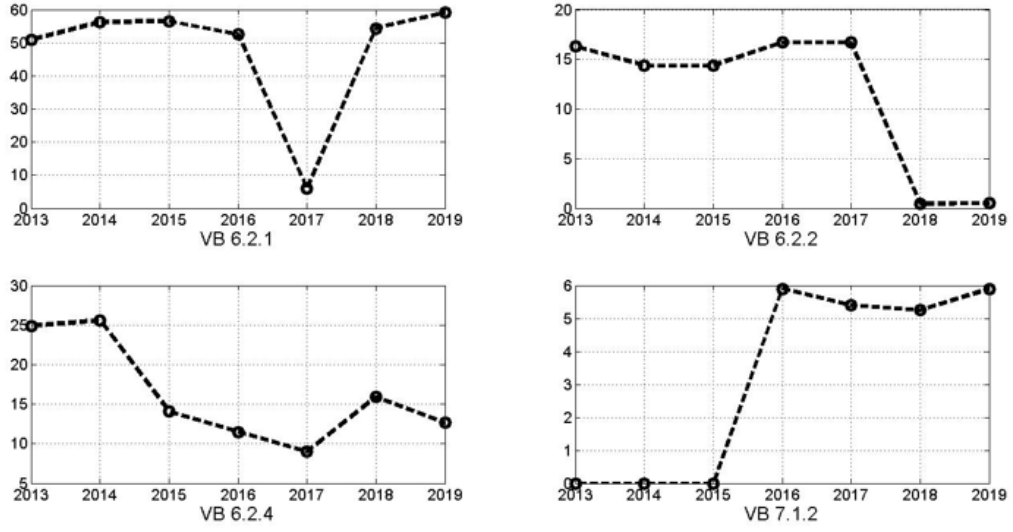
Chart 3 – Time series of anomalous BVs with methodological modifications not identified by TH.



Source: The authors (2021).

Table 3 presents eight BVs in which no methodological changes were found, so, according to the proposed procedure, inconsistencies are inferred. Such BV (6.2.1, 6.2.2, 6.2.4, 6.3.4, 7.1.2, 7.2.2, 7.2.5, 7.3.2) have high APV values. In Chart 4 the evolutions of four of these BVs are presented, in which it is evident that the inconsistencies are associated with significant variations in the indicators that need to be investigated in detail or even treated to correct errors in order to perform trend analyses reliably. In summary, the results summarized in Table 3 indicate that the method was successful in detecting anomalies.

Chart 4 – Time series of anomalous BVs without the occurrence of methodological changes.



Source: The authors (2021).

Tabla 3 –Informaciones obtenidas de los informes del GII para las Variables de Base que no presentaron anomalías en la Prueba de Hipótesis.

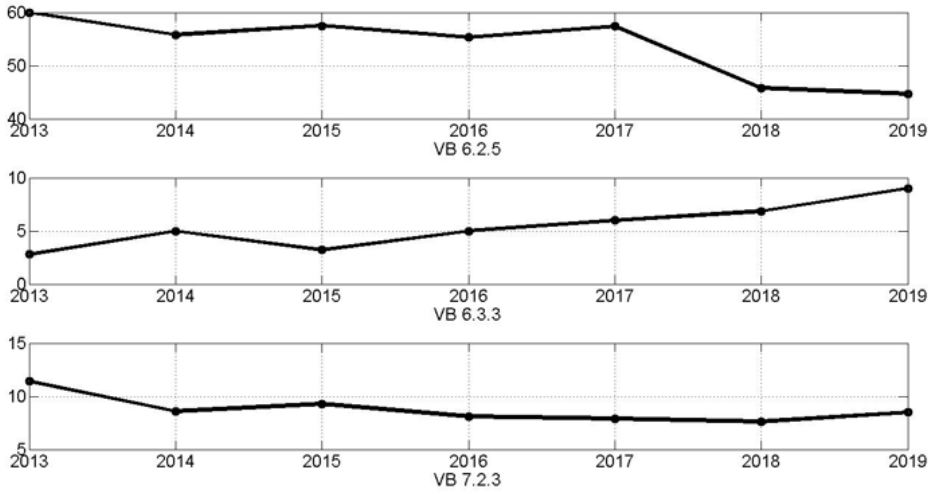
Baseline Variable		Years Reports	Type of anomaly Reports	Percentage Variation Anual* (%)
I	Code			
1	6.1.1	2013	None	80,6
2	6.1.2	2014	None	-125,3
3	6.1.3	2013	None	59,3
4	6.1.4	2017	None	-18,8
5	6.1.5	2014	None	-12,1
8	6.2.3	2013	None	30,6
10	6.2.5	2018	Methodological	-21,5
13	6.3.3	2014	Methodological	40,7
		2016	Methodological	33,3
		2019	Methodological	15,7
15	7.1.1	2013	None	40,1
17	7.1.3	2014	None	-12,2
18	7.1.4	2014	None	-15,2
21	7.2.3	2014	Methodological	-31,9
24	7.3.1	2013	None	-11,3

Source: The authors (2021).

Notes: *When no methodological changes are identified, the maximum APV of BV is presented.

Table 3 presents information from the 14 normal BVs, according to the procedure proposed here. Of these, three (6.2.5, 6.3.3 and 7.2.3) have undergone methodological changes, configuring, in principle, detection error of the statistical test. However, as shown in Chart 5, with the exception of BV 6.2.5, the other methodological changes did not cause significant changes in the indicators for Brazil, which is why it is not reasonable to consider that there was a mistake in the proposed procedure. On the other hand, the methodological change of BV 6.2.5 in 2018 seems to set a new plateau for the indicator, which should have been indicated by the proposed method.

Chart 5 – BV with anomalies that were not detected by the proposed method.

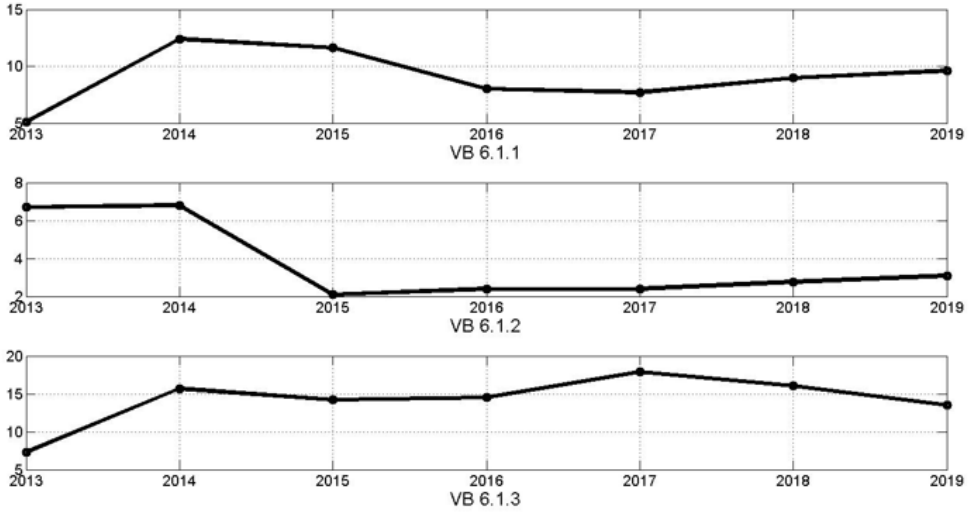


Source: The authors (2021).

Chart 6 shows normal BVs with high APV values. Among them is the variation in 2015 of VB 6.1.2, which can be characterized as a detection failure.

In summary, of all the cases analyzed, HT was wrong in two situations out of a total of 37 reported in Tables 2 and 3, setting a good performance for a hypothesis test, a 95% hit rate, consistent with the value of α used. This is a strong indication that the mathematical modeling performed on the premise of incrementalism and the adoption of a Gaussian distribution for the BVs and the proposed test, which was designed from approximations supported by the principle of incrementalism, are consistent and efficient in detecting anomalies.

Chart 6 - BV without anomalies with high APV values.



Source: The authors (2021).

7 Discussion

Starting from the premise of the incrementalism of the indicators of a NIS, which suggests that abrupt changes in a NIS are unlikely (MICALE, 1990; NIOSI et al., 1993), this paper presented the concept of anomalies in the indicators of GII and developed a technique to detect such anomalies and classify them as methodological or inconsistencies. This technique was built on the usual understanding of anomaly coming from the classical statistical literature (BLÁZQUEZ-GARCÍA et al., 2021; BUDA; CAGLAYAN; ASSEM, 2018; GUPTA et al., 2014) as well as the expected behavior of incremental development of a country's innovation capability (MICALE, 1990; NIOSI et al., 1993).

It was evident from the literature review that many researches use GII time series as a means to analyze the capability of an NIS. It was also shown that, not rarely, the GII variables have anomalies that hinder and compromise the precision of trend analyses, bottleneck identification and the evaluation of NIS capability (ERCIŞ; ÜNALAN, 2016; FAGERBERG; SRHOLEC, 2008; KHEDHAOURIA; THURIK, 2017; MILENKOVIC et al., 2019; WANG; ZHAO, X.; ZHANG, 2016).

The analysis of the case study data allowed us to verify that the main factors generating anomalies in a time series of GII indicators are methodological changes, lack of data, and data with atypical values, the latter considered as inconsistencies. The method was constructed to detect these factors by identifying abrupt changes in GII's BVs without requiring the need to establish a subjective measure of some parameter to encode the concept of "abrupt changes." From the definition of Annual Percentage Variation (APV), it was shown that the method achieved satisfactory results, managing to separate the BVs with data containing small APV values from those with high APV values.

It was verified, empirically, that some methodological changes were not detected by the method, particularly when they did not cause significant variations in the baseline variables. On the other hand, all changes that sensitively affected the values of the variables were detected by the proposed method. Thus, from the perspective of incrementalism, in both cases the hypothesis test worked correctly.

Similarly, the analyses performed here clearly showed that anomaly detections in the absence of methodological changes manifested themselves in situations of missing data and data with values quite distinct from the others in the time series. This is evidence of the relevance of the premise of incrementalism in the context of NIS; the efficiency of the proposed method as a useful mechanism to implement this premise in practice; and the coherence of the approaches that were adopted in its deduction.

As a hypothesis test, the proposed procedure presented satisfactory results, since no Type I critical errors were identified, when the null hypothesis is true and the test indicates that it is false (in this case "there is no evidence of anomalous data" and the test indicates the presence of anomalies) and Type II, which occurs in the opposite situation, that is, when the test accepts the null hypothesis and the alternative hypothesis has in fact occurred (in this case the test states that there is no presence of anomalies when in fact they exist).

Thus, in the context of GII, anomalies can be considered as abrupt changes in the behavior of innovation indicators in a given time period that can be generated by several factors, such as lack of data, methodological changes, or measurement errors. These abrupt changes are identified by estimating the significance level, α. The methodology described in this study was tested for three values of this parameter that controls the sensitivity of the hypothesis test in detecting abrupt changes (α = 1%, 5% or 10%). However, it is up to the analyst to choose the most appropriate α values according to the analyzed phenomenon.

Therefore, by suggesting that innovation indicators do not evolve sharply in a national context, the proposed method highlights the concept of anomaly often referenced by *outliers* in GII reports. The definition proposed in this paper differs from the term *outlier* used in these reports (SAISANA; DOMÍNGUEZ-TORREIRO; VÉRTESY 2018), since many significant changes in the values of the baseline variables arise from methodological changes and cannot be interpreted as *outlier*s.

8 Conclusion

The results presented here for the case study considered show the importance of identifying and classifying GII anomalies, as they can be significant, occur frequently, and mislead experts who analyze these indicators, compromising the accuracy of conclusions about the NIS.

It was shown that, although valuable, the mere analysis of the reports, besides being laborious, is not able to adequately solve this problem, because the effects and intensity of the methodological changes on the basic variables are quite diverse. Moreover, some important inconsistencies cannot be identified with such a procedure.

These characteristics highlight the value of developing procedures capable of identifying anomalies, distinguishing between them, and classifying them, as their causes and effects are distinct and need to be adequately considered in studies of trends and NIS capability.

For practical reasons, the present study was limited to analyzing Brazil's innovation outputs for the period 2013 to 2019, putting the topic in the spotlight and contributing, particularly, to studies on evolutionary analysis of innovation indicators that do not shy away from the rigorous work of detecting and treating anomalies.

Future studies can consolidate the technique proposed here by using it with other GII indicators, countries and time bands. The influence of the significance level value α on the probabilities of loss and detection failures can be studied further and other anomaly detection techniques can be implemented and compared with the procedure proposed here.

Authorship and Collaborations

All The authors participated equally in the elaboration of the article.

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ANNEX A – Critical Values of the Chi-Square Variable for Different Degrees of Freedom and 1– α.

GL	1– α			
	0,9	**0,95**	**0,975**	**0,99**
1	2,71	3,84	5,02	6,64
2	4,61	5,99	7,38	9,21
3	6,25	7,81	9,35	11,3
4	7,78	9,49	11,1	13,3
5	9,24	11,1	12,8	15,1
6	10,6	12,6	14,4	16,8

ANNEX B – List of Pillars, Sub-Pillars, and Baseline Variables (BV) of Innovation Products. The BVs are labeled by the index i, first column of the Chart.

Index (*i*)	Code	Description
	6.	Knowledge and technology outputs
	6.1.	Knowledge creation
1	6.1.1.	National office resident patent applications
2	6.1.2.	Patent Cooperation Treaty resident applications
3	6.1.3.	National office resident utility model applications
4	6.1.4.	Scientific and technical publications
5	6.1.5.	Citable documents H index
	6.2.	Knowledge impact
6	6.2.1.	Growth rate of GDP per person engaged
7	6.2.2.	New business density
8	6.2.3.	Total computer software spending
9	6.2.4.	ISO 9001 quality certificates
10	6.2.5.	High-tech and medium-high-tech output
	6.3.	Knowledge diffusion
11	6.3.1.	Royalties and license fees receipts (% service exports)
12	6.3.2.	High-tech exports
13	6.3.3.	Communications, computer and information services exports, %
14	6.3.4.	Foreign direct investment net outflows
	7.	Creative outputs
	7.1.	Intangible assets

Index (*i*)	Code	Description
15	7.1.1.	National office resident trademark registrations
16	7.1.2.	Madrid system trademark registrations by country of origin
17	7.1.3.	ICTs and business model creation
18	7.1.4.	ICTs and organizational models creation
	7.2.	Creative goods and services
19	7.2.1.	Audiovisual and related services exports
20	7.2.2.	National feature films produced
21	7.2.3.	Daily newspapers circulation
22	7.2.4.	Printing and publishing output
23	7.2.5.	Creative goods exports
	7.3.	Online creativity
24	7.3.1.	Generic top-level domains (gTLDs)
25	7.3.2.	Country-code top-level domains (ccTLDs)
26	7.3.3.	Wikipedia monthly edits
27	7.3.4.	Video uploads on YouTube


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Victory Beyond Superiority: How the Allies won the World War II in Europe

Victoria por encima de la superioridad: Cómo los aliados ganaron la Segunda Guerra Mundial en Europa

Abstract: Current state of international affairs shows the rebirth of near-peer competition. This unveils the likelihood of a conventional conflict between great powers. In the absence of recent clashes of that character, the World War II's (WWII) dynamics can still provide valuable insights on how a new conflict might unfold. To find a useful angle to examine this past-century global war, we formulated the question whether the superiority of the Allies, in terms of manpower and economy, turned their victory practically inevitable in the European theater. It seems an enduring question for today because states usually compete within a security dilemma framework by which they work to enhance defense capacity by increasing numbers of personnel and assets. This paper aimed to respond the question with the support of Michael Handel's theory that states that protracted wars have been won by those who, besides superiority of men, assets and economy, show better leadership, put together a working alliance, and apply geography wisely. Our study concluded that, although superiority was indeed important in the WWII, it was actually only the visible portion of a strategy envisioned and implemented by an experienced leadership who took into account features of geography and established a strong alliance.

Keywords: WWII; Strategic leadership; Alliances; Indirect approach.

Resumen: Las relaciones internacionales actuales muestran el renacimiento de la competencia entre Estados, lo que revela la posibilidad de un conflicto convencional entre grandes potencias. En ausencia de enfrentamientos recientes de este tipo, la dinámica de la Segunda Guerra Mundial (IIGM) sigue siendo una fuente útil de comprensión sobre cómo podría desarrollarse un nuevo conflicto. Para examinar la guerra mundial de este último siglo, nos preguntamos si la superioridad de los Aliados, en términos económicos y personales, hizo que su victoria fuera prácticamente inevitable en el escenario europeo. Es una pregunta todavía válida hoy en día, ya que los estados continúan compitiendo bajo el paraguas del dilema de seguridad según el cual se entiende que la capacidad de defensa significa un número creciente de "soldados" y medios. Este artículo tuvo como objetivo responder a la pregunta con el apoyo de la teoría de Michael Handel, que afirma que las guerras prolongadas fueron ganadas por aquellos que, además de la superioridad económica y el número de "soldados" y otros medios, muestran un mejor liderazgo, forman una alianza fructífera y observan la geografía sabiamente. Nuestro estudio concluyó que, si bien la superioridad era realmente relevante en IIGM, en realidad era solo la parte visible de una estrategia pensada y realizada por un liderazgo experimentado que tomó en cuenta las características de la geografía y estableció un sólido sistema de alianzas.

Palabras clave: IIGM. Liderazgo estratégico; Alianzas; Enfoque indirecto.

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1 Introduction

It was just recently that the United States of America (US) formally stated that the country has joined a competition scheme towards other states, namely Russia and China. According to the country's National Security Strategy (NSS-2017)[1], "China and Russia challenge American power, influence, and interests, attempting to erode American security and prosperity" (THE WHITE HOUSE, 2017, p. 2). The very same document considers both challengers as near-peers, which implies – at least as a means of internal propaganda perhaps – that China's and Russia's sum of national power sources are *quasi*-equivalent to the one of the US. The reality, though, is that the balance of power, at the minimum in terms of military materiel and economy, is still in favor of the North Americans. Just keeping the comparison with China in the maritime realm, the US Navy is reportedly superior to the People Liberation Army-Navy (PLAN). Even with ostensive demonstrations that China is running fast to close the gap, the US still holds relevant alignments with Asian regional powers that are likely to provide extra means to the American side.

"Competition does not always mean hostility, nor does it inevitably lead to conflict" (THE WHITE HOUSE, 2017, p. 3). Although this is true to the point to be written even on the NSS-2017, one cannot deny that theories abound in the sense that, once the competition starts, it is hardly controllable. The Thucydides Trap, according to which war is the likely result when one great power threatens to overcome another (ALLISON, 2017), is certainly an emblematic example of those theories[2]. The Security Dilemma, inextricably intertwined to Thucydides' theory, seems the most suitable to explain the formulation of the ancient Greek writer. In short, an ascending great power will need to take measures, mainly in the military realm, to allow its defensive system develop hand in hand with its economic enlargement and political new assertion. In so doing, "any steps [the new great power] takes to bolster its own defense will be interpreted by an adversary as offensive or provocative, or both" (BIDDLE, 2020, p. 108).

Altogether, formal state of competition amongst some of the most prominent nations of the world, along with the fact that one nation is, in some extent, superior to the others, raise the question whether economic superiority – and more "shining" material, as a result – is a condition for succeeding in the case the current state of affairs evolves to a war. Even though contemporary wars are more likely to unwind in a not clearly defined grey zone, which means it will spend a great deal of its introductory phase as a sort of hybrid warfare, a careful contender may consider looking to the past in search of answers on how a conventional war would unfold. In this regard, the example of the Second World War (WWII, 1939-45), especially in its European theater, seems a valuable example. It was, indeed, the last physical, conventional, clash between two powerful blocs. In the

1 We shall acknowledge that, along with the ascension of US' new government, a new security policy was put in place by means of the Interim National Security Strategic Guidance, March 2021, available at: https://www.whitehouse.gov/wp-content/uploads/2021/03/NSC-1v2.pdf. Access on: Nov 26, 2021.

2 For an opposing view to Allison's Thucydides Trap, see Sullivan (2018).

instance of this past-century war, it shall be mentioned, however, that once the US has joined it, numbers (personnel, warlike and war supporting material production, and the economy as a whole) became way superior in the side of the Allies. This said, examining whether it is true, or not, that the victory of the Allies was practically inevitable given their economic and manpower superiority is, indeed, a valid exercise that will likely apply to the world of nowadays.

Professor Michael Handel (2001, p. 9) offers a sound theory to respond, albeit not directly, the question above. He states that protracted wars have been won by a conjunction of factors that go beyond economic and manpower superiorities [3]. This seems fit as a lesson to the US in a new century again characterized by ostensive competition between states, being one of them – China – a product of the Maoist view on the efficacy of protracted war and, then, an eventual user of this strategy again. Handel's assertion is undoubtedly applicable to the result of the WWII in Europe, where the victory of the Allies reflects a more holistic application of their national powers. Our thesis, thus, is that, besides the strengths in terms of manpower and economy, the Allies' better use of diplomacy and information contributed to a successful "whole of a government" effort. This approach in waging war is translated into three other aspects Handel sets as elements to victory: **a) more effective leadership, b) better cooperation among allies and, c) a wise usage of geography.**

Each of them will be further developed as the arguments to sustain the thesis. This will be carried out – along sections 2, 3 and 4 – by confronting Handel's theory with the reality of the WWII's European theater to examine how well those three aspects were observed by the Allies, ultimately leading to their overall triumph, and how poorly the Axis managed them. Before going on with the arguments, it is worth acknowledging the complexity of the historical events leading to and surrounding the WWII. Coutau-Bégarie (2010) stresses that the historical method to study strategy has, as one of its disadvantages, the likelihood of authors' partial selection of facts to confirm a theory. Trying to overcome this bias of confirmation, we will offer, in section 6, plausible counterarguments to the thesis. As for now, we kick off with the arguments, being the first one related to an effective leadership.

2 Experience against Ideology

One of the most famous sayings in Strategy comes from Carl von Clausewitz, as it is translated by Howard and Paret "war is merely the continuation of policy by other means" (CLAUSEWITZ, 1989, p. 87). This sentence immediately calls our attention that Leadership, at national and strategic levels, is fundamental in waging war. It makes easier the alignment between military, strategic and political objectives, making room, then, for success. Another powerful statement belonging to the Prussian classic emphasizes the importance of a sound Leadership in providing proper flow of assessments and reassessments during [and before] the campaign. Directly quoting Clausewitz,

3 "[...] prolonged wars have been won by **more effective leadership, better cooperation among allies**, greater actual or potential economic strength, and **favourable** [sic] **topographical and geographical conditions**" (HANDEL, 2001, p. 9, emphasis added).

> [...] first, the supreme, the most far-reaching, act of judgment that the statesman and commander have to make is to establish [...] the kind of war on which they are embarking; neither mistaking it for, nor trying to turn it into, something that is alien to its nature. This is the first of all strategic questions and the most comprehensive. [..] the cardinal point of view from which war and theory of war have to be examined (CLAUSEWITZ, 1989, p. 88-89).

Finally, the author's focus on Leadership is also identifiable in his proposed trinity of war (CLAUSEWITZ, 1989, p. 89) and in how it translates into an ideal triangle[4]. The Government, one of the vertexes, although fully exposed to passionate claims coming from its people (another vertex) and affected by the natural uncertainty of military (last vertex) results, shall keep the necessary reason to manage the war machine.

Altogether, and analyzing how the *Clausewitzian* trinity/triangle has operated in the side of the Allies, this section will seek to explain that roles of each vertex (government, military, and people) of the allied triangle were well respected and the interactions between the sides were kept harmonic. Governments (even the Soviet one, just considering the period during the war) were successful in being a reasonable conductor of the general effort. Military planners were meticulous and less vulnerable to the play of chance and showed great adaptability ("creative spirit") during the war. The passionate people turned hatred into power will and permitted itself to be converted into fighting forces and means for large-scale production. Hybrid staffs (civil-military interaction) allowed better flow of orders and assessments, causing political objectives to be compatible with the available means – and attentive to their second- and third--order effects – and military objectives to be tied to the political goals. Through a judicious and constant public communication, the population was kept prone to contribute with the war machine and shielded against eventual opposition.

This was possible thanks to an experienced leadership formed by statesmen with background in occupying high positions in previous wars. Eliot Cohen (2002) is a good reference on how Sir Winston Churchill's (1874-1965) previous experiences, mainly the British failure in "opening" the Dardanelles to reach Turkey, molded his character, leadership, and preparedness for future improved civil-military relations. As for the other two, Franklin Roosevelt (1882-1945) was the Assistant Secretary of the US Navy during the First World War (WWI – here considered its full European period: 1914-18) and Josef Stalin (1878-1953) played a crucial function during the Soviet invasion to Georgia, in 1923, and was of noteworthy political skill in emerging as the Soviet leader after Lenin's passing.

Benito Mussolini (1883-1945) and Adolf Hitler (1889-1945), on the other hand, were enlisted during WWI. As they two ascended from the tactical level of war directly to the political one, without stepping on operational and strategic levels, it is reasonable to infer that, by the beginning of the WWII, they were still very influenced by characteristics pertaining more to the people than to the Government; particularly, passion and hatred.

4 The paradoxical trinity of war is further explained in what scholars call the *Clausewitzian* triangle: people-military-government.

Bringing the discussion back to the successful side of the war, Churchill took the office after several years of failed appeasement policy, being promptly faced with the retreat campaign from Dunkirk, France (May-June 1940). By managing the withdrawal of roughly 350 thousand troops, he set the tone of a new approach towards Germany – an indirect one (MATLOFF, 1986), buying time although ceding space. Not indifferent to the outcry of the people, the Prime Minister acknowledged that "wars are not won by evacuations" (CHURCHILL, 1940), but was firm in avoiding direct confrontation with Germany until a stronger alliance could be forged.

Years later, when the allied triad was formally established, his indirect approach still prevailed. Even with all complaints coming from Stalin, Churchill avoided landing in France first place, choosing the North African (Operation Torch) campaign as a peripherical first amphibious offensive against the Germans in November 1942. Surely, Churchill's experience during the WWI showed that an attrition trench war tends to impact the national morale much more than an apparent inaction, as an indirect campaign can be perceived. "Certainly the [WWI] dominated British thinking about acceptable levels of casualties in major military operations on the Continent" (COHEN, 2002, p. 110). All this in mind, Churchill was skillful in, at the same time, putting an end in the appeasement policy and avoiding direct engagement with the enemy.

Meanwhile, at the other side of the Atlantic, Matloff (1986) points that, inside the US, Roosevelt's independent voice in strategic matters was bold in postulating Germany as the American prior foe, regardless the will of the people who were looking to Japan as an obvious first choice in response to the attack on Pearl Harbor (December 7, 1941). Roosevelt's resolve was also related to his unconditional support to Churchill. George Baer (1993) shows that this turned flagrant in 1942 when, against the advice of his military high staff, he chose to support Churchill's Torch Plan rather than the direct attack over Europe, through the Bolero Plan. The author states it was the right decision. Indeed, jumping over Europe, the war's mainland, with inexperienced American soldiers, could have caused a dangerous setback or, at the minimum, a possibility for a prolonged stalemate. With the US joining the Allies, the operational factor time was now their side, at least on the Western front. That gave sense to the indirect approach while provided a positive impact in the national morale – with less attritional victories over enemy's more vulnerable stations – and strengthened the alliance with Britain. All in all, the campaign on North Africa was the only possible offensive venture by that time, being Bolero, at least under a naval perspective, "unrealizable before 1944" (BAER, 1993, p. 223). Ultimately, it was Roosevelt's bold leadership in pushing strategy to a different direction than proposed by the high military ranks that made possible the military objectives be in congruence with the political goals, being the main one the alliance with Britain.

At the operational level, the US Navy demonstrated great evolution during the Battle of the Atlantic. That was probably due to an adjustment in the Leadership. In the beginning, affected by a turbulent civil-military relation over its design and the control of its budget, it developed a flawed strategy to deal with the submarine threat: a *Mahanian*-inspired seek for a decisive battle against a non-surface fleet to dispute the command of the sea. Worst, this offensive behavior was not supported by enough scouting. All this is sufficiently covered by Baer (1993) who also shows that the course of the battle provided the Navy with a valuable reassessment that the military negative aim (protecting the cargoes) was more suitable to the overall political goal of assuring the continuous supply of Britain. Going after submarine packs was neither necessary nor productive. Also, the convoy scheme was more aligned with the indirect approach carried on land. Few years after the maritime strategy was adjusted, including the use of land-based antisubmarine aircraft, the patrolling (scouting) capability has been enhanced and the Atlantic gap was finally closed to German U-boats. All this without an overall increase of assets, just by the correction of the military objective and more focus on intelligence.

On the other hand, and bringing Clausewitz again to the discussion, German (the Axis) trinity sides "passion - calculation - reason" not always matched the triangle vertexes "people - military - government". Often, passion and ideology drove government's goals while military campaigns were marked by flawed assumptions, sometimes in deliberate disregard of the intelligence piece. Murray & Millett (2000) argue this happened in the campaigns against Norway, England, Crete, and Russia. A strategy for a conventional war that disregards the aforementioned harmony is useless, and we may postulate that a state will fail in waging war while subverting the bijective correspondence of the trinity's sides with the triangle's vertexes. A wise strategy would work to maintain, and take advantage of, the passion associated with the people; chance, friction and calculation with the military; and reason, to manage all rest, with the Government.

In Germany, Hitler was the first to occupy a different vertex in the war polygon: "in effect, only Hitler would determine the strategy and provide the guidance for [...] the military operations of the three services" (MURRAY; MILLETT, 2000, p. 44). The three Service chiefs were directly under him, and there was no atmosphere for joint preparation and even combined operations. The intermediate strategic level has been eliminated with a consequential compromise in the definition of correct military objectives. The result was that Hitler's ideology of a *Lebensraum* was always an impeller, with no filter, for new territorial campaigns. Blinded by initial quick and decisive triumphs, Hitler's ideology pushed Germany into a trap of fighting just to reach its culminating point, especially after accepting a two-front war, invading Russia without finishing business against the Brits. Even considering the Soviet regime a threat, Nazi political guidelines should have avoided an invasion first place, maybe playing with the Soviets a sort of hybrid warfare, while not formally denying the Molotov-Ribbentrop Pact. For example, execution of an informational campaign against Stalin, coupled with low-intense movements and informal "occupations",

could have capitalized on the effects of the Stalin's Purge in the Red Army and on the outcry of satellite provinces' people. This would likely have been more efficient than the ethnical steamroller that brought the Soviet – especially those who were not Russians –, desperate people into the arms of its tyrant and, ultimately, enhanced the force of the Soviet triangle.

As for the Italians, it was no different. Moved by the ideology to recreate the ancient-Roman *Mare Nostrum* by conquering lands around the Mediterranean, Italians got stuck in less important theaters, while allowing the most valuable target – the British – to maintain their haven in Egypt. Worse, after losing manpower and assets in Yugoslavia, Greece and Albania, Italian dictator Mussolini was no longer able to sustain its eroding leadership. He lost, then, the minimal harmony between government, military, and people, meaning that the Italian *Clausewitzian* triangle collapsed. That gave room to the rise of a relevant internal adversary – the once-supporter King Vittorio Emanuelle III – who welcomed the allied invasion to Sicily in 1943, which, in turn, led to the Italian capitulation.

Wrapping up, this section meant to discuss the influence of leadership on the outcome of WWII in favor of the Allies. In regard to some of Clausewitz's writings, we were given lenses to visualize that an experienced leadership is more likely to maintain the desirable harmony within the state, keeping stable relations between government, military leaders, men on the field, and the people as a whole. That is what happened on the allied side and failed to be observed inside the Axis. In addition, except for the USSR, allied states' systems of governments and democratic experience have been in frank development for, at least (considering the US), more than a century. This also contributed to stronger internal institutional relations. Altogether, the Allies were led to a more balanced flow of political goals, strategic ends, and military objectives. As a secondary consequence, it became easier the establishment of a stronger commitment to the allied coalition, but this is a subject for the next section.

3 Alliances need a glue of pragmatism

To this section, Stephen Walt (1987) provides a sound theoretical support. According to him, alliances tend to be stronger when forged based upon a sort of existential threat rather than when created as an instrument of balance of power. Also, he offers that, in view of an emerging threat, states have two options: *balancing* – allying with others against the perceived mutual menace –; or, *bandwagoning*, which means simply joining the threat (WALT, 1987). Finally, the author underscores that "balancing is far more common than *bandwagoning*" and that "ideology is less powerful than balancing as a motive for alignment" (WALT, 1987, p. 5). The study of the alliances operating in the WWII's European theater shows that the Allies, truly based on a balancing system, were able to keep stronger ties within it and, as a result, was more pragmatically successful than the Axis.

Beginning our analysis with the side of the Axis, we shall recollect that diplomatic successes collected by the Nazis had their apogee in the first half of 1939. That followed the union with Austria (the *Anschluss* in March 1938), the acceded claim over the Czech Sudetenland, in September of the same year, and the final annexation of the whole Czechoslovakia, in March 1939. This success is attributed more to the weakness of the Anglo-French will to deter Germany than to a strong diplomatic proficiency in the Nazi side. Anyway, German diplomacy was able to show a last breath of effectiveness with the Nazi-Soviet Non-Aggression Pact (Molotov-Ribbentrop) of August 1939, which came out aligned with general objectives of the *Führer* in preventing waking up the Soviets and allowing the concentration of efforts on the Western front soon. After that, once the pact was torn apart, war became much more than "the continuation of policy by other means", but the only instrument of policy the Nazis used until the end of the WWII. War was turned into an end in itself. Even before that, the acceleration of German's military plans and the movement over Poland finally brought, after years of appeasement, a resolute Churchill-led Britain to the war. The latter's boldness, as it was not compelled by the Nazi "aerial diplomacy" to surrender in 1940, may have represented, according to some writers, like Stephen Bungay (2009, p. LIX), the war's turning point and the beginning of the Nazi defeat.

Britain's survival reignited German's fear that a stronger naval blockade would paralyze its war machine by 1941. Especially because the acceleration of German plans did not allow the conclusion of Plan Z (started in 1939), for recreating the High Seas Fleet to counter British naval superiority. The plan was organized in a way to materialize only by 1945, when Erich Raeder (1876-1960), Grand Admiral of the *Kriegsmarine*, was told the war against the Brits would be inevitable (HUMBLE, 1971). Pressed by the British, the envisioned solution to keep the supply of food and raw material, Operation Barbarossa (June-December 1941), came in total disregard to the Molotov-Ribbentrop Pact, to Nazi-Soviet economic agreements, and to the Soviet pledge to join the Axis[5] . Military might had overthrown the reason; the belief that Germany was able to beat the Union of Soviet Socialist Republics (USSR) before the Soviets had the chance to reorganize the Red Army turned a blind eye to the fact that the USSR aid was of decisive military importance to German (MURRAY; MILLETT, 2000). The venture, besides cutting off important supplies for Germany, opened a second front with very extended lines of communication and geographically divergent military objectives (Leningrad[6] , Moscow and the Caucasian region Rostov-Stalingrad[7] - Baku). Politically, it ended up providing Britain with the foremost instrument of its traditional and "comfortable" warfighting scheme: a powerful allied continental army.

5 Roman Brackman (2001, p. 289) argues that "the purpose of Molotov's visit to Berlin in November 1940 was to reach an agreement with Hitler on the conditions under which the Soviet Union would join the Berlin-Rome-Tokyo 'Axis'."

6 Saint Petersburg nowadays.

7 Volgograd nowadays.

Still discussing German flawed diplomatic movements, another despised ally willing to *bandwagon* the Axis was Spain. "Francisco Franco [...] was making clear [...] his eagerness to join the Axis as quickly as possible" (MURRAY; MILLETT, 2000, p. 84). After years of civil war, it was not a power in Europe, but its strategic bases in the Canaries and its proximity to Gibraltar would have provided a less difficult enterprise to deny the Mediterranean to Britain and to avoid the future execution of the Torch Plan. Again, it was Hitler's belief in an easy victory over Europe that prevented the alliance with another second-class power with which the spoils would have been shared.

Italy was already a burden, with its parallel war to assure the Mediterranean as its *Mare Nostrum*. Whether Italy joined the Axis in a *bandwagoning* attempt or because of a similar ideology shared with the Nazis, or both, the reality was that the Axis in Europe lacked common objectives and each member was aiming its expansion in different directions; Germany towards the European Heartland and Italy, the Mediterranean and its periphery. There was no mutual trust and no formal combined staff. Italy invaded Greece without informing Germany, while the latter invaded the USSR without consulting Italy (HOSCH, 2010). Hence, the Axis in Europe was a fallacy and Italy did very little to the overall campaign. Quite the opposite, Hitler blamed the Italians for the failure of the Nazi campaign against the USSR. He argued that German intervention to save the Italian failed conquest of Greece delayed the invasion to the Soviet Union (KERSHAW, 2007). All in all, Italy soon became identified as the weaker side and an obvious target of the Allies (in this case, the US and Britain), who, in their indirect approach towards Germany, came to Sicily in 1943. Italy finally served itself as a strategic beachhead to satisfy both the periphery war against German and, partially, Stalin's eagerness for a second, Western, front in Europe.

Although this paper is focused on Europe, it is worth mentioning Japan as well, as some of its actions had serious repercussions in the Old Continent. The way Japan fought its own war also shows the lack of common ground in the Axis. Aloof of Hitler's objectives, the attack on Pearl Harbor, without German previous knowledge, brought the US to the war in the exact moment Barbarossa has become a failure. After the American declaration of war directed only against Japan, Hitler unilaterally declared war against the US. That gave the latter a legitimization[8] of its alliance with Britain – and consequently with the USSR – and a reason to point to Germany (not to Japan) as the first enemy to be defeated. Rewinding the time before Pearl Harbor, although Japan was not willing to confront the Soviets because of a previous failed experience in Mongolia (YEGOROV, 2019), had Berlin offered Tokyo an expectation of material rewards over Russia (oil, perhaps), the latter might have been interested in opening a second front over Russia, instead of attacking the US in Hawaii.

Once it was inevitable the US jump into the war, more coordination of the Axis should have happened to prevent the concentration of the American assets in the European theater. Baer (1993, p. 204) argues that "because [the Japanese] did not [also

8 The American support to the Allies was already in place since the early war and turned flagrant by the Lend-Lease Act of March 1941.

mount *a guerre de course*], throughout the war, the United States could devote its limited escort and patrol resources to [counter] the German threat." At the end of the day, the strategy of then-Captain Karl Dönitz (1891-1980, Grand Admiral of the *Kriegsmarine* from 1943 to 1945) "destroy more cargo ships than the enemy can resupply" should have had Japanese adherence to it. That would have possibly denied the US taking full advantage of its economic (industrial) power, due to its eventual reduced shipment capacity.

Previous examples show the Axis as simply a non-aggression pact, rather than a true alliance or coalition. Other than those examples, the late joining of Romania (November 1940) and Bulgaria (March 1941), once the Nazis were already close by their territories, reinforces the *bandwagoning* character of the Axis in Europe. Walt (1987) puts together some characteristics of a successful coalition, being them: the existence of a mutual threat; burden-sharing and a joint economic policy; a common strategy to neutralize the agreed-upon threat; a public sense of solidarity; shared mechanisms for the formulation of policy, strategy and planning operations; and a unified command. From all of those, the Axis' sole feature was that Britain and the US (not even the USSR) were mutual threats. On the other hand, the Allies (especially the binomial US-Britain) established a unified command, with shared mechanisms, that defined and executed a common strategy, marked by a shared burden and a joint economy, towards a unanimous enemy: German. The early establishment of the Combined Chiefs of Staff (CCS) synthesizes the mutual commitment inside the US-Britain partnership. Altogether, the Allies formed a pragmatic coalition, regardless of particular ideologies, and values of each partner. Neither the lack of agreement on the objectives for war termination nor the Soviet suspicion that a second front would ever come into reality were definitive hindrances for the alliance. Disagreement was usually surpassed by negotiations, several being a face-to-face meeting of their maximum leaders, as it happened in Tehran, Yalta, and Potsdam.

This section discussed the systems of alliances within the WWII, particularly those operating in Europe. By using the theory of Stephen Walt, the Allies were identified as a truly balancing alliance, according to which a mutual powerful threat is the main glue that holds states together, even those with different or opposing ideologies. The Axis, on the contrary, was formed in Europe by weak states joining Germany in a *bandwagoning* initiative. As a result, it was simply a non-aggression pact and its states did not orchestrate their efforts. Altogether, as an alliance, we had that the Allies were much stronger than the Axis, and, in so being, their tactical victories were able to produce strategic and political effects that made more sense. Especially because they pressured Germany in two geographic fronts. The discussion around geography and its features, by the way, pertains to the ensuing section.

4 Geography matters

For Sun Tzu, "who fights with full knowledge of [distance and difficulty of the terrain] is certain to win; he who does not, will surely be defeated" (SUN TZU, 1963, p. 128). What seems to be only of tactical concern, Vego (2009) also finds suitable, actually a fundamental factor, in the operational realm; for him, the operational factor **space** is key in determining the positioning of bases and in designing lines of operations. He also calls attention for the space's sort of determinism; while the operational factor time is manageable, the space is less likely to be modeled in one's advantage (VEGO, 2009). The consequence, then, is that Commanders shall be fully aware of the features of geography, so they can properly accommodate the disposition of force, in the proper time, to either overcome obstacles or take advantage of a benign terrain. Finally, Clausewitz (1989, p. 348) wraps everything up, bringing the result to the next level: "principal effect [of geography and character of the ground] lies in the realm of tactics, but **the outcome is a matter of strategy**" (our emphasis). When comparing the contenders of the WWII, geography was in clear favor of the Allies or more carefully considered by them. In general, geographic isolation and territory size – and its disposition and conformation, as well – have all played an important role to provide the Allies with freedom of action and the possibility of trading space for time.

Besides American geographic isolation to the European theater, the US was also able to enjoy a self-cultivated diplomatic isolation, during the first years of the war, as far as possible. This allowed the country to remain neutral, gaining sufficient time that permitted not only better military preparation and economic (and industrial) growth but also fighting a weakened Nazi enemy, after the long struggle of the latter in Russia. Also, had the US joined WWII in its beginning, American people could have been not as supportive as it happened after Pearl Harbor.

Once joining the war on the side of the Allies, geography played again to the US' advantage. The vastness of the North Atlantic, along with German lack of capability to dispute command of the sea against the Americans, contributed to a comfortable condition of untouched territory in the whole US. All in all, the Western side of the Atlantic was preserved throughout the war as a haven for continuous large production of warlike material and goods to be consumed by the Allied war machine.

Regarding Britain, its geography kept it protected from the *Blitzkrieg* in its peak and a very unlikely *Kriegsmarine's* amphibious campaign. For Murray & Millett (2000, p. 84), "an amphibious landing on the British Isles was never a serious option. Few senior German military leaders had a clue as to the complexities of such an operation." Thus, the Battle of England became a *Luftwaffe's* sole business, tasked to execute strategic bombing. Again, the operational factor space was fundamental in denying Germany, despite its numerical slight advantage, any possibility of conquering the necessary air superiority to proceed with the main mission.

Flying in the limit of their range, Nazi aircrafts ended up in a battle of attrition that favored the British. Flying over inimical territory, every engaged aircraft represented a definitive loss of aircrew and equipage. Even if the Germans had conquered air superiority, the bombing campaign would have been impaired anyway due to a poor intelligence gathering in terms of defining targets (MURRAY; MILLETT, 2000). At the end of the day, this early experimentation of *shock and awe* strategy was fruitless.

As for the Soviets, Stalin took advantage of his territory's size and moved the Soviet military-industrial complex east of Moscow during the preparation for war (MURRAY; MILLETT, 2000). During the struggle, the Red Army kept its continuous resupply and, even weaker than the German attacker, successfully traded space for time. Then, as professed by Vego and other scholars of the operational art, Red Army skillfully applied the correct combination of space and time, extending the fight until the heavy winter came and, along with it, gaining time to replenish its contingent – we cannot forget the Purge – and putting together the conditions for a counterattack.

As previously mentioned, Operation Barbarossa was the German response to their unsuccessful campaign against the Brits. Once implemented, though, the features of the battlespace were in favor of the Soviets. Luckily for them, Berlin chose to advance on three equally valuable objectives, being them very much apart from one another, in a Northwest-Southeast line more than 2,000 kilometers long. This caused the Germans not only to march over a huge terrain, under inclement weather, but also to do this in three divergent lines of operation. One towards Leningrad (Saint Petersburg), to detain the constant threat posed by the Soviet Baltic Fleet; the southernmost one directed to the oil fields of the Caucasus; and a third one aiming to smash the political center of Moscow. Had this movement done in a single line of advance, it would have already been a complicated enterprise with over-stretched lines of communication (MURRAY; MILLETT, 2000). The concomitant moves towards the three objectives caused a vast front scarcely supported by overwhelmed logistics. This eventually slowed the campaign and the German Army lost its main tactical advantage: The *Blitzkrieg*. Besides, when the counterattack came, the very wide and, then, poorly cohesive front was not in condition to hold it.

Same way geography was in favor of the Allies, Germany was seriously impacted by it. On land, it faced a two-front war without any major topographic feature to support its defense[9]. Especially in what concerns the eastern front, the cone shape of the space between Russia and Germany naturally implies in the principle of concentration when the attack comes from the East. Coincidence, or not, the Soviets were first to step on Berlin.

At sea, geography also played hard against Germany imposing natural difficulties in developing a sea power *vis-à-vis* Britain. Enclosed within the North Sea, the Kriegsmarine leadership should have not developed a *Mahanian*-inspired project to build a battle fleet to fight

9 Only referring to the eastern and western fronts, and not considering the front in the South, where the Cassino Range, south of Rome, provided enough natural support to build the Gustav Line that successfully slowed the Allied movement over Italy in 1943.

a decisive battle for the command of the Atlantic. The *Kriegsmarine* was to take into account that the classical Alfred Mahan's recipe for developing a powerful sea power considered not only means but also geographic features. None of the latter, as prescribed by Mahan (1991), was favorable to Germany. Then, the Nazis were not to reedit the WWI mistake in mirroring Britain to develop an antagonist fleet. Likely, it would have been blocked anyway. Hence, once again, twenty plus years later, the fleet showed its inutility: used as a fleet, it suffered definitive losses during the campaign against Norway (April-June 1940); when dispersed, isolated ships like the pocket battleship Graf Spee, adapted as commerce raiders, also failed (MURRAY; MILLETT, 2000). Considering Germany's geographical position, the battle fleet should have not been an option first place. Instead, the *Kriegsmarine* was to favor the production of the original number of U-boats requested by Dönitz (BAER, 1993). Had this happened, Germany would have presented far better results in the Battle of the Atlantic, reaching a greater deal of tonnage sunk in the side of the Allies. Possibly, the ultimate goal of the submarine campaign in provoking British paralysis might have been reached.

In short, this section argued that Germany neglected that geography did not favor its expansion war. German position in the European Heartland and its enclosed waters caused a war in two fronts, with no support from an organized battle fleet and over-extended lines of communication. Thus, geography was another factor that pushed the Nazis to their culminating point. Especially because they were fighting against a protected island, an industrial continent at the other side of the Atlantic, and a huge continental territory, full of maneuvering space for counterattacks.

5 Counterarguments favoring the numbers

Whenever doing research, especially in social sciences, which unveils preferences and sometimes passion, we may all be susceptible to bias. This said, it is recommended to raise counterarguments before someone else does so. So, despite these three aspects favoring the Allies, it might be argued that the answer to our proposed question is that the allied victory was indeed practically inevitable in view of their economic and manpower superiority. This counterargument can be supported by the *Clausewitzian* principle of the predominance of the defense (CLAUSEWITZ, 1989), with a resultant necessity of massive numbers of troops and materiel to carry offensive campaigns, especially amphibious assaults. With a focus on this principle, one looking for numbers would see a confirmation of this antithesis on both fronts of the allied territorial campaign; in the East, by noticing the capacity of the Red Army in implementing a counteroffensive even after the loss of roughly five million troops; in Western Europe, by examining the magnitude of the numbers involved in the execution of the Operation Overlord, in which amphibious operations were brought to a next level in military history.

At sea, where there is no such defensive advantage in *Clausewitzian* terms, another antithesis needs to arise. In this regard, the fight over shipping tonnage (resupply of ships vs. ships sunk) in the Battle of the Atlantic can be pointed as nothing but a war for numbers; a truly struggle for statistics. Also, it is a counterargument that counts in favor of the economic superiority and industrial power, for which the most emblematic example is the surprisingly high production rate of the Liberty Ships (BAER, 1993). The same reason applies to the aerial domain in which there is a compelling need of establishing air superiority before any other mission, being it terrestrial, maritime, or aerial. All the exposed can be synthesized in a correlation with the Lanchester's Square Law, by which an N-fold increase in quantity is only surpassed by an N-square-fold increase in quality.

6 Rebuttal – means are important but let's also consider the ways

Unlimited wars are those in which at least one of the contenders fights for unlimited ends, generally the complete overthrow of an antagonist regime. The study of those war types tends to overemphasize the importance of "unlimited" means. The counterarguments above reinforce this trend. What they do neglect, though, is that strategy, as presented by Arthur Lykke, Jr (2001), reflects the proper balance between ends and not only means, but also ways. Not by coincidence, Professor Milan Vego (2009) recognizes operational art as, among other things, a tool that works in saving resources – material and human –, by employing them wisely. Expanding this concept, the judicious usage of operational art helps, thus, overcoming technological limitations and even tactical setbacks vis-à-vis the adversary. In short, operational art turns asymmetry, as a strategy, viable. Returning to Lykke and not ignoring the ways, all the proposed counterarguments can be confronted against one, or more, of the triad of arguments: sound leadership, pragmatic alliance, and wise consideration of geography.

When it comes to manpower superiority, it is worth mentioning that Stalin's actions towards the Red Army, before Barbarossa, show that his own Army was more a source of skepticism than of trust. Its leadership was one of the main targets of the Soviet leader's Great Purge, with 65% of its 1936's ranks eliminated (KUROMIYA, 2013). Stalin, to be sure that the Red Army would fight the Nazis [and the Japanese], and not with them, promoted a cleansing to rebuild a bottom-up army (KUROMIYA, 2013).

That said, the size of the Red Army would have served for nothing had the Germans adopted a "hearts and minds" strategy directed to the Soviet people and the opponent's army. Even simpler, the Nazis should have waited for, or sponsored, insurgencies in Soviet satellite republics, while preserving, as far as possible, its part in the Non-Aggression Pact. To use a buzzword from nowadays, a hybrid warfare, a grey-zone strategy, would have maybe sufficed against the USSR. The ideological component of Hitler's strategy was, however, truly relevant in denying the pragmatic proverb "the enemy of my enemy can be my [eventual] friend."

When Barbarossa came into reality and it became clear the Red Army would fight it back, its huge size would have been equally unimportant had Stalin implemented his first plan of sending everyone to the furthest front with no reserves behind. In his mind, that was an attempt to hold the Nazi first blow in order to buy time. That, however, would have contradicted Clausewitz (1989), who reminds the dispersive nature of the defense against the nature of concentration of the attack. Had the Red Army stayed all in line beforehand, the *Blitzkrieg* carried closer to German centers of support, would have conserved its maximum speed and shock power and, then, would have likely smashed the Soviet line the same way it did against the French. All previous preparation in moving industrial support to the East would have been of no value.

In the Western front, the superiority of the Allies was already clear after the US joined the war. It is not an exaggeration, however, to state that it was the indirect approach, represented by choosing to carry first blows in Northern Africa and Italy, that allowed the Operation Overlord to happen at the appropriate time and place. Even though the manpower superiority and the abundancy of means indicated the operation was feasible in June of 1944, the Allies did not neglect the use of evasion – Plan Bodyguard and Operation Fortitude – before its execution. "All warfare is based on deception", prescribes Sun Tzu. Also, Overlord was preceded by proper isolation of the battlefield (JOHANSON, 1994), with judicious application of air interdiction and the destruction of Nazi transportation and communication networks in France. Altogether, those two procedures reinforce the importance of taking the ways into account in parallel to the consideration of the means. All in all, they are classic examples we have for the study of operational art when it comes respectively to the operational functions "maneuver" and "fires", as they are defined in doctrinal documents like the American JP 3-0, Ch.1, *Joint Operation*s (UNITED STATES, 2018). The success of the amphibious assault can also be attributed to General von Rundstedt's "let them come" strategy, according to which only a light resistance would be stationed at the beaches to slow down the first phase of the allied movement and a steadier defense would be assembled around Paris (MARGARITIS, 2019).

As for the repercussions at sea, it can be argued that the submarine campaign, carried alone, was an insufficient venture and a bad strategy overall. It would hardly come to its tonnage objective and the American production would have been augmented anyway, considering that the US is a continent in itself, full of industrial centers that were physically threatened by no enemy. At the end of the day, the German submarine campaign finished off providing Roosevelt with another argument to ignite the Americans with his "Germany first" policy. Had the Germans not attacked the American shipping at sea, the outcry of American people might have pushed Roosevelt to point Japan as a first enemy. Authors, as Murray and Millett (2000), propose that the submarine campaign should have never carried out, and its resources allocated to the German Army and *Luftwaffe*. Possibly, the increased speed of the *Blitzkrieg* in the tactical level would reflect more vigorously and rapidly in Nazi overall strategy, deterring antagonist powers to join the war.

In the air, the superiority in numbers early gained by the Allies has never been a reason for them to try attrition battles for the skies. The allied air campaign followed the same rationale of the one used in land, facing the *Luftwaffe* in its periphery. Only when it was weakened enough to not be able to dispute the command of the heights, the Allies began their strategic bombing campaign over German interior objectives and the operational interdiction of German lines of communication in France.

In rebutting the counterarguments, it becomes clear that states need to meet some prior requirements that will allow the proper (right time, right place, and with the correct concentration) deployment of their means. Even if they are abundant. WWII in Europe shows how the Allies, by having a better leadership, a stronger commitment within the alliance, and a truly geographic-led strategy, granted massive numbers of men and assets that heavily contributed to their overall success. Manpower and economy were only the visible and measurable portions of a strong and comprehensive strategy; one that, by committing all instruments of national power to the war machine, was able to create a series of tactical victories and to take full political advantage of them.

8 Conclusion

"History doesn't repeat itself, but it often rhymes." Whether this nifty saying can be attributed to an acknowledged writer[10] , or it is simply anonymous, it offers a great incentive to examine the past in search for how things may unfold now. This is true for the studies in strategy because, although war involves a great deal of ever-evolving technology that eventually changes the war's character – the way it manifests –, what war really is, its nature, is immutable. Then, it is still valid the *Clausewitzian* definition that war is a violent clash between two parties trying to accomplish conflicting political ends. This said and considering there was no ensuing conventional war between near-peer competitors after WWII, that past-century war can, even now, provide valuable insights on the dynamics of a future eventual armed conflict between two great powers and their allied states.

Regarding the fact that war may have its character evolved, we fully acknowledge that any near-future war would develop in a context of a much more interdependent economy – and, broadly speaking, more intertwined affairs – than it was in WWII's epoch. Technology, also, would likely bring into play an escalating amount of new [robotized] war machines. Furthermore, current international relations are no longer the sole business of the states and we deal today with countless sub-state and multi-state actors. Thus, a considerable amount of these new actors represents security threats and challenges, sometimes with shining new material and a proxy given by a formal state. Behind all these, there is a profusion of international legal regimes in an attempt to govern a system that, according to a realistic view, is anarchic by nature.

10 Although the sentence is commonly associated with the writer Mark Twain (real name Samuel Clemens – 1835-1910), there is no formal evidence that the sentence is really of his own.

Altogether, the result is that our lexicon has recently incorporated new expressions such as lawfare, grey-zone strategy, and hybrid warfare. This paper lacks any analysis of them all. However, we bet that, more than ever, numbers of men and assets, alone, will not respond to this scenario.

On the other hand, considering the perpetuation of war's nature, this paper, looking the background of engagements, relations, and other affairs about the WWII, aimed at confirming that conventional and prolonged wars have been won by the side that presents, not only manpower superiority and economic strength, but also, and mainly, a more appropriate adjudication of all instruments of the national power. All that supported by a sound strategy that combines leadership, loyalty to an alliance and, observance to the features of the surrounding space. At any moment, we intended to deny the importance of numbers of men and assets and of the industrial power to deliver continuous support to the front. Rather, we wanted to emphasize what shall run in parallel to those. Superiority is only meaningful if it gets to the battlefield at the proper time, coming from the most suitable axis and with an adequate goal to achieve. Stepping down a little and reaching the realm of war's operational level, the operational art wraps everything up by calling our attention to the importance of a balanced interrelation between force, time, and space. Superiority in economy and manpower (force) is not a panacea for winning wars. Consequently, they are far from being the sole objective of a sound strategy.

Because this paper was started by acknowledging nowadays' great power competition, it is compelling that we wrap everything up by tying the lessons from the past to a recipe for the near future. Looking to the side of the US, the past indicates that the partisan politics of nowadays shall give room to bold and unifying leadership, the empowerment of the institutions, and interagency effort. Moreover, the US should keep enhancing true partnership around the globe, especially in areas to counter its rivals' influence. In this regard, it seems reasonable that the US shall seek, in the wake of the Interim Security Strategy Guidance, to achieve better outcomes from the international organizations and multilateral forums by working within their framework. As for its near-peer competitors, the US must understand that, although both have been proving to be good in "fighting" in the grey zone for limited objectives in their immediate vicinity, it sounds unlikely that any of them would try more pretentious goals. At least for now, such an enterprise – that demands warlike capabilities not recently tested in combat – seems an unreasonable effort for them. While one is enclosed by geography (First and Second Islands Chains in East and South China Seas) and overwhelmingly dependent on foreign resources, the other struggles with declining population and a stagnant economy. Direct confrontation does not serve well to the US. Instead, containment and indirect approach, especially if carried with the support of a solid net of allies, under a committed and wise leadership, still fit US' purpose of not losing its hegemonic status.

Authorship and Collaborations

All authors participated equally in the elaboration of the article.

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FAB Dimension 22 in terms of defense and integrated security: analysis of the FX2 Gripen and KC 390 Millenium strategic projects

La dimensión 22 de la FAB frente a la defensa y la seguridad integrada: análisis de los proyectos estratégicos FX2 Gripen y KC 390 Millenium

Abstract: Under the light of Defense and Integrate Security issues in Brazil is of utmost importance concentrating efforts on the Brazilian Air Force (FAB) Dimension 22 and its respective objectives, which, in order to be attended, require the strengthening of Brazilian airpower, what is described on the National Defense Strategy (END). As a result, the searching for air command and, consequently, for space command is something particularly important in order to enable Brazil to control, integrate and protect its 22 million km2. This context encompasses the FAB strategic projects, the F-X2 Gripen and the KC 390 Millenium, which will be analyzed under the perspective of an alleged complementarity and contribution to the rising of Brazilian air power, based on an exploratory study that allows the elaboration of hypothesis and according to a qualitative methodology. It is expected to verify if such projects can contribute to Brazilian Defense and Security.

Keywords: Brazilian Air Force (FAB) Dimension 22; Defense and Integrate Security; Air Power; F-X2 Gripen and KC-390 Millenium; Complementarity.

Resumen: Bajo la perspectiva de la Defensa y Seguridad Integrada en Brasil, es fundamental prestar atención a la Dimensión 22 de la Fuerza Aérea Brasileña (FAB) y sus respectivos objetivos, que, para ser cumplidos, exigen el fortalecimiento del poder aeroespacial brasileño, lo que está descrito en la Estrategia Nacional de Defensa (END). Dicho esto, la búsqueda del dominio del aire y, en consecuencia, del dominio del espacio, es algo de gran magnitud para que el país pueda controlar, integrar y proteger sus 22 millones de km2. En ese sentido, se incluyen los proyectos estratégicos de la FAB, en el caso aquí considerado, el F-X2 Gripen y el KC 390 Millenium, que serán analizados a la luz de una supuesta complementariedad y contribución al aumento del poder aéreo brasileño, a partir de un estudio exploratorio que genera hipótesis de metodología cualitativa. Se espera, por tanto, verificar si, efectivamente, dichos proyectos contribuyen a la Defensa y Seguridad del país.

Palabras clave: Dimensión 22 de la FAB; defensa y seguridad integrada; Poder Aéreo; F-X2 Gripen y KC-390 Millenium; Complementariedad.

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1 Introduction

The beginning of the 21st century is the scene of a resurgence of security and defense imperatives at a global level, in view of the emergence of new and potential threats of a diffuse nature that start to demand emergency responses from countries, which include development of efficient deterrence mechanisms, as well as modernization and strengthening of military power in general. Such initiatives engendered by the most diverse countries seek, above all, to protect their respective borders from threats such as drug trafficking, illegal immigration flows, illegal maritime explorations in coastal zones and other border illicit acts.

With regard to Brazil, a country with a large territorial extension and which still has an important Exclusive Economic Zone, as well as International Agreements, totaling 22 million km2, the challenges regarding defense and security have been increasingly complex, which is why the imperatives of modernizing the Armed Forces and the Defense Industrial Base (BID) have been growing, with a view to increasing the country's ability to deter external threats.

For the purposes of developing this article, it is imperative to point out that security and defense are defined in the National Defense Policy (PND), as it follows:

> Security: the condition that allows the country to preserve its sovereignty and territorial integrity, promote its national interests, free from pressure and threats, and guarantee citizens the exercise of their rights. National defense: the set of state measures and actions, with emphasis on the military field, for the defense of territory, sovereignty and national interests against predominantly external threats, potential or manifest (BRASIL, 2012, p. 13).

That said, it is worth considering the spectrum of FAB Dimension 22 (BRASIL, 2019) and the needs to strengthen Brazilian air power, investigating whether, in fact, the development of the strategic projects F-X2 Gripen and KC 390 Millenium can contribute jointly to increased security and defense against external threats.

To this end, this article firstly contemplates a brief explanation of the air power concept, which is essential for the directions intended here. Next, it is intended to analyze the FAB Dimension 22 and how the objectives listed in it require the strengthening of Brazilian air power. The following section enters the field of the military aeronautical platform, seeking to conceptualize it and analyze the development of the strategic projects F-X2 Gripen and KC 390 Millenium. Finally, are analyzed the presence or absence of complementarity between the aforementioned strategic projects and the implications inherent to the strengthening of Brazilian air power, essential to guarantee the defense and security of Dimension 22.

2 Concept and importance of air power

Quite relevant in studies that deal with matters related to defense, Geopolitics is essential in the analysis of the conditions that guide the performance of States and, above all, in the

definition of the strategies to be adopted by them. Territorial position, population vocation, territory size and other aspects have been used countless times to support geopolitical conceptions. From the different conceptions and based on different aspects, theses that sometimes proclaimed the supremacy of maritime power and sometimes that of land power emerged. Mahan's maritime power, Mackinder's Heartland and Spykman's Rimland are often present in geopolitical debates and in the defense planning of states, often aligning defense policies with foreign policy (BANDEIRA, 2010). In this context, it is appropriate to address another geopolitical aspect, the one that shifts supremacy to the domain of the air, the so-called air power. It should be noted that, with the scenario of technological innovations that has been present since the end of the last century, air power is allied to space, transforming itself into aerospace power.

Regarding this transformation caused by the advent of technology, the Basic Doctrine of the Brazilian Air Force (BRASIL, 2020) points out that both the inclusion of the outer space and cyberspace dimensions, now combined with the air dimension, transforms air power into aerospace power. In addition, it highlights that:

> On the subject, subsidiary theories identify this domain separately from the aerial context, due to distinct physical characteristics, despite its contiguity (difference between aerodynamics and astrodynamics). In fact, the current aircraft do not have the conditions to operate in outer space, as well as satellites or other similar devices only transit through the air until they reach their operating environment, commonly above 100 km of the Earth's surface. Despite these technological limitations, today it is no longer possible to conceive a Theory of Aerospace Power that does not contemplate the use of potentialities (telecommunications, images, geographic positioning, digitalization etc.) arising from outer space. Thus, the contemporary understanding that war in the air and in space is no longer restricted to confrontations between aircraft makes sense (BRASIL, 2020, p. 27-28).

As Rosa (2014) points out, the introduction of aircraft in wars, which took place at the beginning of the 20th century, brought about a significant change in the perspective of employment of military forces, generating a revolution in military affairs insofar as it provides the emergence of a new dimension on the battlefield. Also according to this author, although there is no precise and unique definition of air power, as it varies among the different theorists on this topic, the relevance that it represents for the military forces of a country is unquestionable. As an example of this diversity of definitions one can quote William Mitchell, one of the precursors in the defense of the use of aircraft as a combat instrument and who defined air power as the ability to do something in or through the air, and, since the air covers the whole world, aircrafts are able to go anywhere on the planet (ROSA, 2014).

It is important to emphasize that air power is not built independently, but rather is based on a close link between the material means to be used, that is, military capabilities, and the strategies to be adopted to achieve previously defined objectives. In this sense, the importance of the military aeronautical platform and government policies in the pursuit and maintenance of a

country's air power should be highlighted. Thus, the Brazilian case emerges as an example of a country that has been making efforts – modernization of the combat air fleet, development and production of air transport aircraft, modernization of space satellite systems, revitalization of an industrial defense base – in order to develop its air power and guarantee the defense, control and integration of Dimension 22 and, consequently, increase the Brazilian deterrent power.

Gates (2003, p. 152-153) identifies that:

> The ability to protect and employ military forces in the air and space, or from a platform or missile operating above the Earth's surface [...] air power is not only performed by the air forces, but also includes the air capabilities provided by other services (army, navy or marines). It is not only composed of weapons systems, but refers to the people who employ them, the infrastructures to operate them, and the spare parts vital to their employment.

In addition, it should be borne in mind that efforts in this direction contribute decisively to the technological development of the country and to the modernization of the BID, something clearly verifiable in Brazil (ANDRADE; LEITE, 2017).

According to the main theorist of air power, Giulio Douhet, "*dominating the air means being able to prevent the enemy's flight while guaranteeing this faculty to ourselves*" (1988, p. 59). He also advocated that air power would contribute to increasing the depth of the battlefield, expanding it to the entire territory (DOUHET, 1988), which is perfectly in line with the size of aerospace power. It should be noted that Douhet preached that conquering the air domain would mean winning, with the guarantee of national defense being ensured, in time of war, by the conquest of the air domain, a precept that finds resonance in the strategic objectives of FAB Dimension 22, which will be analyzed later.

Through the analysis of Douhet's thought, it can be seen the search for a deterrent power having the plane as the main military means, which is in line with the Brazilian defense precepts, especially those specified in the National Defense Strategy (END) and present in FAB Dimension 22, which demand the renewal of the Brazilian air fleet, that is currently unable to fulfill the intended objectives. As stated in the END:

> Exercising airspace surveillance, over the national territory and Brazilian jurisdictional waters, with the assistance of space, air, land and sea resources, is the first of the Air Force's responsibilities and the essential condition to prevent the overflight of aircraft contrary to the national interest (BRASIL, 2012, p. 85)[1].

In this dynamic, the need to modernize the Brazilian defense apparatus is inserted, especially with regard to aerospace power, that is, new ultramodern aircraft and monitoring systems, via satellite, that may come to operate in an integrated way in order to control, moni-

1 The current version of the END, which dates from 2020, has modifications that, however, do not change the essence of the intended objectives.

tor and combat any threats or border illegalities that may arise. This is how systems such as the Amazon Surveillance System/Amazon Protection System (SIVAM/SIPAM)[2], the Integrated Border Monitoring System (SISFRON) and the Blue Amazon Management System (SisGAAz), essential elements of Brazilian aerospace, should be included in the order of priorities of the Brazilian government, in order to expand the country's defense and security. Along with the aircraft, these are part of the strategic projects within the scope of Dimension 22, which will be further outlined below.

3 Dimension 22 in view of the brazilian air power

The current century brings up very recurrent international security and defense imperatives, given the growing process of securitization of new existential threats that have been present (BUZAN; WAEVER; DE WILDE, 1998). In the current scenario, a diffuse distribution of power can be seen, in which the formation of regional defense complexes denotes increasing investments in military capabilities and in the re-equipment of the countries' armed forces (BRASIL, 2012). For Brazil, a country of continental dimensions and a regional power endowed with a unique geostrategic position, with a strategic environment that includes the South Atlantic and a Continental Shelf of great dimension and relevance, avoiding threats to its territory and interests is essential. In this sense, the view that being a peaceful country does not mean being an unarmed country is resumed.

With regard to the Brazilian Armed Forces, it can be observed that they have been undergoing an important process of modernization and expanding their international performance, whether in peace missions approved by the UN or making efforts to assert their status as a regional power. At the domestic level, the Armed Forces are more concerned with training, development, incorporation of technological innovations and, above all, with the revitalization of the IDB. In view of this dynamic, FAB's performance and the principles and lines of action of Dimension 22 stand out, with strategic projects that represent a foundation for Brazilian technological development and for the strengthening of the so-called air power, which was once defined as the domain of the air also encompasses space, transforming itself into aerospace power.

Essential to understand the efforts aimed at modernizing the Brazilian air fleet – to be engendered, at first, through the acquisition of new aircraft by FAB and, later, through the national production of aircraft - is the premise of developing an "Air Force of great deterrent capacity, operationally modern and acting in an integrated manner to defend national interests" (BRASIL, 2019, p. 4). Moreover, it is up to this Air Force to maintain airspace

2 It should be noted that, currently, the Management and Operational Center of the Amazon Protection System (CENSIPAM), an agency subordinated to the Ministry of Defense, is responsible for integrating information and generating updated knowledge for the articulation, planning and coordination of global government actions in the Legal Amazon and the Blue Amazon, in favor of environmental protection and sustainable development in both regions.

sovereignty and integrate the national territory, acting in the 22 million km^2 that comprise the territory (approximately 8.5 million km^2), the Exclusive Economic Zone (approximately 3.5 million km^2) and International Agreements (approximately 10 million km^2), aiming to control, integrate and defend (BRASIL, 2019).

Briefly, FAB's activities to control, integrate and defend present in Dimension 22 are defined as follows: the control alludes to FAB's responsibility regarding the control of flights not only in Brazilian airspace, but also – due to international agreements signed – beyond the continent, over the Atlantic, in a total of 22 million km2; the defense aims to guarantee airspace sovereignty, which includes both the Brazilian territory and the borders, as well as the Exclusive Economic Zone, making up a total of 12 km2; the integration is related to providing humanitarian aid, civic-social actions, transporting people and supplies, transporting electoral bodies and ballot boxes, etc., actions that are more focused on meeting the needs of Brazilian citizens (BRASIL, 2019).

With a connotation more focused on military activities, the mission of defending the country's territory and the strategic environment presupposes a strong power of deterrence, which will only be possible if there are adequate military capabilities, deriving from this the efforts for the modernization of the Brazilian air fleet, given that most of the aircraft owned by FAB are of advanced operating age and are no longer in line with Brazilian aspirations. Furthermore, new monitoring systems and technological innovations in radar systems are also part of the list of current needs, in view of defense and integrated security requirements. Thus, FAB's Strategic Projects, designed in order to equate such demands, are present in Dimension 22 (BRASIL, 2019).

One of FAB's Dimension 22 strategic projects is the KC-390 Millenium, a multi-mission freighter capable of operating on unpaved runways anywhere in the world and equipped with self-defense systems that are less susceptible to threats in hostile environments. Produced to replace the old Hercules C-130, the KC-390 Millenium is a military transport and refueling aircraft, which has an optimized aerodynamic compartment with useful space for various cargo possibilities (BRASIL, 2019).

Of great magnitude for the development of Brazilian air power, the F-X2 Gripen Strategic Project, also part of the list of strategic projects in Dimension 22, is a major driver of technological development and innovation (FERREIRA; NERIS, 2018). Considering that the internalization of advanced technologies has the capacity to provide technological independence for Brazil, as well as increase the competitiveness of the defense industry, one of the tools adopted by the Brazilian government for the revitalization of the IDB is the determination that foreign suppliers must enter into Commercial, Industrial and Technological Compensation, with technology transfer being one of these compensation modalities (TAVARES, 2017).

It can be seen, therefore, that the strategic projects developed within the scope of Dimension 22 are very relevant in order to guarantee integrated Brazilian defense and security. To this end, it is essential to strengthen the Brazilian aerospace power, which involves growing concerns and improvements in the military aeronautical platform, hence the need

to modernize the Brazilian air fleet, meeting the requirements of modernity, efficiency and, above all, complementarity. In this sense, it is important to situate the importance of the military aeronautical platform for Brazil.

4 The military aeronautical platform and its relationship with defense and security

Few countries in the world are able to fulfill the necessary requirements in terms of technology and industrial development that can create and maintain enterprises in the aeronautical segment. However, this is a very closed segment, with barriers to entry and dominated by a few large conglomerates. Among the developing countries, the only one that appears as a relevant actor in this segment is Brazil, through Embraer. According to Miranda:

> The aeronautical industry is considered a strategic asset precisely because it generates and operates in highly qualified engineering, an essential basis for the entire process of technological development and innovation. At the same time, by its nature, this industry is obliged to work permanently on the technological frontier, whether to absorb, create or demand innovations in a wide spectrum of equipment and products. Not by chance, few countries around the world have dared to develop and control this industry. Brazil, until recently (early 2000), occupied a differentiated position among emerging countries due to Embraer and its surroundings (MIRANDA, 2016, p. 169).

The contribution of the aeronautical segment to the development of countries is of great magnitude, being decisive in the generation of jobs, the qualification of human capital, the technological training, the obtaining of foreign exchange and, above all, the development of military capabilities, given that the segment can be divided into two distinct sectors: civil/commercial aviation and military aviation, the latter better known as military aeronautical platform. By definition, the segment of military aeronautical platform:

> Covers the entire set of aircraft and aeronautical equipment used in military activities, from combat aircraft used to ensure air superiority, to support aircraft, such as transport, training, search and rescue (Search and Rescue – SAR). In this sense, this segment is characterized by the high amplitude and variety of aeronautical platforms for military use, which are grouped into six subsegments: combat aircraft, training, transport and surveillance, in addition to helicopters and unmanned aerial vehicles.
>
> It is also important to emphasize that the aeronautical segment covers the entire life cycle of these aircraft, which is divided into nine phases: conception, feasibility, definition, development, production, implementation, use, modernization

> and deactivation. The first five phases are developed by aircraft manufacturing companies, almost always under orders from their customers, in this case, the Armed Forces. The implementation phase is carried out by the customer together with the manufacturer. In turn, the use (maintenance) and modernization phases, which were almost exclusive to customers, have been increasingly explored by aircraft manufacturers themselves or specialized companies. Finally, the deactivation phase, increasingly linked to the issue of sustainability (FERREIRA, 2016, p. 399-400).

Another point to be highlighted about the military aeronautical platform is the great importance it has for the Defense Industrial Base (BID), being one of the catalysts for its revitalization and development, according to the guidelines established in the National Defense Strategy (END), for example:

> In an effort to modernize the BID, partnerships will be sought with other countries, with the objective of developing national technological capacity, so as to progressively reduce the purchase of services and finished products abroad. To these foreign interlocutors, Brazil will always make it clear that it intends to be a partner, not a customer or a buyer. The country is more interested in partnerships that strengthen its independent capabilities than in the purchase of finished products and services. Such partnerships should contemplate, in principle, that a substantial part of the research and manufacturing is developed in Brazil and will gain greater importance when it is the expression of comprehensive strategic associations (BRASIL, 2012, p. 22).

In this way, the need to continuously incorporate technological advances in order to guarantee efficiency is a primordial characteristic of the military aeronautical platform, given that it has as a guideline the continuous and growing introduction of technological innovations, which are generated through investments in R&D made by companies, research centers and universities, the triad on which competitiveness in the sector is based. In addition, the increase in competitiveness at a global level has led to efforts on the part of companies in the segment, aiming to diversify activities in interrelated sectors, with military aircraft manufacturing companies advancing towards the space industry, which favors the integration of complex systems (FERREIRA, 2016).

A trend observed in the segment, aiming at the expansion and diversification of companies, is the merger and acquisition operations and the establishment of strategic alliances between them. Thus, while mergers and acquisitions have generated a process of concentration in the organizational structure of the segment, strategic alliances have enabled – by integrating and associating the financial and technological resources of companies – the development and production of new military aircraft (FERREIRA, 2016).

A relevant feature of the military aeronautical platform segment should be highlighted: it arises from a state decision, centered on the imperatives of national defense. In the Brazilian case, the intention was to develop capabilities to be used in the production of air-

craft for military use, given that these platforms are the main defense instruments of the State, as well as being essential as a percussive element of national integration. According to Ferreira (2016):

> The military aeronautical industry is of great importance for national defense, as it enables the mastery of sensitive technologies, both on-board and those used in the development, production and adaptation of military aircraft, allowing the supply of modern and updated military aircraft, in addition to greater autonomy and availability in their employment. In the Brazilian case, the national aeronautical industry has a prominent position in the national defense structure, as it internally produced about 60% of the planes and 40% of the helicopters used by the Brazilian Armed Forces (2016, p. 438).

A key company and leader in the Brazilian defense sector, Embraer – created in the 1960s, created by the State, and after going through a serious crisis at the beginning of the years, was privatized in 1994 – is the most important company in the military and aeronautical platform segment responsible for the conception, development and production of the KC-390 Millennium project, in partnership with the Brazilian Air Force (FAB). In recent years, the company has devoted special attention to the Brazilian defense sector, given its performance in the F-X2 and KC-390 Millenium projects. Seeking to reinforce the company's presence in the military segment through the development of new services and aircraft, Embraer created, in 2011, Embraer Defense and Security (EDS), with operations restricted to the defense sector (FERREIRA, 2016).

4.1 The F-X2 Gripen and KC 390 Millenium Strategic Projects

As previously mentioned, both the F-X2 and the KC 390 are part of efforts to strengthen Brazilian air power, which is essential given the current situation in the present century. However, the importance of the satellite surveillance system and other developments relevant to the aerospace domain and, more recently, to cyberspace, is highlighted. With regard specifically to aircraft, although efforts have been made to provide a more integrated environment of security and defense, budgetary constraints and certain technical issues must be considered when judging the success of this endeavor.

With regard to the F-X2 Project, it appears in a scenario in which it was inevitable not to think about the modernization of FAB's aircraft fleet (especially combat aircraft), which used fighters that were not capable of complying with the new guidelines for the country's defense policy that arised at the beginning of the 21st century. Thus, the F-X2 Program emerged, which was already considered to be decisive for Brazilian ambitions, especially due to the requirement of technology transfer aimed at reducing Brazilian technological dependence in the sector, as well as aiming at future gains with the export of defense products

high technology, especially those from the military aeronautical platform segment (FERREIRA; NERIS, 2018). Certainly, prioritizing the acquisition of cutting-edge technologies from developed countries was essential when establishing the process of choosing new fighters for FAB, which was one of the most important reasons for justifying the choice of Saab, manufacturer of Gripen NG (TAVARES, 2017).

In this way, the new fighters to be chosen should replace, in the short term, the old Mirage F-2000, and in the medium and long term, the F-5M and A-1M fighters, and be the backbone of Brazilian fighter aviation (TAVARES, 2017). It should be noted that the main criteria to be considered in the evaluation of the companies' proposals would be technology transfer and compensation agreements (offset), that is, such criteria would define which company would provide the 36 (thirty-six) new multipurpose fighters for FAB (ANDRADE; LEITE, 2017).

In this sense:

> In order to achieve lasting strategic objectives, the aircraft should incorporate the possibility for Brazil to enter as a partner in a high-technology program, with repercussions for the national defense industry, either through contractual obligations, with direct involvement of companies in the development, production and maintenance of the aircraft, or for commercial compensation (offset). Both cases sought to obtain technologies critical to the country (TAVARES, 2017, p. 27).

At the time, the French company Dassault had the initial sympathy of the Brazilian government, due to the technical cooperation agreements in terms of defense that already existed between Brazil and France, especially those signed jointly by then President Sarkozy with the, at the time, President Lula, which were relevant to the Brazilian Navy Submarine Development Program (PROSUB). On the other hand, FAB preferred the Swedish Saab, given that the Gripen NG better met the technical requirements demanded by FAB and had better cost-effectiveness than the Rafale (ANDRADE; LEITE, 2017). It was clear, at first, that the foreign policy interests embodied in Brazil-France bilateral relations seemed to dictate the outcome of the choice and to overlap with a more technical and careful analysis made by FAB. Finally, after comings and goings, the MD announced, on December 18, 2013, the option taken by Gripen NG.

On the choice process, Tavares (2017) states that:

> The projects presented were evaluated quantitatively and qualitatively in relation to the technology transfer aspect and classified according to their adherence to each of the areas presented and considered essential for the development and national production of a fifth-generation fighter aircraft (2017, p. 29).

Furthermore, there was an important competitive advantage for Gripen NG, which resided in the fact that it was an ongoing project, that could be contributed by Brazilian companies, especially Embraer Defense and Security (EDS), and with technology transfer. Moreover, the potential for Brazil to absorb state-of-the-art fighter aviation technology and the possibility

that, in the future, EDS would export the same aircraft was a very determining factor (ANDRADE; LEITE, 2017).

As for Gripen NG, the aircraft that will be the backbone of Brazilian fighter aviation as soon as FAB is in possession of the 36 acquired fighters, is characterized by its multifunctionality (flexible platforms), given that the same aircraft has the ability to be used in several missions, requiring only the choice of the appropriate armament for each of them, making the old combat aircraft intended for specific purposes obsolete. Having sophisticated data intercommunication systems with other aircraft, satellites and command, control and intelligence centers are also characteristics of Gripen NG (FERREIRA; NERIS, 2018).

As the F-X2 Project, the KC 390 Project arises from the concept that maintaining airspace sovereignty is FAB's mission. Therefore, it is essential to have an air force equipped with technical infrastructure and human resources that enable it to fulfill its respective mission. For this, FAB must have skills related to the acquisition and technological modernization of its equipment. In this sense, the acquisitions made by FAB are not limited to bidding acts as they involve other activities such as design, engineering, testing and evaluation, that is, the development of defense products is acquired.

Entering the list of the innovation model on the demand side, the order of the KC-390 by FAB had a large capital contribution from the state (RIBEIRO, 2017). In this way, the KC-390, the largest aircraft ever produced by the Brazilian aeronautical industry, has been setting a new and modern standard in the segment of medium-sized military transport aircraft, considering the performance and load capacity presented, as well as the advanced mission and flight systems, which makes the KC-390 fly higher and faster than its biggest competitor, the C-130. The forecast is that the new aircraft will bring significant benefits in terms of mobility to its operators, thus reducing the mission time (KLOTZEL, 2016).

Another highlight is that the KC-390 has state-of-the-art technology in terms of electronic warfare, active and passive capability against infrared missiles, armor, cutting-edge flight command system and reduced operating and maintenance costs, specificities which provoked a marked optimism on the part of Embraer and the Brazilian government regarding the export prospects of the aircraft (RIBEIRO, 2017).

It is worth noting that the order for the KC-390 made by FAB is fully part of the END guidelines regarding the re-equipment and modernization of the armed forces, as well as the objectives of Dimension 22. In this way, it appears that the development of this aircraft fulfills a dual and extremely significant function, namely: to meet FAB's operational needs regarding the replacement of the old C-130 by the new multi-mission freighter; and to stimulate the development and technological training of the military aeronautical platform.

In addition, given that the segment is a strategic asset due to the high technological overflow it provides, the development of the KC-390 is expected to generate numerous benefits for the Brazilian IDB. Expectations indicate that the KC-390 will "mean an operational leap for the Armed Forces and an advance for the Brazilian aeronautical

industry", and should become, over the next few years, FAB's "backbone of transport aviation" (BRASIL, 2018).

It is essential to mention that both the F-X2 Project and the KC 390 went through (and are still going through) some significant problems such as production and/or delivery delays motivated by budget cuts as a result of recent economic crises that have been causing global impacts. A highlight is the recent announcement[3] by FAB that it will reduce the number of aircraft to be acquired along with Embraer from 28 to 22 units (DIAS, 2022).

However, it is important to consider that, with regard to the Brazilian objectives of integrated defense and security and strengthening of air power, there are serious questions about the complementarity between both Projects, a topic that will be the subject of the next session and that resides in the fact of KC 390 Millenium being a tactical and non-strategic level freighter.

5 The F-X2 and KC-390 projects in terms of complementarity and strengthening of air power

It is questioned whether the acquisition of Gripen fighter aircraft and the production of KC-390 multi-mission freighters will in fact contribute to the strengthening of Brazilian air power. Although both projects provide technological development for the country and are essential for the modernization project of the Brazilian air fleet, they lack complementarity, which, however, may not generate the desired effects on Brazilian air power and harm efforts in the sense of seeking an integrated defense and security.

Developed and advertised as the future backbone of Brazilian military transport aviation, would the KC 390 Millenium really be an adequate aircraft for that, and would it represent a vector of complementarity to the F-X2 Gripen NG Project? In this aspect, a question could be raised to guide the entire analysis, namely: would the KC-390 be a strategic aircraft with a high capacity for in-flight and long-range refueling, in order to fulfill the needs of the construction of the Brazilian air power?

Firstly, I take as a parameter the conception of Douhet, who stated:

> Mastering the air means being in a position to prevent the enemy's flight, at the same time guaranteeing this faculty for ourselves [...] One who has command of the air and has an attacking force adequate and capable of protecting his territory and surrounding seas against air attacks and preventing the enemy from taking any air action to the benefit of its land and naval components (DOUHET, 1988, p. 48).

In this sense, it should be highlighted that, until 2013, FAB had four long-range in-flight refueling aircraft with high load capacity – the military version of the Boeing B707-320C, the KC-137 – that operated since 1986 and were already close to the end of their life cycle, with a

3 The agreement between FAB and Embraer was announced on 02/9/2022 and provides for the delivery of the aircraft by the year 2034. According to allegations by the actors involved, this new production rate fits the Defense budget conditions without compromising the production line.

maximum of five more years of continuous use. However, in June 2013, there was a serious accident with one of these aircraft while on a mission in Haiti, almost exploding and causing total loss. This fact, combined with the end of the aircraft's life cycle, motivated the decision of the Air Force High Command to end activities with these aircraft, thus FAB lost the strategic capacity aircraft it had (MOURE, 2014).

There was, at the time, a project in the proposal submission phase which aimed to acquire/develop aircraft that would replace the old KC-137, the so-called KC-X2 Project. However, due to the troubled political and economic moment experienced by Brazil, this project lacked continuity (MOURE, 2014). It is important to note that at the same time, the critical design review (CDR) for the KC-390 project took place, which may indicate the intention not to continue with the KC-X2 because it was believed that the KC-390 would be sufficient for FAB's objectives. Regarding a supposed thought in this sense, according to Aviator Colonel Marcel Gomes Moure, flight instructor and element leader in REVO, with more than 1200:00H and who operated in more than 46 countries on five continents:

> In the area of Fighter Aviation, all displacements of Fighter Units were supported by aircraft FAB 2401, FAB 2402, FAB 2403 and FAB 2404 (KC-137 registrations) that served in the Air Force from 1986 to 2013. Only with the use of the KC-137 was it possible to move fighter "vectors" to the extremes of Brazil, with in-flight refueling capacity unparalleled in FAB's history (MOURE, 2014, p. 17).

Still according to Moure:

> The continental dimensions of the country and the recent approval of the new fighter aircraft, the F-X2 program, will require an in-flight refueling support that allows covering the entire national territory, at any time and place. This is only feasible with a "vector" of great logistical capacity for cargo, passengers and, above all, fuel transfer, in quantity and flow that meet the Gripen NG and other combat vectors of Air Power (MOURE, 2014, p. 22).

The KC-137 was a four-engine jet, with 40 tons of payload available in its full cargo configuration, which focused its strategic role on the REVO of F-SEM, F-2000 Mirage and A1 fighters precisely due to being able to carry fuel (90,000 liters) at greater distance and higher altitude, with the possibility of transferring 1700 liters per minute and by acting as a long-range transport aircraft and great strategic capacity to support the use of air power by FAB (MOURE, 2014). On the other hand, Embraer never invested in large aircraft, and the KC-390, although more modern and better performing than the C-130, does not have the operational capacity of the old KC-137. To what extent could this be the backbone of Brazilian military transport aviation in this context and in the absence of effective complementarity with Gripen NG?

Certainly, an Air Force needs a fighter plane that allows it to counter any and all external threats, however, it must be kept in mind that the wars of the 21st century will not only be decided by the so-called fighter vectors, but by a complete and integrated data link network, supported by advanced communication and control aircraft and REVO that provides a wide security coverage throughout the national territory, especially for countries that have the dimensions of Brazil. Such aircraft are called High Value Aircraft due to the strategic importance they have in the theater of air operations, and their absence makes the use of air power in its fullness, which becomes an unquestionable fact for Brazil, in view of Dimension 22.

In this context, even though the KC-390 is more modern and superior to the C-130, Embraer's corner business is at the tactical level and not at the strategic level, a segment of the KC-137, which means that FAB lacks a strategic vector of REVO. At the comparative level, a KC-137 was capable of carrying twice the load of a modern KC-390. In addition, the F-X2 program demands, aiming at the operation of all its installed capacity, a strategic aircraft with long-range, autonomy, cargo and REVO capabilities, characteristics not present in the KC-390 and, therefore, it is not capable of supplying the demand generated by Gripen NG, that is, there will not be such a complementarity that could manifest Brazilian air power in its entirety.

In view of the above, it can be deduced that even in the presence of all the new fighter jets and freighters there would not be a perfect complementarity between them. If solutions could be taken to reduce this lack of complementarity and the risks inherent to it should be considered. Faced with the need to strengthen aerospace power, it is extremely necessary to have complementarity and, above all, interoperability. If the choices adopted denote the total non-observance of these essential precepts to build an integrated defense and security in the country, such choices should be rethought.

6 Final considerations

There is an indisputable need to re-equip the Armed Forces and this is a trend that has been present since the beginning of the 21st century, so that countries have been making efforts to adapt to the conditions of a world order with a diffuse distribution of power and in which the imperatives of security and defense are precepts that dominate the policies of States. Thus, military capabilities, defense industrial base and technological development are very urgent demands for countries. It is seeked to engender efforts to protect the territory and especially the borders in the face of the most diverse threats that tend to be multifaceted and in exponential growth.

Brazil is part of this dynamic, which seeks to make efforts towards the revitalization and modernization of the necessary apparatus so that the risks of existential threats to its strategic surroundings can be reduced, multiplying care for border illicit, drug trafficking, human trafficking, among others. In this sense, seeking the development and streng-

thening of the necessary means to fulfill this mission in the best possible way becomes something of paramount importance.

Within this context, it was sought to analyze the direct implications of strengthening air power for the development of an integrated defense and security environment in Brazil by questioning the effectiveness of the F-X2 and KC390 Strategic Projects in fulfilling the objectives described in Dimension 22.

One can think of a lack of efficient defense planning in the country, which results in the debatable option of modernizing the Brazilian air fleet through the acquisition of aircraft that are not complementary to each other, both seen as essential for FAB's mission in Dimension 22 and to obtain what Douhet calls the mastery of the air, the fundamental foundation of air power, which nowadays broadens its spectrum to aerospace power, including cyberspace. What would have been the reasons that led to the prioritization of the F-X2 and KC-390 projects and the abandonment of the KC-X2 project given that being the latter what, in fact, would complement the F-X2 project is something that would be worth investigating.

In addition, seeking initiatives that aim to develop a higher interoperability between the armed forces in the country would certainly be a great and very significant contribution to the improvement of initiatives aimed at defense and integrated security in Brazil in the face of the numerous threats to the Brazilian sovereign space.

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Knowledge creation in the Armed Forces: an analysis of the lessons learned systems in the light of the SECI model

La creación del conocimiento en las Fuerzas Armadas: un análisis de los sistemas de lecciones aprendidas a la luz del modelo SECI

Abstract: The Lessons Learned Systems are important tools for the innovation on military doctrine. This research aimed in compare the knowledge creation theoretical model known as SECI – Socialization, Explicitation, Combination and Internalization – with the way these systems operate. Through a literature review, the models of NATO and the Brazilian Army were analyzed, and compared with the SECI cycle, in order to observe the similarities between them. With this, it was possible to perceive a proximity between the theoretical and practical models, thus allowing the use of this framework as an element of analysis for the Lessons Learned Systems. In this way, this work intends to contribute to the advancement of knowledge management studies within the Armed Forces, enabling the application of models established in the literature where similarities are observed and seeking to improve these theories to better meet the particularities of military environments.

Keywords: Innovation Index; Incrementalism; Global Innovation Index GII; National Innovation Systems.

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Keywords: Knowledge management; knowledge creation; lessons learned systems; literature review; military doctrine.

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1 Introduction

The Lessons Learned Systems (SLA, acronym in portuguese) have been used by various types of civil and military organizations as a tool for learning and disseminating knowledge acquired through organizational experience (PATRICK; JIMMY, 2006; WEBER; AHA; BECERRA-FERNANDEZ, 2001). This type of knowledge is of great value to organizations, since it originates within their environment, thus being better adapted to their reality and organizational culture, in addition to its practical character (DAVENPORT; PRUSAK, 1998). The ability to transform the knowledge deposited in the human element into something that can be incorporated into an institution's own repository is a powerful tool for developing the knowledge capital of any organization.

The concept of lesson learned has varied over time. In its most recent form, there is an important emphasis on validation and on the impact caused in the organization by the knowledge absorbed:

> A lesson learned is knowledge or understanding gained through experience. The experience can be positive, as in a successful test or mission, or negative, as in an accident or failure [...]. The lesson must be significant in the sense that it has an actual or perceived impact on operations; valid, in the sense of being factually and technically correct; and applicable, in the sense of identifying a specific form, process or decision that reduces or eliminates the potential for failures or accidents, or reinforces a positive result (SECCHI; CIASCHI; SPENCE, 1999, apud WEBER; AHA; BECERRA-FERNANDEZ, 2001, p. 18).

This concept is compatible with the one used by the Brazilian Army, which distinguishes "lessons learned" (knowledge that collaborates with the land military doctrine assuming innovation) and "best practices" (related to techniques, procedures and methodologies identified as the best way to act, but that do not generate doctrinal innovations) (BRASIL, 2017a). Therefore, the lessons learned work as a way to oxygenate current knowledge, incorporating novelties arising from the observation of practice, avoiding the crystallization of concepts and the stagnation of organizations.

Despite already having their own structures for absorbing lessons learned since at least the mid-twentieth century, the topic of knowledge management has received little academic attention within the Armed Forces (DYSON, 2019). In view of this, this article aims to shed light on the topic, highlighting the similarities between theories of knowledge creation and the way in which the military SLA works. In addition to serving as a stimulus for academic debate on the subject, it can serve as a theoretical basis for other more applied studies focused on the SLA.

In order to achieve these goals, this article will begin by explaining the main concepts related to the theory of organizational knowledge creation. Then, it will analyze how the North

Atlantic Treaty Organization (NATO) and Brazilian SLA work, highlighting the similarities of these two systems with the concepts previously presented. Finally, it will put into perspective the importance of the SLA for the armed forces, especially with regard to their doctrinal evolution.

2 Organizational knowledge creation

The theories of Organizational Knowledge Creation are considered by some authors as a subarea of Knowledge Management, although this is not a consensus (LOERMANS, 2002). Authors such as Gore and Gore (1999), Nonaka and Takeuchi (1995), Swan, Scarbrough and Preston (1999) consider creation to be an essential management process, being, therefore, framed by it. Others, such as Davenport and Prusak (1998) and Loermans (2002), claim that the term "management" is misused when working with something as personal and immaterial as tacit knowledge.

Regardless of the nature of this relationship, the most important aspect to note is that both share a relevant theoretical load. The main divergence perceived in the consulted works is found, mainly, in the approach they employ: while knowledge management theories look at the objects of study from a higher position, having the company as a focal element and individuals as satellites of the processes, theories of knowledge creation have a greater focus on understanding the roles of individual actors, placing the business environment as something that contextualizes them.

The use of information to generate innovation goes beyond the activities of gathering, cataloging and distributing data. The mere accumulation of these does not produce something new (DAVENPORT; PRUSAK, 1998). Only individuals in possession of data and within a given context are able to innovate. Organizational Knowledge Creation theories seek to understand the way in which organizations "amplify the knowledge created by individuals and crystallize it as part of the organization's knowledge system" (NONAKA; TAKEUCHI; UMEMOTO, 1996, p. 834).

2.1 Data, information and knowledge

One of the fundamental points to study knowledge management is to understand what knowledge itself is, and what differentiates it from data and information. Broadly, data can be defined as meaningless stimulus patterns, provoked by changes of state in the physical world and detected by an agent's ability to perceive (AAMODT; NYGÅRD, 1995; BOISOT; CANALS, 2004). Data are raw facts, measurements and statistics, which say nothing about the contexts, motives or relationships of the events they report. By its nature, data does not have meaning by itself and its excess can even be harmful, given that extracting meaning from large amounts of data can be an arduous task. Even so, they are important, since they are the raw material of information (DAVENPORT; PRUSAK, 1998; AL-ALAWI; -MARZOOQI; MOHAMMED, 2007).

Information, in turn, can be defined as "a message, usually in the form of a document or a visual communication. [...] Think of information as data that makes a difference" (DAVENPORT; PRUSAK, 1998, p. 3). Chyi Lee and Yang (2000, p. 783) define it as "data organized into a pattern of significance" and Aamodt and Nygard (1995, p. 197) as "data with meaning; the output of an interpretation of data and the input to, or output from, a knowledge-based decision-making process". Information, like any message, has both a sender and a receiver. The objective of information is to cause an impact on the receiver, to the point of altering their perception, or, as explained by Boisot and Canals (2004, p. 47) "information is an extract of data that, by modifying the distributions of relevant probabilities, has the ability to do useful work on an agent's knowledge base.

Although it has a greater added value than the raw data, information by itself is not capable of generating knowledge, in the same way that having a racing car does not transform its driver into a Formula 1 driver. To become knowledge, information needs to be worked on in people's minds, being placed within a context that allows it to give rise to something new (BALESTIN, 2007; ISKE; BOERSMA, 2005).

Levitt and March (1988) argue that organizations learn more from their interpretations of the past than from anticipations of the future, encoding these inferences from their history into routines, which are transmitted among their members through socialization, education, imitation, professionalization, personnel movement, mergers and acquisitions. Along the same lines, Davenport and Prusak (1998, p. 5) define knowledge as:

> [...] a fluid mix of structured experience, values, contextualized information and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the mind of its possessor. In organizations, it can still be incorporated not only in documents or repositories, but in organizational routines, processes, practices and standards. [...] It is a mixture of several elements; it is both fluid and formally structured; it is intuitive and therefore difficult to grasp in words and to understand completely in logical terms.

Some authors also define knowledge as a "grounded true belief", built on the basis of the individual's interactions with the world and used to prepare, take concrete actions or understand the context and be ready to solve the situations encountered (NONAKA, 1994; NONAKA; TAKEUCHI, 1995; NONAKA; VON KROGH, 2009). From this perspective, knowledge can be tacit or explicit.

Tacit knowledge is related to the being's intimacy. They are formed by both a cognitive and a technical dimension, in a system of analogies composed of a mixture of mental models, schemes, paradigms, beliefs, points of view, know-how and skills (NONAKA; VON KROGH, 2009). This knowledge is continuously mobilized on demand, in specific contexts, according to the user's

need. As it is more related to practice and intuition, tacit knowledge is difficult to formalize, which makes its dissemination more complex. Its transmission needs to involve interaction between the carrier and receivers through joint work, controlled practices, meetings, seminars, videoconferences, virtual reality technologies or online communities. (CHOI; LEE, 2002; NONAKA; TAKEUCHI, 1995; POPADIUK; CHOO, 2006).

Explicit knowledge, in turn, is codified in a formal, systematized and materialized language, or even symbolic (words, numbers, forms, formulas). In this format, they have a universal character that makes them more easily shareable with other people (NONAKA; TAKEUCHI; UMEMOTO, 1996; NONAKA; VON KROGH, 2009; POPADIUK; CHOO, 2006) and transmitted through traditional information processing technological systems (CHOI; LEE, 2002). Reports, texts, assessments, spreadsheets, models, tables, images, rules, routines, standard operating procedures, are all examples of explicit knowledge (POPADIUK; CHOO, 2006).

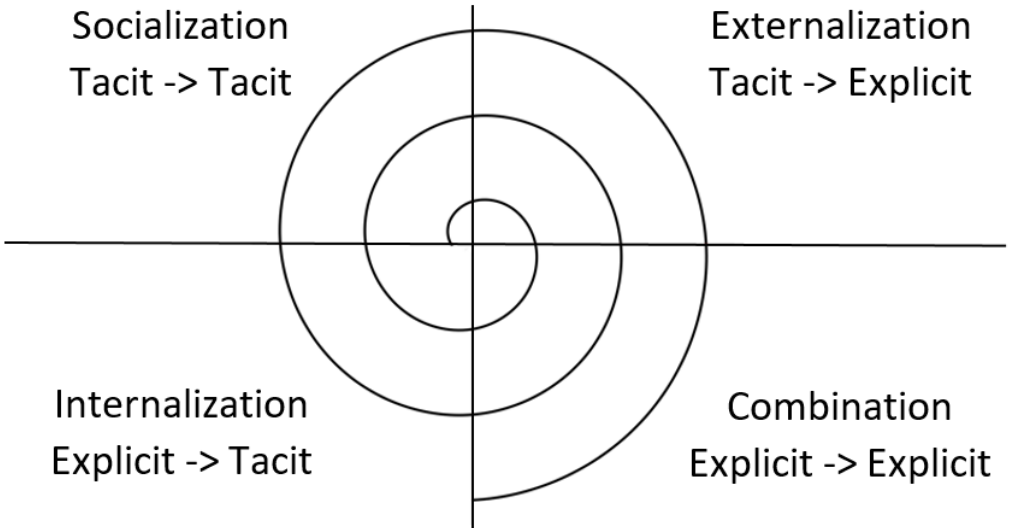
Tacit and explicit knowledge are not watertight elements in their forms, or even the antithesis of each other, but something like two mutually complementary entities, which interact and transform themselves along a continuous flow (NONAKA, 1994; NONAKA; TAKEUCHI; UMEMOTO), 1996; NONAKA; VON KROGH, 2009). This distinction between tacit and explicit was incorporated and widely used in theories of organizational knowledge creation and promoted a break with previous theoretical paradigms that equated information and knowledge (NONAKA; VON KROGH, 2009).

2.2 The SECI model

In order to explain how knowledge creation happens within organizations, Nonaka and Takeuchi (1995) and Nonaka, Takeuchi and Umemoto (1996) proposed the SECI model (acronym for Socialization, Externalization, Combination and Internalization). This model seeks to understand the creation and transmission of knowledge as an interconnected phenomenon (CHOI; LEE, 2002; POPADIUK; CHOO, 2006).

In their theory, the authors postulate that "knowledge is created and expanded through social interaction between tacit and explicit knowledge" (NONAKA; TAKEUCHI; UMEMOTO, 1996, p. 835), a process they call knowledge conversion. This conversion process takes place in four different ways: socialization (tacit to tacit), externalization (tacit to explicit), combination (explicit to explicit) and internalization (explicit to tacit). When tacit and explicit knowledge go through a flow of interactions and conversions, innovations are created. This flow was called by the authors the knowledge spiral (NONAKA; TAKEUCHI; UMEMOTO, 1996), and is illustrated in Figure 1

Figure 1 – Knowledge Spiral



Source: Nonaka, Takeuchi and Umemoto (1996).

Knowledge, on its way through the spiral, goes through four quadrants associated with the way in which its holders interact with each other and transform them (knowledge conversion). The socialization quadrant is where the conversion of tacit knowledge to other tacit knowledge occurs, through social interaction, joint activities and learning through experience, among other activities of this nature (POPADIUK; CHOO, 2006). Through socialization, individuals share experiences, mental models, techniques, skills through observation, imitation, and practice (NONAKA; TAKEUCHI; UMEMOTO, 1996). However, tacit knowledge, due to its highly subjective nature, needs to be articulated more efficiently – that is, transformed into explicit knowledge – so that it can be transmitted to a greater number of people (NONAKA; VON KROGH, 2009).

The externalization sector is characterized by intellectual work that aims to consolidate tacit knowledge into explicit concepts, through constructions such as metaphors, concepts, hypotheses, models or prototypes, aiming to facilitate their sharing (POPADIUK; CHOO, 2006). This sector "carries the key to innovation, because [it is where] explicit new concepts are created from tacit knowledge" (NONAKA; TAKEUCHI; UMEMOTO, 1996, p. 838). This creation of new concepts occurs through dialogue processes or collective reflections (CHOI; LEE, 2002). The discrepancies arising from the crystallization of knowledge in metaphors and analogies promote the reflection and dialogue of individuals, who make new concepts emerge when they interact (POPADIUK; CHOO, 2006).

In the combination sector, the varied pieces of explicit knowledge created in the previous phase are processed within the knowledge management systems. Through ordering, adding, combining and categorizing tools, explicit knowledge is recombined and reconfigured, giving rise to new emerging knowledge. Diffusion and recombination are the keywords in this sector (POPADIUK;

CHOO, 2006), which normally occurs at mid-management levels, and where explicit knowledge is converted into new explicit knowledge (NONAKA; TAKEUCHI; UMEMOTO, 1996).

Finally, this knowledge is disseminated by the rest of the organization and absorbed by its members through training, simulations, and other dissemination and learning tools, converting into new tacit knowledge, in a process called internalization. Internalization works through practical learning (NONAKA, 1994; POPADIUK; CHOO, 2006), and is facilitated when knowledge is externalized in the form of oral presentations or diagrammed in documents and manuals.

Several authors emphasize the importance of the company's performance in creating an environment conducive to the creation of knowledge and innovation (NONAKA; TAKEUCHI, 1995; NONAKA; TOYAMA; KONNO, 2000; POPADIUK; CHOO, 2006; BALESTRIN, 2007; DYSON, 2019; FRANCO-AZEVEDO, 2018; VON KROGH; NONAKA; RECHSTEINER, 2012). Situations in which individuals are exposed to new challenges and demanded to break pre-existing routines, habits and cognitive structures favor the creation of new knowledge. In the case of the Armed Forces, the employment in combat situations provides an environment of great potential for the emergence of innovations, given the due degree of freedom for troops to experiment and adapt previously organized concepts (DYSON, 2017, 2019; MARCUS, 2015, 2019).

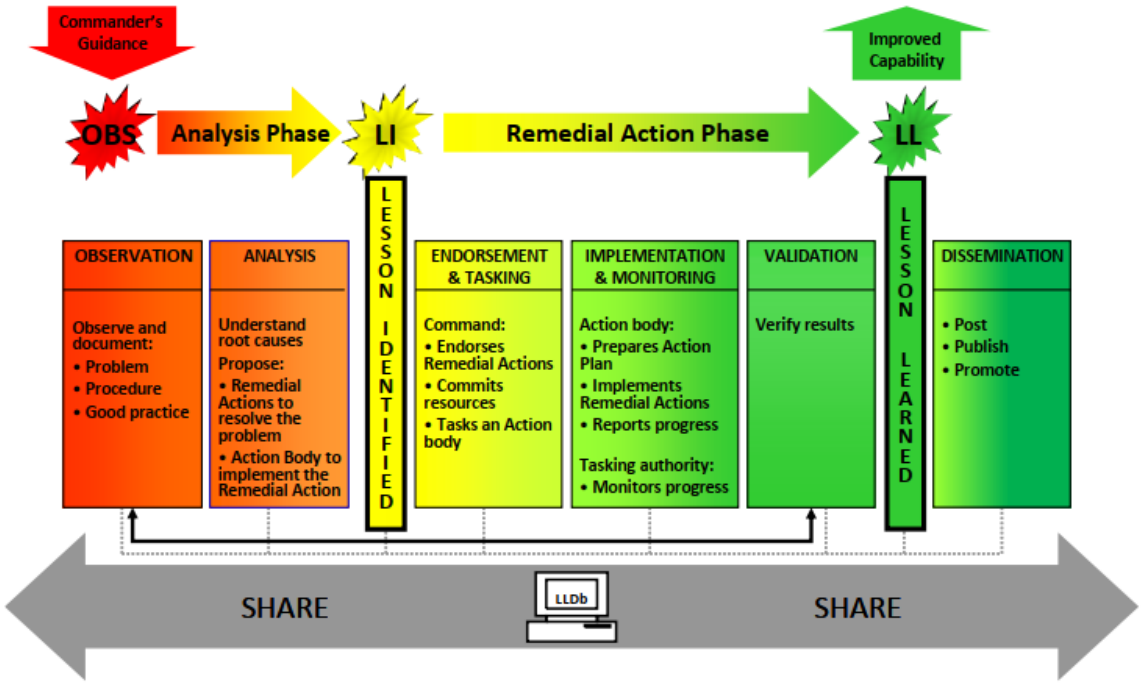
3 Knowledge creation in military institutions

Military innovation systems can be top-down or bottom-up. In top-down systems, innovations arise through changes proposed by the upper echelons of forces, which are adopted by all subordinate echelons (GRISSOM, 2006). An example of this model is the process of planned cultural change[1] proposed by Farrell and Terriff (2002). In bottom-up models, new ideas can arise from anywhere in an organization and reach its highest levels, being adopted as an institutional project (GAYNOR, 2013). The SLA are the best example of a system of bottom-up innovations existing in military institutions (DYSON, 2019; MARCUS, 2019).

The lessons learned systems are intended to collect knowledge and promote innovation within military institutions. These systems, such as the North Atlantic Treaty Organization's Lessons Learned System (NATO Lessons Learned System) or its national equivalent, the Doctrinal Monitoring and Lessons Learned System (SADLA), function as a means of "learning efficiently and providing valid justifications to improve the way of doing things, seeking to improve performance, both during operations and in the following moments" (DYSON, 2017, p. 3). Below, the Figure 2 illustrates the way in which the NATO Lessons Learned System works, in order to produce a doctrinal innovation.

1 Process by which an organization's leadership engages in a process of reshaping the organization's culture to allow for innovative behavior.

Figure 2 – NATO Lessons Learned System



Fonte: North Atlantic Treaty Organization (2011).

Analyzing the figure above and the description of the system presented in the NATO Lessons Learned Handbook, it is possible to draw a parallel between the doctrinal innovation process and Nonaka and Takeuchi's Knowledge Spiral. In the observation phase, the soldier is faced with situations, typical of their function or not, which, through interaction with other professionals or with the environment that surrounds them, leads them to acquire new tacit knowledge, different from what is recommended in the military doctrine (NORTH ATLANTIC TREATY ORGANIZATION, 2011). This phase can be seen as a moment of Socialization.

Then, in the analysis phase, the soldier, alone or in a group, carries out an intellectual work to describe the observed problem, analyze its causes and propose measures or changes in the doctrine to solve this problem. The findings are outlined in a standard report and transmitted through the NATO Lessons Learned Portal[2] (NORTH ATLANTIC TREATY ORGANIZATION, 2011). In other words, the soldier performs a mental work of reflection on their knowledge, seeking to materialize it in the format of a report and transmit it to others through the system. This activity aligns with the concept of Externalization.

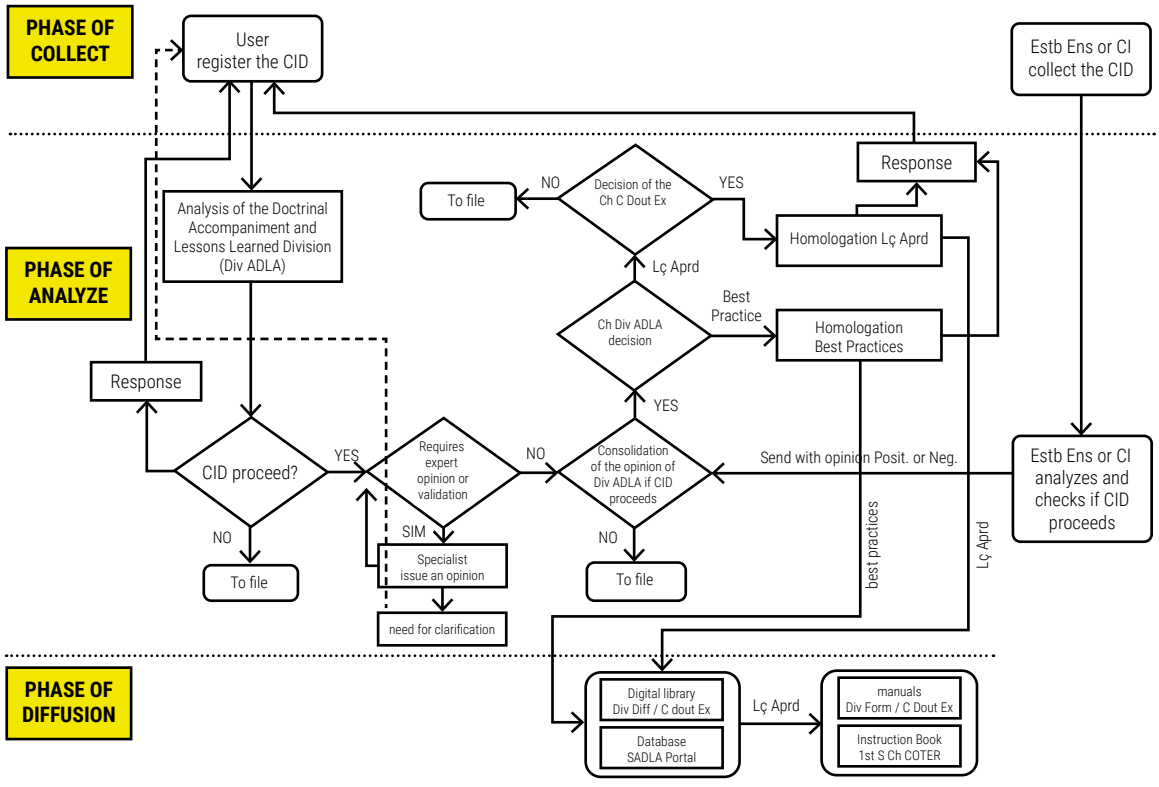
2 Available at: https://nllp.jallc.nato.int/Pages/HomePage.aspx. Access on: Mar. 25, 2022.

In the following three phases, this information is tested by a series of mechanisms that act on demand from the Lessons Learned Center. These mechanisms generate reports (other explicit knowledge) that will be confronted with the knowledge submitted and will validate, refute or improve it. The result of this process is a new Lesson Learned, a new knowledge that causes a change in the current military doctrine (NORTH ATLANTIC TREATY ORGANIZATION, 2011). Roughly speaking, this phase can be compared to the Combination phase of the Knowledge Spiral.

The last phase, called dissemination, comprises the dissemination of the lesson learned with the rest of the organization. The NATO publication emphasizes that it is not enough for the knowledge created to be only published in manuals, it is necessary to communicate it through different means, such as training, communities of interest and other information technology means so that it reaches those who need it (NORTH ATLANTIC TREATY ORGANIZATION, 2011). This last phase is in line with the idea of internalization proposed by Nonaka and Takeuchi.

SADLA, in turn, works in a very similar way, despite having its own system, illustrated in Figure 3. In it are also detailed phases of collection (externalization), analysis (combination) and diffusion (internalization). The socialization phase is not detailed in the systematics itself, but it is possible to perceive it implicit in the process by the way in which the concepts are presented in the collection phase (BRASIL, 2017a).

Figure 3 – SADLA Flow Diagram



Source: Brasil (2017b).

For a member of the Brazilian Army to share their tacit knowledge with the institution, they must first materialize this knowledge in the form of a product, such as reports, work of a professional nature or articles for specialized publications (BRASIL, 2017a, 2017b). These products can be transmitted to the SIDOMT through the command channel[3] or through the SADLA portal, characterized as an Externalization process (NONAKA; TAKEUCHI; UMEMOTO, 1996).

After being received by the system, this knowledge will undergo a validation process by a series of mechanisms coordinated by the Army Doctrine Center (C Dout Ex). Approved in the analysis phase, this knowledge will be classified according to its impact. If it is considered as capable of implementing changes in the current military doctrine, it will be considered as Lessons Learned; otherwise, it will be classified as Best Practices. At the end of this process, it becomes part of the force's doctrinal databases (in particular, the SADLA Lessons Learned and Best Practices base), so that, in due course, it will be recombined to create doctrinal innovations. This part of the process presents the characteristics of the Knowledge Spiral Combination phase (NONAKA; TAKEUCHI; UMEMOTO, 1996).

The final phase of this process consists of disseminating new knowledge through the publication of various doctrinal products, such as campaign manuals or doctrinal update bulletins, which will be absorbed by the troops in military instructions and training exercises (BRASIL, 2017a). The new knowledge produced will be included in these publications and will reach the troops through the Force's teaching and training mechanisms. This last phase is in line with the idea of internalization proposed by Nonaka and Takeuchi.

4 The importance of the lessons learned systems for military doctrine evolution

At this point in the debate, it is interesting to observe how Davenport and Prusak's concept of organizational knowledge[4] dialogues with the concept of military doctrine[5]. In both, it is remarkable the fact that both knowledge and doctrine go beyond the limits of the primary objective of their creation and end up pervading all sectors of its organization's life. The authors also emphasize the practical character of knowledge, and its connection with experience. For them, practical experience is what allows the contextualization of information by the human mind, providing a historical basis for comparing events and creating inferences about its applicability in future events.

3 This remittance process through the command channel involves the knowledge process explained by a series of echelons of the Force, starting from the unit where the military is framed up to the highest management levels (Sectoral and Operational Management Bodies).

4 Apresentado na seção 2.1.

5 According to Barros (2021), Military Doctrine is "the harmonious set of ideas and understandings that defines, orders, distinguishes and qualifies the activities of organization, preparation and employment of the Armed Forces". It is a set of diverse knowledge, such as norms, concepts, beliefs and values, which, combined, enable the Armed Forces to organize, prepare and act in the fulfillment of its missions".

On these same bases, Murray (1996) builds the argument that military doctrine must always be built based on real operational experiences and taking into account the analysis of lessons from previous conflicts. Not surprisingly, Davenport and Prusak use the US Army's Lessons Learned Center as an illustrative example of the importance of incorporating previous experiences for the creation of organizational knowledge (DAVENPORT; PRUSAK, 1998).

The authors highlight how the ability to transfer knowledge from the past to future actions is critical for the military, and how this need was met by establishing lessons learned frameworks. Within these structures, the performance of Post-Action Analyzes[6] Another relevant function of lessons learned centers in the context of organizational learning theories is to promote a constant judgment on the pertinence of established knowledge. "Knowledge can be compared to a living system, growing and changing as it interacts with the environment. When knowledge stops evolving, it becomes opinion or dogma" (DAVENPORT; PRUSAK, 1998, p. 10). The same can be said of military doctrine. Given that the war is a phenomenon characterized by opposing efforts, it is natural that new strategies, tactics and technologies are constantly created in order to make their previous versions obsolete and guarantee the advantage on the battlefields to the holders of the state of the art (CLAUSEWITZ, 2015). Military history is full of cases in which a power considered as a military reference is overcome by an emerging element by repudiating the innovation based on the justification that what worked in the past would continue to serve indefinitely for the future (MURRAY, 1996, 1997; STEPHENSON, 2010).

Although the Brazilian Army has its own lessons learned system, it is possible to observe that the Force has adopted a model of doctrinal innovation that privileges the knowledge that arrives through formal command channels or that is obtained abroad through the officers of connection – what Farrell and Terriff (2002) call emulation (BARROS, 2019). In other words, the Army has privileged the acquisition mode over the allocation of resources for the production of knowledge, and even when using the latter, it prefers a top-down model. In addition to this being, from the start, a point that shows the distance between the organizational culture of the Armed Forces and that of business organizations, where the prevalence of aversion to ideas brought from outside is more common (AGRAWAL; COCKBURN; ROSELL, 2010; ANTONS et al., 2017; ANTONS; PILLER, 2014; KATZ; ALLEN, 1982), this fact also leads us to think about its applicability, for Brazil, in the production of doctrinal knowledge.

6 An exercise where the military, together, analyze a recently completed operation from the perspective of what was planned, what was effectively executed, the reasons for the difference between the two and what can be learned from this difference.

The area of Political Sciences, during the mid-1990s, witnessed an increase in studies related to the phenomena of convergence, diffusion and transfer of public policies. According to Dolowitz and Marsh (2000), these phenomena have been enhanced by the telecommunications revolution, the pressure exerted by the global economic system and the growing influence of international organizations. These factors have made political actors in a country increasingly interested or even compelled to adopt policy solutions developed in (and designed specifically for) other countries.

The actors in question can see in this transfer process the advantages of having a solution that can be quickly applied, with low development time and cost, and with the guarantee of previous success. However, the literature on the subject points out that not all transfers are successful, especially for three reasons: lack of information about the policy or its implementation (ill-informed transfer); some essential elements that promote the success of the policy in the country of origin are not imported (incomplete transfer); and the importing country pays little attention to differences in political, social, economic and psychosocial contexts between itself and the exporting country (inappropriate transfer) (DOLOWITZ, 1998; DOLOWITZ; MARSH, 1996, 2000). Therefore, the policy transfer process, despite appearing to have a number of advantages over the development of an own solution, has pitfalls that can completely make the application of a given solution in another context unfeasible.

Looking through this prism, it is possible to observe that the same advantages and risks associated with the transfer of public policies can be applied to the process of military doctrine emulation. Mattis (2008) uses the example of adopting the Effect Based Operations (EBO) doctrine as one of the main reasons for the failure of the Israel Defense Forces (IDF) in their campaign against Hezbollah in 2006:

> Doctrines inspired by the Effects-Based Operations (EBO) and Systemic Operations Design (SOD) that heavily embrace air power over a classic ground maneuver campaign was, of course, a decisive factor in the disappointing performance of the IDF. [...] According to Ron Tira, one of the IDF's biggest problems was 'the over-enthusiasm with which they adopted the American EBO idea. EBO aims to paralyze the enemy's operational capability, rather than destroying its military strength. This is achieved by reaching its headquarters, communication lines and other critical nodes of the military structure. EBO was used most vividly in the Shock and Awe campaign that opened the Iraq War in 2003. However, Americans used EBO to pave the way for their land maneuvers, not as an alternative to them' (MATTHEWS, 2008, p. 61-62).

In the report by Israeli general Ron Tira presented by Matthews (2008), it is possible to recognize characteristics of ill-informed and inappropriate transfers pointed out by Dolowitz and Marsh (2000). In this case, the IDF did not understand the way in which the EBO doctrine was applied in the larger context of operations in the US military doctrine, as well as they did not understand that the context of the two conflicts was different - in the case of the Iraq war, a conventional combat with the massive use of military power to achieve a quick and overwhelming victory, whereas the war against Hezbollah was an unconventional combat against an irregular force in an urban environment.

The case of failure presented by Mattis and Mathews contrasts with the success cases presented by Marcus (2015, 2019) when analyzing the same conflict. Marcus suggests that the development of an agile and efficient knowledge management system, based on the rapid production and dissemination of lessons learned in combat by IDF soldiers, enabled the continued adaptation of Israeli forces to Hezbollah guerrilla tactics (in turn, a small, poorly hierarchical and matricial organization, which gives it great adaptability). The lessons learned system adopted in 2006 was based on three main mechanisms:

> First, a network formed by the Lessons Learned Officers present in the field, acting as liaison elements between the units and sharing lessons from the bottom up, enabled real-time learning. Second, the Post-Action Review process emphasized the reflection, flexibility, and adaptability among ground units for future combat scenarios. Third, the GFC CALL [IDF Lessons Learned Center] analyzed and disseminated tactical lessons from the top down. While tactical-level lessons were collected at lower levels of the IDF, changes were usually made to Standard Operating Procedures or even quickly codified into doctrine by the GFC, quickly moving up the command channel to the highest levels of the IDF (MARCUS, 2015, p. 19).

This procedure, very similar to the SECI cycle, moved the IDF's lessons learned process, which was encouraged by an organizational culture characterized by initiative, autonomy and risk appetite, as well as a non-punitive mentality for those who challenge traditionally established knowledge. Marcus (2019) also emphasizes that the presence of a structure dedicated to the recording, analysis, codification and dissemination of lessons learned is essential to preserve the knowledge built by the end of the line.

Despite the comparison made between the modes of knowledge creation, it is important to emphasize that it is not the objective of this work to demonstrate the superiority of one model over the other, but only to point out that privileging only one of them tends to weaken the capacity for doctrinal innovation. Dyson (2020) and Farrell (1998), for example, point out a number of advantages of the acquisition/emulation model, but emphasize that the existence of a formal structure of lessons learned is a key factor for military emulation processes. In this way, it is clear the importance of systems of lessons learned, within the context of innovation systems for the constant evolution of military doctrine.

5 Conclusion

Today, the SLA are a fundamental part of the evolution and innovation processes of military doctrine within the Armed Forces, either as a bottom-up innovation system or in support of emulation processes. In modern battlefields, where volatility, uncertainty and ambiguity reign, just as important as being able to present innovative solutions to unprecedented problems is having the ability to absorb, incorporate and disseminate these innovations throughout the operating environment. Systems designed to convert the tacit knowledge that circulates among the troops and transform them into institutional knowledge are a key part of this process.

Throughout this article, it was possible to perceive how these systems are aligned with the theories of knowledge creation, incorporating the cycle of socialization, externalization, combination and internalization to its working methodology. These similarities allow the study of the SLA in the light of a theoretical framework consolidated in the academic literature, expanding the range of tools for their analysis and understanding, in addition to framing them within the sphere of knowledge management.

As a tool for the evolution of military doctrine, the SLA fulfill a highly relevant function by enabling the connection of holders of tacit knowledge with the echelons responsible for formulating doctrine in a quick and unbureaucratic way, thus avoiding the loss of relevant information along the command chain. This role is of capital importance to avoid the crystallization of military doctrine, especially in hierarchical institutions such as the Armed Forces.

The study and development of processes related to the SLA within military institutions should be encouraged, in order to enable their continuous improvement. This constant improvement must aim not only at the systemic point of view, but also seek to recognize and improve other areas related to knowledge management, such as organizational culture and the motivating factors of knowledge sharing. In this sense, the understanding and use of the theoretical framework already consolidated in the academic literature can be of great help.

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Coordination and planning: central categories in interagency relationships

Coordinación y planificación: categorías centrales en las relaciones interagencias

Abstract: The article reflects, based on a literature review and document analysis, on the coordination and planning categories as central to interagency relations. The study results indicate that cooperation is the most basic level in this type of relationship, given its informality and being based on personal and little institutionalized relationships. Coordination, on the other hand, would be the improvement of cooperation through elaborate arrangements, when agencies would consider the objectives, visions, purposes and desired end states of the other agency in the planning. The second category was worked from theorists and professionals of the interagency environment, who highlighted the importance of relationships to materialize through a planning process that produces an intelligible plan and that increases the chances of success of operations. We conclude that the full interagency relationship effectively materializes when it occurs through joint planning with the participation of all agencies involved in solving the problem.

Keywords: coordination; planning; interagency relationships; interagency operations; planning doctrine.

Resumen: El artículo reflexiona, a partir de una revisión bibliográfica y análisis documental, sobre las categorías coordinación y planificación como ejes centrales de las relaciones interagencias. Los resultados del estudio indican que la cooperación es el nivel más básico en este tipo de relación, dada su informalidad y por estar basada en relaciones personales y poco institucionalizadas. La coordinación, por otro lado, sería el perfeccionamiento de la cooperación a través de arreglos elaborados, cuando las agencias considerarían, en la planificación, los objetivos, visiones, propósitos y estados finales deseados de la otra agencia. La segunda categoría fue trabajada desde teóricos y profesionales del ámbito interagencias, quienes destacaron la importancia de que las relaciones se materialicen a través de un proceso de planificación que produzca un plan inteligible y que incremente las posibilidades de éxito de las operaciones. Concluimos que la relación interagencias plena se materializa efectivamente cuando se da a través de una planificación conjunta con la participación de todos los organismos involucrados en la solución del problema.

Palabras clave: coordinación; planificación; relaciones interagencias; operaciones interagencias; doctrina de planificación.

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1 Introduction

In January 2011, what appeared to be another typical summer storm marked the mountainous region of Rio de Janeiro as one of the biggest climatic and geotechnical catastrophes in the history of Brazil. The combination of heavy rainfall and specific geological conditions was one of the determining factors for the disaster: torrents of mud, rocks, trees, and debris came down, sweeping everything along the way. It is worth noting that on this route there were dozens of properties, from slums to high-end houses and hotels. The rains have also caused flooding of the river sources high up in the mountains, which has led to the rivers overflowing and the cities flooding. In this way, streets were covered by a sea of mud, with the consequent destruction of houses, piling up of cars, and many deaths.

Furthermore, the collapse of bridges on highways left towns isolated, which aggravated the situation for residents, who already lacked basic essential services such as drinking water, electricity, and communications of any kind. The tragedy imposed severe damage on the infrastructure, economy and geography of the affected region. It is estimated that this occurrence affected 20 municipalities in the region, affecting 90,000 people, of whom 30,000 were left homeless or displaced and 916 were fatal victims (BANDEIRA; CAMPOS, BANDEIRA, 2011).

During the same period, subsequent heavy rainfall also caused a series of floods in northeastern Australia, mainly in the state of Queensland. It is estimated that 80% of the state's 1.8 million kilometers of land was hit by the waters and as a consequence roads and rail lines were closed as well as mines flooded. Although Queensland was the hardest hit, the flooding spread to neighboring states of New South and Victoria. It is estimated that at least 22 cities and more than 200,000 people were affected and that about 35 people died in the floods (ARKLAY, 2012).

With similar coastal topographies, in which increasingly dense conurbations occupy the ravines, streams and floodplains that would naturally carry water between the mountain and the sea, heavy rains, floods and landslides were therefore experienced in both realities. However, when comparing the number of deaths caused by the rains in the mountainous region of Rio de Janeiro and Australia, Margareta Wahlström, UN Under-Secretary-General for Disaster Risk Reduction at the time, said that the tragedy in Rio was greater, mainly because of the lack of planning of the agencies involved in disaster prevention and response in the country (ROTHIER, 2011). To this aspect, Busch and Amorim (2011), added the lack of coordination between the public agencies involved in the response to the Rio de Janeiro disaster in 2011.

It is on these two concepts, coordination, and planning, that this study will focus, from a literature review and document analysis, on the centrality of both categories, specifically, in the interagency relationships.

The first concept is notably grounded in the studies of Kaiser (2011), Nolte, Martin and Boenigk (2012), Nolte, Martin and Boenigk (2012), Raza (2012), Saab et al. (2008), Wankmüller and Reiner (2020), which treat interagency relationships under three complementary approaches: coordination and its interrelation with collaboration and inter-agency coope-

ration. The second, interagency planning, is anchored in the works of Carafano (2011), Field (2021), Moynihan (2005), Quarantelli (2005), and Warmington et al. (2004).

The choice for such an object of investigation is directly related to the importance acquired by the theme of the interagency relations nowadays, notably when its derived operations are triggered, and the perception that the complexity of the problems to be faced in these situations demands a sophisticated level of coordination and necessary planning prior to the actions. Therefore, it is clear that it is necessary to reflect more deeply on these concepts.

It is important to point out that the so-called interagency relations are a broad and sometimes unresolved issue, both in academia and among professionals who work in operations with these characteristics. Expressions such as collaboration, cooperation, coordination, integration, and networking get mixed and confused when thinking about this kind of relationship.

It is worth adding that there is already a significant theoretical production in academia about interagency relations. From this perspective, the following section seeks an approximation with these theories, aiming to situate the main aspects of the debate.

2 Situating the debate around Interagency Relations

Interagency relationships are not something new, since for a long time, even if through simple, disjointed, and sometimes purposeless interactions, organizations have established relationships to share knowledge, achieve joint objectives, obtain material resources, and sometimes compete with each other. In this perception, Kaiser (2011), in his report to the Congress of the United States of America (USA), stated that

> Interagency collaboration among federal agencies with overlapping jurisdictions and shared responsibilities is not a new phenomenon. Attempts to foster cooperation among agencies, reduce their number in particular policy areas, or clarify the division of labor among them date to the early days of the republic (KAISER, 2011, n.p., emphasis added).

Although it is not a new phenomenon, the interagency theme may never before have been as relevant as it is now, given the emergence of complex problems[1], to be faced at the dawn of the third decade of the 21st century, namely[2]: transnational crimes of all kinds, increasingly frequent environmental disasters, health epidemics such as COVID-19, migratory crises,

1 Also called in the literature "wiked problems". Term coined by Horst Rittel and Melvin Webber, in the article entitled "Dilemmas in a General Theory of Planning" (1973). These would be problems with the following characteristics, among others: a) they have no definitive formulation; b) each problem is always unique; c) understanding the context that surrounds them is fundamental; d) they can be considered a symptom of another problem; e) the way the problem is explained and formulated will determine the nature of the solution.

2 Challenges described in the Global Humanitarian Overview 2021, published by United Nations-Coordinated Support to People Affected by Disaster and Conflict (UNOCHA).

among others, and to which no public entity is able to provide answers "relying solely on the efforts of a particular institution" (GARCIA, 2014, p. 72).

Despite the importance of the subject, it should be noted that the specific use of the term interagency is still relatively recent, especially in Brazil. The popularization of the expression in the world increased, especially from the 1980s, when it began to be used in the UK and the US (SOUZA; GARCIA, 2014), where the first practices of interagency cooperative relationships were suggested in order to integrate the actions of the US Departments of State and Defense (LEITE; FIGUEIRA, 2019).

In the Brazilian case, there is no time frame that enshrines the use of the term, although, according to Souza and Garcia (2014), the relationship between agencies in Brazilian public management has always occurred to a greater or lesser extent. We can see that the word agency first appeared formally, with the sense of a governmental body endowed with competencies, functions and planning, in law no. 9,649 of May 27, 1998 (RAZA, 2012).

The derivative term interagency, on the other hand, seems to be more common in the military environment (ARAUJO NETO; BARP; CARDOSO, 2017), which may be explained by the diffusion of the manuals[3] published by the Brazilian Armed Forces with the theme of interagency operations[4] in the 2010s, following a trend presented in the US manuals, published from the second half of the 1990s[5].

At present, this term is understood as explained in the 2017 edition of the manual "Operação Interagências", published by the Brazilian Ministry of Defense:

> The term interagency derives, then, from the partnership and synergy of efforts involving governmental and non-governmental agencies, which may be national and/or international, structured to achieve political and strategic objectives of national interest, harmonizing diverse cultures and efforts, **in response to complex problems**, adopting coherent and consistent actions (BRASIL, 2017, n.p, emphasis added, translated).

It is noteworthy that, in this work, interagency relations are understood as the collaborative arrangement that marks the relationship between state and non-state agencies, national or international, at all levels (political, strategic, operational, and tactical), which jointly act to solve some common and usually complex problem, which could not be solved by an individual agency. The solution to the problem must be obtained by triggering one or more interagency operations.

3 MD33-M12: Operações interagências (BRASIL,2012); e EB20-MC-10.201: Operações em ambiente interagências (BRASIL, 2013).

4 According to the Armed Forces Glossary, interagency operations are defined as: interaction of the Armed Forces with other agencies for the purpose of conciliating interests and coordinating efforts to achieve converging objectives or purposes that serve the common good, avoiding duplication of actions, dispersion of resources, and divergence of solutions with efficiency, efficacy, effectiveness, and lower costs. Same as Operations in Interagency Environment (BRASIL, 2015, p. 196, 288).

5 We cite some US manuals on the interagency theme published since the 1990s: Joint Publication 3-08. Interagency Coordination during Joint Operations (1996), later renamed as Interagency, Intergovernmental Organization, and Nongovernmental Organization Coordination during Joint Operations (2006); and Joint Publication 3-33. Joint Forces Capabilities (1999).

These arrangements range from informality to complete institutionalization, substantially impacting the product obtained from these interactions, that is, the solution. From this perspective, the study of these relationships is relevant to ultimately increase the likelihood of solving problems by achieving the goals that guided the relationship itself, thus providing the correlation between theory and practice. We argue that coordination and planning are key aspects throughout this process. Aspects to be developed in the following sections.

2.1 Interagency Collaboration, Cooperation and Coordination: a dialogue between fundamental concepts

According to Nolte, Martin, and Boenigk (2012), several definitions of the terms surrounding interagency relationships have been published in recent years and the discussion about their interchangeability and connectivity is not yet pacified both in academia and among professionals working in the interagency environment. A similar conclusion was reached by Wankmüller and Reiner (2020) when they analyzed 202 articles on the subject in their *paper*[6] on logistics supply chains for disaster relief. Other authors, such as Kaiser (2011), simplistically prefer to treat all interagency activities using the term collaboration, encompassing cooperation and coordination, in addition to other terms such as integration and *networking*.

Although there is semantic confusion between the words collaboration, cooperation, and coordination, it is evident in the work of Raza (2012) the importance of trying to distinguish between them in order to better understand what kind of interagency relationship is underway when two or more agencies relate to each other, and thus avoid unpleasantness during the execution of operations. Such perception is supported by Saab *et al.* when stating that

> Another reason for performance impediments might be a common misunderstanding about the core aspects of coordination, cooperation and collaboration, because when talking about these terms, it is important to differentiate between them [...] (SAAB *et al.*, n.p, emphasis added).

Contributing to this discussion, Bardach (1998), an author often cited in interagency articles for his work on management theory and practice, postulates that collaboration can be defined as an activity of two or more agencies with the intent of enhancing public values by working together, rather than performing activities in isolation, and that in this interaction there is a noticeable gain for all agencies, when acting in collaborative arrangements.

6 Coordination, cooperation, and collaboration in relief supply chain management.

In the wake of this contribution, Raza understands that this perceptible gain is materialized by

> a better response to the demands that define and justify their organizational missions, natures, and existences, by adapting, reconfiguring, or transforming their installed capabilities to solve a common problem (RAZA, 2012, p. 17, translated).

The aforementioned author also considers collaboration as a synthesis of cooperative and coordinated arrangements, suggesting that there is no coordination without initial cooperation[7].

Adding to the debate, Moreira (2018, p. 393), considers collaboration the "structuring concept of the entire interagency relationship." In light of the author's statement, it can be suggested that collaboration would be in the structure of all relationships between agencies. It would permeate and be present in the other arrangements (cooperation and coordination). Without collaboration, there would be no interagency cooperation and no interagency coordination. Collaboration would be the foundation upon which the other arrangements could happen.

From the approaches to the concept of collaboration, one can enter the discussion about the meaning of the term cooperation. And from this perspective, we borrow Rovere's (1999) definition in his book that deals with the organization of health institutions in hospital networks. The author defines it as follows:

> cooperation [...] has to do with a co-problematization to cooperate. Sometimes we don't disarm the word cooperation with its logic, but to cooperate is to 'operate with', to operate together. To operate together we must have a common problem, co-problematize (ROVERE, 1999, p. 64).

This idea of a common problem also runs through Franz's (2001, p. 242) definition, who understands cooperation "as a conscious and combined action between individuals or associative groups toward a certain end." Underlying both definitions is the issue of the need to cooperate, either to solve a problem or to achieve some goal, both of which are common to agencies.

However, this cooperation generated by common needs does not yet have a well-defined systematization, as it is characterized by "less formalism in institutional relationships" (RAZA, 2012, p. 16). In the cooperative arrangement, collaboration is present as a link between agencies, but it occurs in an unstructured way, based on personal relationships, and according to Kaiser (2011), voluntarism and discretionary participation of its members. Therefore, in gradual terms, cooperation can be considered as the first level of interagency relations, but let's not forget that it takes place on a collaborative basis, which supports the inter-agency relationship.

7 Such consideration is replicated in the fundamentals of interagency operations described in the manual on the subject, edited by the Brazilian Ministry of Defense (BRASIL, 2017, p. 17-72). In the doctrinal publication, collaboration appears as one of the guiding principles of interagency operations.

Another relevant factor concerning cooperation is that it almost always occurs without proper joint planning, since the institutions usually continue planning and executing their operations in a singular way, mainly because they have not established formalized relationships, which may be insufficient to solve complex problems. In fact, such an arrangement can even negatively impact the results of the interagency operation, leading to not achieving the desired end state[8].

In his work, Raza (2012) details some examples[9] of what he called cooperation failures during operations. However, it seems that more than errors in the collaborative-cooperative model, the mentioned interagency operations lack proper coordination, and the deficient results lead to indicate this. The collaborative-cooperative relationship tends not to be the most suitable for solving the problems described by the author.

Interagency coordination allows, on the other hand, through more elaborate arrangements, agencies to consider in their planning the goals, visions, purposes, and desired end-states of the other agency participating in the relationship. According to Saab *et al.* (2013), coordination, being more formal, is the next step to cooperation. In this way, coordination could be defined as an enhancement of cooperation, thanks to the institutionalization of the interagency relationship.

However, such a definition is not at all complete. Although it is an improvement, coordination can still be considered hierarchically superior to cooperation in relational terms. This is because the collaborative-coordinated arrangement is an important breakthrough in the search for the solution of complex problems.

According to the Brazilian Army's interagency operations campaign manual (BRASIL, 2017), coordination would even be necessary for mission accomplishment, a statement referenced by Santos Filho (2013, p. 32, translated, emphasis added) when he adjectives it as essential:

> Recent experience gained in the interagency environment shows that the coordinated action of the various vectors, whether civilian or military, is **essential** to ensure that the mission objectives are fully achieved.

Less assertively, one could say that without coordination the chances of a successful interagency operation in complex environments would be reduced. The examples listed by Raza (2012) lead to corroborate such a conclusion.

It is still necessary to postulate that the collaborative-coordinated arrangement, or simply coordination, because it is a more institutionalized and structured relationship, tends to be pre-established and imposed by higher levels of decision[10], when an interagency working group is formed to face a complex problem, assigning to one of the agencies the leadership/coordination and the formal and temporal decision-making authority over the others, in a hierarchical model

8 The desired end state is defined as "a succinct description of the conditions that, once achieved, will allow [...] to assume that the [...] mission has been effectively accomplished [...]" (BRASIL, 2020, p. 43/393, 44/393, translated).

9 Described in Raza (2012, p. 9-12).

10 "Echelons into which war management is organized, to which the responsibilities and activities inherent in the war effort are assigned. In terms of the organization, preparation and conduct of war, responsibilities are scaled at the political, strategic, operational and tactical decision levels" (BRASIL, 2015, p. 181/288, translated). The military also calls them levels of war conduct. Such a definition is valid for the organization of the interagency working/planning groups.

of attribution of competencies, as in the Sentinela, Ágata and Fronteira Blindada operations, coordinated respectively by the Federal Police, the Armed Forces, and the Internal Revenue Service (ARAUJO NETO; BARP; CARDOSO, 2017).

However, coordination can also emerge by consensus during the planning phase that precedes action and after the correct definition of the problem to be addressed, which allows all agencies to be participants in the proposed solution described in the plan and to act from a minimum consensus.

The next section will turn to the difference between these two possible collaborative-coordinated models, during the description of the second category discussed in this paper: interagency planning.

2.2 Interagency Planning as a fundamental aspect for successful operations

We take in this study the concept of planning adopted by the Glossary of the Brazilian Armed Forces (BRASIL, 2015). In the aforementioned manual, the term is defined as

> The act or effect of idealizing and fixing, with a greater or lesser degree of detail, the action, operation or activity to be carried out, through the determination and ordering of a set of actions that allow a certain objective to be reached. It comprises the identification of: what; when; how it should be done; and who should do it. 2. Permanent and continuous activity that develops in a guided and rational way, **systematizing a decision-making process in the solution of a problem**, which also involves implementation and control (BRASIL, 2015, p. 206/288, translated, emphasis added).

We have chosen this approach because we believe that this definition can be used by analogy for interagency operations, whose basic difference from purely military operations is the participation of agencies in the decision-making process aimed at solving problems. It could be inferred that the agencies' participation in the process would be closely related to the discussed topic 2.1, which dialogues with the concepts of collaboration, cooperation, and interagency coordination, that is, the more elaborate the arrangement among the agencies and the more it tends to coordination, the greater their participation during planning.

Despite the definition in the Armed Forces Glossary (BRASIL, 2015) and beyond, several authors make considerations about the preparation of plans, a *sine qua non* condition to materialize the interagency relationship. In the wake of this debate, Warmington *et al.* (2004) point out that interagency action materializes when at least two institutions work together, under the guidance of a formal plan, in which it is possible to act both at the operational and strategic decision levels.

Along this same line of reasoning, Moynihan (2005) states that interagency work happens when more than one agency acts jointly, in a collaborative effort and under the direction of a formalized plan, which enables its employment beyond the strategic decision level, that is, also at the tactical level of action.

There is no doubt that having a plan is important for the success of the operation, and that its absence is detrimental to the development of interagency work. Moreira (2018), makes this clear in his article, which takes Operation Serrana 2011 as its object of study[11]. After interviewing Brazilian Navy officers who helped flood victims in Nova Friburgo, Rio de Janeiro, the author comes to the following conclusion:

> Analysis of the testimony allows us to identify informal relationships established between [...] [the] agencies involved in disaster responses. For, even though [...] [they] interacted and executed a joint work, [...] these relations occurred in a spontaneous way, not institutionalized and without the guidance of a common planning. Therefore, [...] it can be said that the interagency relationship [...] remained in the realm of cooperation. [...] The [...] statement announces the need for planning measures to cope with disasters (MOREIRA, 2018, p. 385, translated).

But it is not enough just to produce a plan to ensure successful interagency operations. The focus, according to some authors, should not be limited to the production of a plan only, but should be directed to the planning process as a whole.

For Quarantelli (2005), what matters is the collective planning process, not the plan itself. According to the author, it is not a matter of managers producing written plans, broadcasting them as a panacea, formalizing public intentions, but of effectively promoting interactions and relationships that allow knowledge exchange, joint training, and expanded capacity for evaluation, mutual support, as well as committing to the constant updating/socialization of information.

Also contributing to the debate on the planning process, Carafano (2011) points out in his article that in addition to the plan, there must be an interagency methodology to address complex contemporary problems, which is built before addressing them. The author, in his criticism of the US government, indicates that one of the obstacles to better coordination would be the lack of a common language for understanding the agencies involved in the problem, a situation that has not been solved so far and that could be solved with the creation of a standard joint interagency planning process, to be used by all federal agencies in that country.

Still on this subject, Field (2021), in his report on previous experiences of the Australian Armed Forces in interagency disaster response operations, makes a contribution. The author focuses on how to make the planning process more intelligible to civilian agencies and thus more effective in its execution.

11 Operation Serrana was triggered by Ministerial Directive n°001 of January 14, 2011, signed by the Minister of Defense. It aimed at the cooperation of the Armed Forces to the Civil Defense actions in the mountainous region of Rio de Janeiro to deal with the consequences of the heavy rains that year. See (BRASIL, 2011).

> The effective application of a planning process is a core leadership skill in disaster relief operations to deal with the uncertainty and complexity of these environments [...]. Time is lost and plans delayed when people are frozen by an inability to write, understand or develop products needed for operational governance (FIELD, 2021, p. 17).

After the above considerations, it can be said that the full interagency relationship, that is, with the proper coordination, effectively takes place when it occurs through joint planning with participation in the decision-making process of all agencies involved in solving the problem. This relationship can even determine which agency will be supported by the others and which agencies will be considered as supporters (FIELD, 2021). In other words, it can define which agency will be appointed as coordinator of the others, to the detriment of the hierarchical model of attribution of competencies predetermined by the higher levels of decision.

In summary, the planning category can be understood as the moment in which inter-agency relations are consolidated through the participation of agencies in the decision-making process. This degree of involvement is fundamental to the success of the operations.

3 Concluding Remarks

This work aimed to reflect, based on a literature review and document analysis, on the categories of coordination and planning as central to interagency relationships.

The first category is part of the studies by authors who treat inter-agency relations from three complementary approaches: coordination and its interrelationship with interagency collaboration and cooperation.

In this category, the levels of interagency relationships and the basis on which they would be sustained were described. It was expressed that collaboration would be the structuring relationship, upon which the other interagency relationships would rely. Without collaboration, there would be no interagency cooperation and no interagency coordination.

The gradation regarding the level of interagency relationship was also presented. Cooperation was characterized as the most basic level, as it is more informal and based on personal and not very institutionalized relationships. Coordination, on the other hand, would be the enhancement of cooperation through elaborate arrangements, when agencies would consider in their planning the other agency's goals, visions, purposes, and desired end-states participating in the relationship. In addition, coordination would be hierarchically superior to cooperation, because it is an interagency relationship more conducive to the solution of complex problems.

The second category, interagency planning, was worked on by theoreticians and professionals from the interagency environment, who emphasize the importance of the relationships between the agencies being materialized through a decision-making process that produces a plan, which formalizes these relationships, is more intelligible to the agencies, and promotes greater possibilities for successful operations.

Following this reasoning, it can be pointed out that the full interagency relationship, that is, with the proper coordination, effectively takes place when it occurs through joint planning with the participation of all the agencies involved in solving the problem.

It is also important to stress that planning is the moment in which interagency relations are consolidated through the participation of the agencies in the decision-making process. This degree of involvement is critical to the success of the operations.

Finally, we understand that the issues raised and the results obtained by this work constitute a contribution to the development of further studies that may lead to the development of an interagency planning doctrine, which is understandable to the agencies and which facilitates the solution of complex problems, the reasons why the interagency relationship takes place.

Everything leads us to believe that disasters like the ones that happened in the mountainous region of Rio de Janeiro and in Queensland, Australia, in 2011, will continue to occur, producing disruptions in social life, in determined geographical areas and with aggravating impacts on specific social groups. From this it can be inferred that studies related to the interagency theme, especially the coordination and planning failures in the management of crises caused by these events, will be increasingly relevant, as they provide inputs for the improvement of planning and execution of disaster response operations, pointing paths for future research.

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Law and Order Guarantee Operations in the Legal Amazon: fight against environmental illicit

Operaciones de Garantía de la Ley y del Orden en la Amazonia Legal: combate a los ilícitos ambientales

Abstract: The adoption of Law and Order Guarantee Operations (GLO) by the Federal Government in the Legal Amazon represents a paradigm break, since these operations, in a way, are recurrent in other regions of the national territory. Common to be adopted in cases of public security crisis, this mechanism provided for in the Federal Constitution was adopted to guarantee the protection of the environment in 2019 and 2020/2021. The work, based on bibliographic research and websites, aims to analyze sources and data about Operations Verde Brasil 1 and 2, called by the author as "GLO Ambiental" and found that both were fundamental to reduce and inhibit environmental illicit, as well as, promoted the strengthening of the actions of partner institutions Operations of Cooperation and Coordination with Agencies (OCCA).

Keywords: legal Amazon; deforestation; burning; environmental GLO.

Resumen: La adopción de Operaciones de Garantía de la Ley y del Orden (GLO) por el Gobierno Federal en la Amazonia Legal representa la ruptura de paradigma, una vez que esas operaciones, de cierta forma, son recurrentes en otras regiones del territorio nacional. Comunes de ser adoptadas en los casos de crisis de la seguridad pública, este mecanismo previsto en la Constitución Federal fue adoptado en el ámbito de garantizar la protección del medio ambiente, en los años 2019 y 2020/2021. El trabajo, basado en la investigación bibliográfica y en sitios, busca el análisis de fuentes y datos sobre las Operaciones Verde Brasil 1 y 2, denominados por el autor como "GLO Ambiental" y constató que ambas fueron fundamentales para disminuir e inhibir ilícitos ambientales, así como, promovieron el fortalecimiento de las acciones de instituciones asociadas por medio de Operaciones de Cooperación y Coordinación con Agencias (OCCA).

Palabras clave: Amazonia legal; deforestación; quemas; GLO ambiental.

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1 Introduction

Actions that cause damage to the environment in the Legal Amazon gain visibility in Brazil and abroad, generating the adoption of measures by the State, which seek to mitigate the effects of these harmful actions and make public the country's commitment to legality and respect for commitments made abroad regarding environmental preservation.

Among the actions that degrade the environment (REDE AMAZÔNICA DE INFORMAÇÃO SOCIOAMBIENTAL GEORREFERENCADA, 2012) it can be mentioned the fires caused by human action, the illegal deforestation and the clandestine extraction of mineral resources in Conservation Units (Unidades de Conservação – UC), in Legal Reserves, in Environmental Protection Areas (Áreas de Proteção Ambiental – APA) and in Indigenous Lands (Terras Indígenas – TI). Similarly, one can mention as a State measure the adoption of Law and Order Guarantee Operations (Operações de Garantia da Lei e da Ordem – GLO), by Presidential Decree, as an infra-constitutional instrument to curb attitudes that violate the legal system and cause disorder in society (BRASIL, 1999, 2001, 2004b, 2010).

Also, it should be noted that the binomial development and preservation (PENNA FILHO, 2013) is present in the national and international agendas given its importance for the socio-economic growth of countries, sometimes becoming a dilemma and being widely discussed by public opinion in Brazil and abroad. In this context, Brazil's role on the world stage is relevant for having almost 60% of its territory covered by the Amazon biome (SOUTO; PAIM; FRANCH, 2018).

The Legal Amazon covers the states of Mato Grosso, Rondônia, Acre, Amazonas, Roraima, Amapá, Pará, Tocantins, and part of Maranhão (west of the 44th meridian), and according to the Institute for Applied Economic Research (DESENVOLVIMENTO CHALLENGES, 2008) this space is intended to foster the economic development of the region, which, according to Penna Filho (2013), encompasses immeasurable biodiversity:

> The **forest** holds the largest number of living species on the planet, the largest reserve of fresh water, **precious woods**, vast mineral deposits (many not even mapped), and great potential for generating hydroelectric power, among other resources (PENNA FILHO, 2013, p. 96, emphasis added).

Because of these and other unique characteristics found in the Amazon, the National Defense Policy (Política Nacional de Defesa – PND) (BRASIL, 2020e, p. 25) advocates as one of its national defense objectives to guarantee the sovereignty, national heritage, and territorial integrity. The region in question is the focus of several studies that address the issue of environmental securitization (CAVALCANTE, 2012; URT; PINHO, 2010; WAEVER; BUZAN; WILDE, 1998). In this sense, on this theme there is a search for the dominance of the narrative, sometimes seeking to discourage the economic growth of Brazil, and in particular of its agribusiness, by propagating ideas that the country does not preserve the Amazon environment. In a way, the dilemma arises and is supported by some statements of authorities and foreign Non-Governmental Organizations

(NGOs) (RAMIRES, 2010; PENNA FILHO, 2013), as well as through advertising campaigns that associate the country's development with the disrespect for the environment.

In this context, it is possible to exemplify the above considerations by mentioning the speech of French President Emmanuel Macron, who, on January 12, 2021, declared: "Continuer à dépendre du soya brésilien, ce serait cautionner la déforestation de l'Amazonie. Nous sommes cohérents avec nos ambitions écologiques, nous nous battons pour produire du soja en Europe!" (Figure 1).

Figure 1 – Tweet by Emmanuel Macron

Source: Macron... (2021a, 2021b).

Likewise, it can be observed the NGO WWF-Brazil (2021) that considers that: "The dismantling that the government has been promoting in the environmental area, with the weakening of enforcement agencies, is evident." Also, Greenpeace Brazil (2021, n.p.), with the campaign "Todos pela Amazônia", says: "[...] last year alone, every minute, an area larger than two soccer fields was illegally deforested. More than a thousand trees cut down every minute! That's right: a thousand trees a minute!." The advertising campaigns: "IAmazonia"[1] promoted by Greenpeace of the Netherlands; "Farms here, forests there" (FRIEDMAN; DAVID GARDINER & ASSOCIATES, 2019); and "DefundBolsonaro"[2], articulated by Brazilian activists, add to the aspects listed above, generating the need for a prompt response from the Brazilian State, in order to guarantee its legitimacy to the nation and the world.

1 Available at: https://media.greenpeace.org/CS.aspx?VP3=SearchResult&ALID=27MZIFJ80RSKF&_ga=&VBID=27MDQ5NPZK-VOH&POPUPPN=1&POPUPIID=27MZIFJ8X9TVQ. Accessed on: Mar. 22, 2021.

2 Available at: https://www.defundbolsonaro.org/. Accessed on: Mar. 22, 2021.
Available at: https://twitter.com/gen_heleno/status/1307038961555079168. Accessed on: Mar. 22, 2021.

Thus, Brazilian authorities, such as the current president of the Federative Republic of Brazil, Jair Messias Bolsonaro, have spoken out, aiming to affirm the country's commitment to environmental preservation. As an example, the president's speech at the opening of the 74th United Nations General Assembly in New York on September 24, 2019 can be cited:

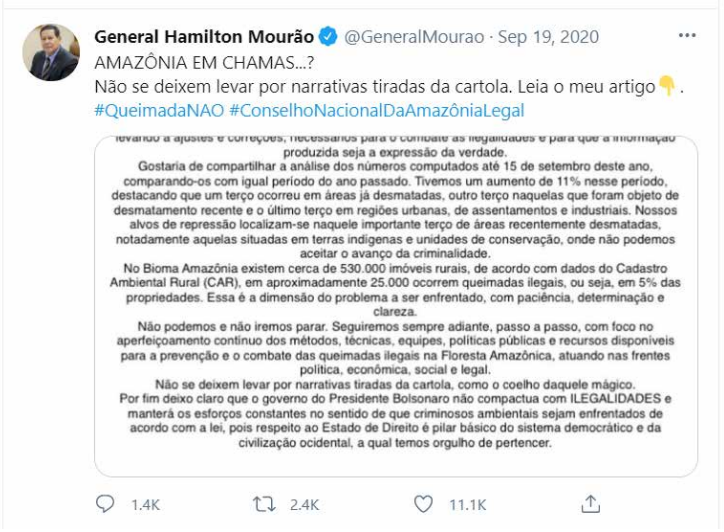
> First, my government has a **solemn commitment to the preservation of the environment and to sustainable development** for the benefit of Brazil and the world.
> Brazil is one of the richest countries in biodiversity and mineral wealth.
> **Our Amazon** is larger than the whole of Western Europe and **remains almost untouched**. Proof that we are **one of the countries that most protect the environment** (BRASIL, 2019c, n.p., emphasis added).

President Bolsonaro's October 22, 2020 speech at the Itamaraty Palace on the occasion of the graduation ceremony for the new Diplomats of the Rio Branco Institute reaffirms the same narrative:

> We are finalizing a **trip Manaus – Boa Vista**, where we will invite diplomats from other countries to show in that short trip of an hour and a half, that **they will not see** in our Amazon forest **anything burning** or even a hectare of **devastated** jungle (MAZUI, 2020, n.p., emphasis added).

Similarly, the vice president of Brazil, Army Reserve General Hamilton Mourão, who is also the president of the National Council for the Legal Amazon (BRASIL, [2021d]), whose motto is: "Protecting and preserving the Amazon is developing Brazil," has positioned himself in response to arguments that associate the country with environmental degradation practices (Figure 2).

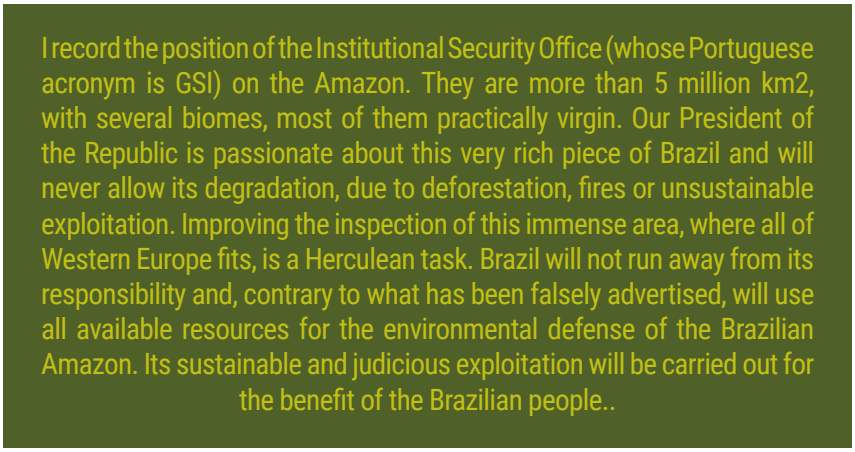
Figure 2 – Tweet by General Hamilton Mourão



Source: Mourão (2020).

Likewise, the then Minister Tereza Cristina, of the Ministry of Agriculture, Livestock and Supply (Ministério da Agricultura, Pecuária e Abastecimento – MAPA) broadcasted on her Twitter (DIAS, 2020) a video on Brazilian land title regularization, showing that the Federal Government has obtained excellent results in agribusiness allied with environmental preservation; the Chief Minister of the Institutional Security Cabinet (Gabinete de Segurança Institucional – GSI) of the Presidency, Army Reserve General Augusto Heleno; among others seek to counterpoint foreign and domestic statements and campaigns in order to preserve the country's image on the international scene (Figure 3).

Figure 3 – Tweet by General Augusto Heleno



Source: Heleno (2019).

Thus, this qualitative study aims to address the GLO Operations conducted in the Legal Amazon through Operations Verde Brasil 1 (2019) and Verde Brasil 2 (2020 and the first months of 2021), which the author chose to call "Environmental GLO" Operations because they are related to the fight against environmental crimes in the Amazon region (SOUZA, 2020), emphasizing that the numbers of hot spots and deforestation that occurred in the Amazon in the years 2019 and 2020 and in the months of January and February 2021 will be taken into consideration in order to answer the following problem question: how did the Environmental GLO conducted by the Armed Forces contribute to the reduction of the rates of burning and deforestation in the Legal Amazon between the years 2019 and 2021?

Thus, to answer the question above, a bibliographic and documental research was carried out in governmental and non-governmental sites, in Brazil and abroad, in order to obtain subsidies to be analyzed for the solution of the problem in question. In addition, the legal instrument of GLO operations for the preservation of the environment will be highlighted by analyzing Verde Brasil Operations 1 and 2, which represent a paradigm shift by not being specifically aimed at responding to public security crises, when they were commonly adopted.

The paper is organized as follows: the present introduction, a section dealing with deforestation and fires, and the tools for monitoring deforestation and hot spots in the Legal

Amazon. This is followed by a section talking about Environmental GLO Operations and, finally, the final considerations of the article.

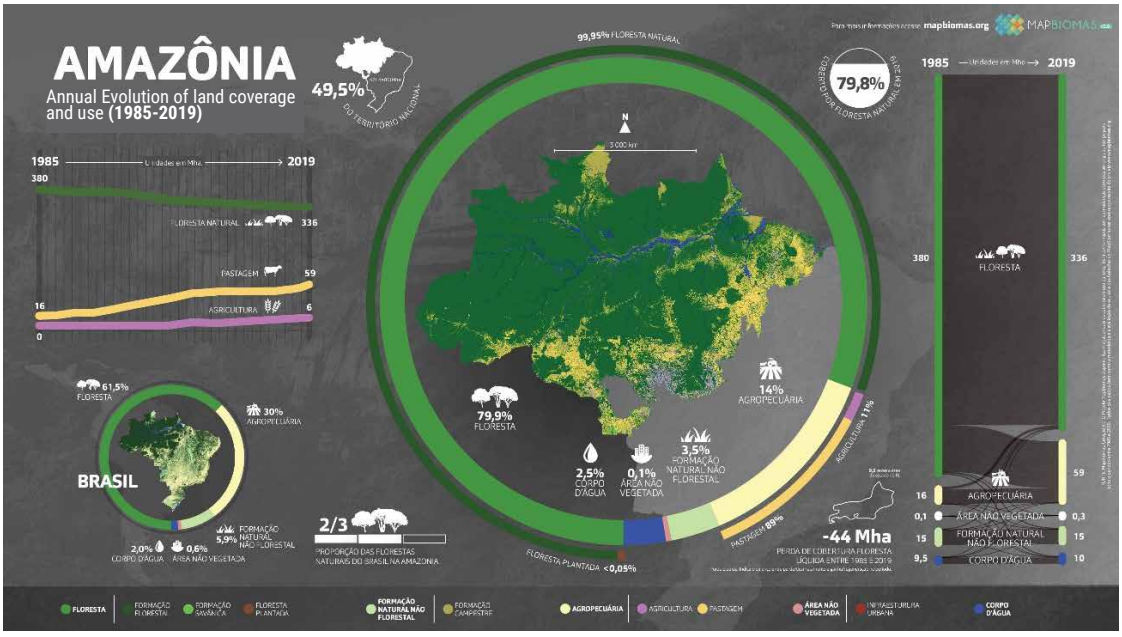
Furthermore, the ideas listed in this paper are academic considerations and do not translate the official word of any actor mentioned.

2 Deforestation and fires in the legal Amazon

This section will briefly present data on deforestation and fires in the Legal Amazon in order to analyze the numbers on the theme in question, which directly impact government actions aimed at preserving the environment. In addition, it will briefly bring to light some mechanisms available and used by the various competent institutions that monitor deforestation and hot spots in the region.

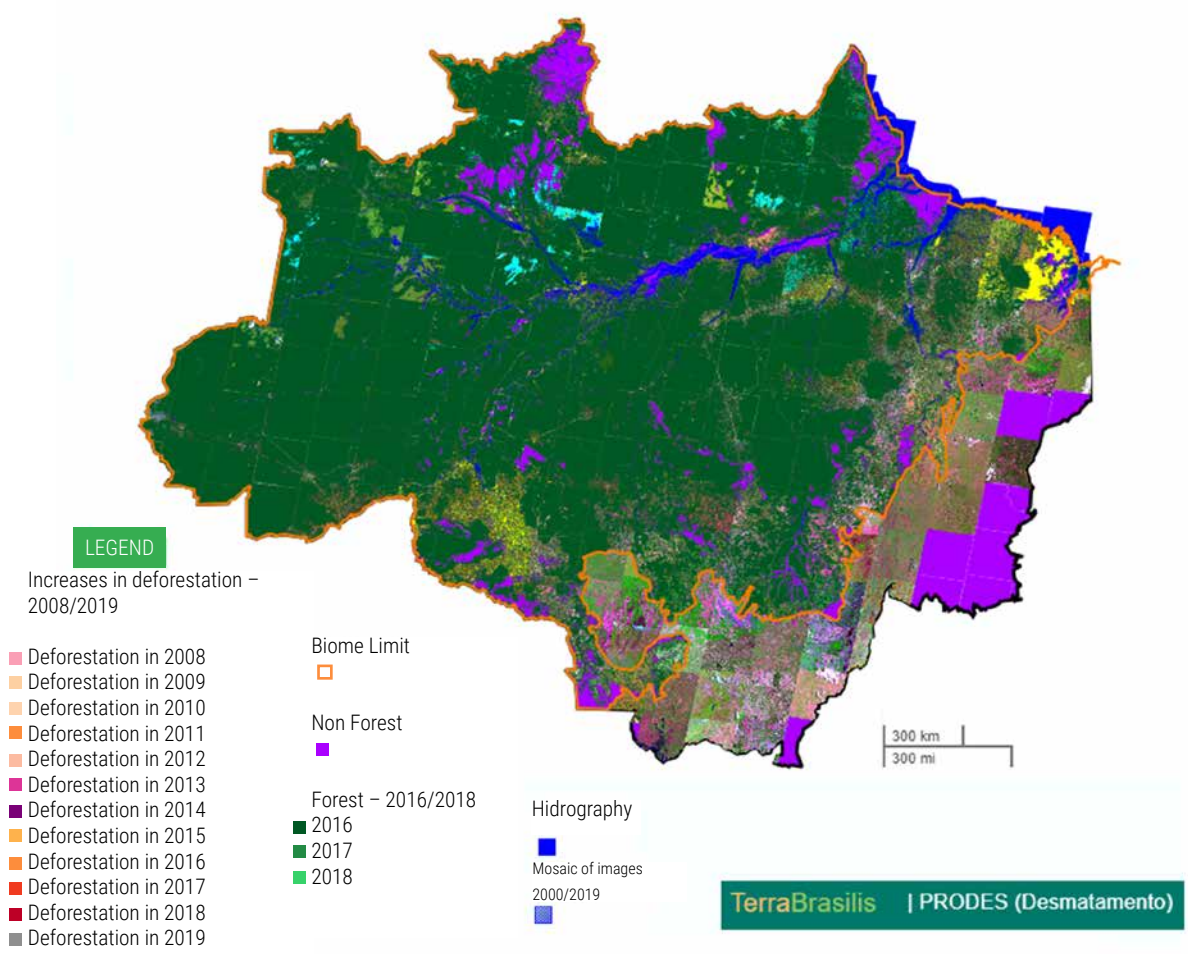
In this sense, Infographic 1 below allows visualization of the Amazon biome, highlighting the evolution of land cover and land use in the region, in the period 1985 to 2019, as well as the percentages of these various land uses in the Amazon in relation to the country, highlighting the information that, according to MapBiomas (2020a), the Amazon had a net loss of forest cover, between the aforementioned years, of 44 Mha, which is equivalent to 9.5 times the area of the state of Rio de Janeiro, reinforcing the importance of works aimed at discussing the theme of sustainable development and environmental preservation. The natural wealth of the Amazon is in dramatic contrast to the region's low socioeconomic indices, with low demographic density and increasing urbanization. Thus, the use of forest resources is strategic for the development of the region.

Infographic 1 – Amazon Biome



Source: MapBiomas (2020a).

Map 1 – Amazon Biome and Legal Amazon[3]



Source: Adapted from TerraBrasilis (2020).

In this context, Map 1 (below), which also presents the Amazon biome (delimited by the orange line) and the Legal Amazon (black line), consolidates information about the deforestation that occurred in the Amazon region in the period from 2008 to 2019, aiming to characterize the problem at hand by listing aspects related to deforestation itself and the fires that occur in the region. It is worth noting that deforestation is the operation that aims at the total suppression of native vegetation in a given area for alternative land use (BRASIL, 2019b) and, in turn, degradation is a partial disturbance in the forest caused by timber extraction and/or forest burning, according to the Amazon Institute of Man and Environment (Instituto do Homem e Meio Ambiente da Amazônia – IMAZON, 2020).

3 Map generated with the following settings: platform TerraBrasilis – Project for Monitoring Deforestation by Satellite (Projeto de Monitoramento do Desmatamento por Satélite – PRODES), no deforestation mask, biome boundary enabled, no cloud (2016/2019), forest option (2016/2018) enabled, hydrography and non-forest options enabled, deforestation increments (2008/2019) enabled, image mosaic option (2000/2019) enabled, and use of the *blank* layer.

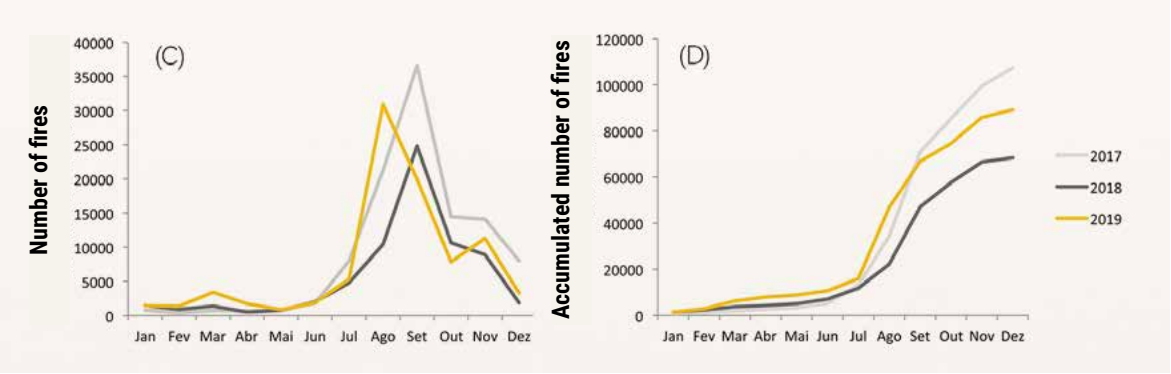
Alencar et al. (2020, p. 3) addresses how the Amazon being "a humid and evergreen forest becomes susceptible to fire during certain periods of the year" by listing three fundamental elements that organize themselves in the so-called "fire triangle" and that, when combined, create conditions for fires and wildfires to thrive.

> The first of the three ingredients of this triangle is the existence and quality of **the combustible material** (what burns). The second is the **climatic conditions** (when it burns) and the third is the **ignition source** itself (who or what causes the burning) (ALENCAR et al., 2020, p. 1, emphasis added).

In this sense, Alencar et al. (2020, p. 4, emphasis added) emphasizes that "the third ingredient is the one that is easiest to control: the ignition source. [...] Therefore, in the Amazon, every fire has as its source a match lit by a human being."

Building on the considerations of Alencar et al. (2020), the author included in the present work Graphs 1 and 2 (see below)[4] that consolidate data from the years 2017, 2018, and 2019 on the numbers of hot spots and on deforestation in the Amazon in the months and cumulative of the respective year, after mentioning the periods from 1985 to 2019 (Infographic 1) and from 2008 to 2019 (Map 1) that allowed for a holistic view on the topic at hand.

Graph 1 – Numbers of hot spots in the month (C) and cumulative (D) in the Amazon (2017, 2018 and 2019)



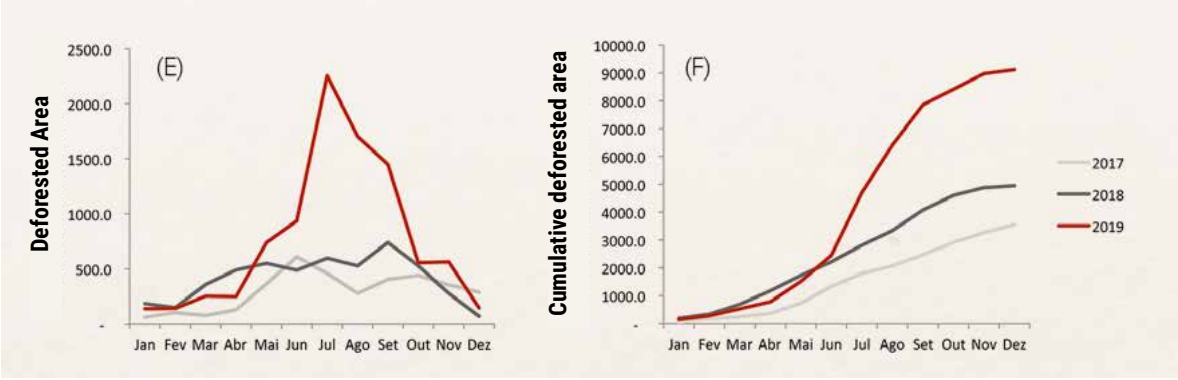
Source: IPAM (2019) apud Alencar et al. (2020, p. 6).

4 From climate data from the Chirps satellite and fire and deforestation data from INPE through November 2019.

It is inferred that in the analyzed period (2017, 2018 and 2019), the highest incidence of hot spots occurs between the months of July to December and that the year 2019 was marked by an increase in hot spots compared to 2018, since in the year 2018 there was a reduction compared to 2017 (see Graph 1).

The fact that more fires occurred in 2019 than in 2018, was also noted by Non-Governmental Organization that expressed, "The world watched in astonishment as the number of fires in the Amazon increased" (WWF BRASIL, 2020, p. 40). According to official data from the Brazilian National Institute for Space Research (Instituto Nacional de Pesquisas Espaciais – INPE), the jump was 30% in 2019 compared to 2018. From January to December 2019, 89,178 fires were recorded in the biome, compared to 68,345 in the previous period (WWF Brazil, 2020).

Graph 2 – Deforestation in the month (E) and accumulated (F) in the Amazon (2017, 2018 and 2019)

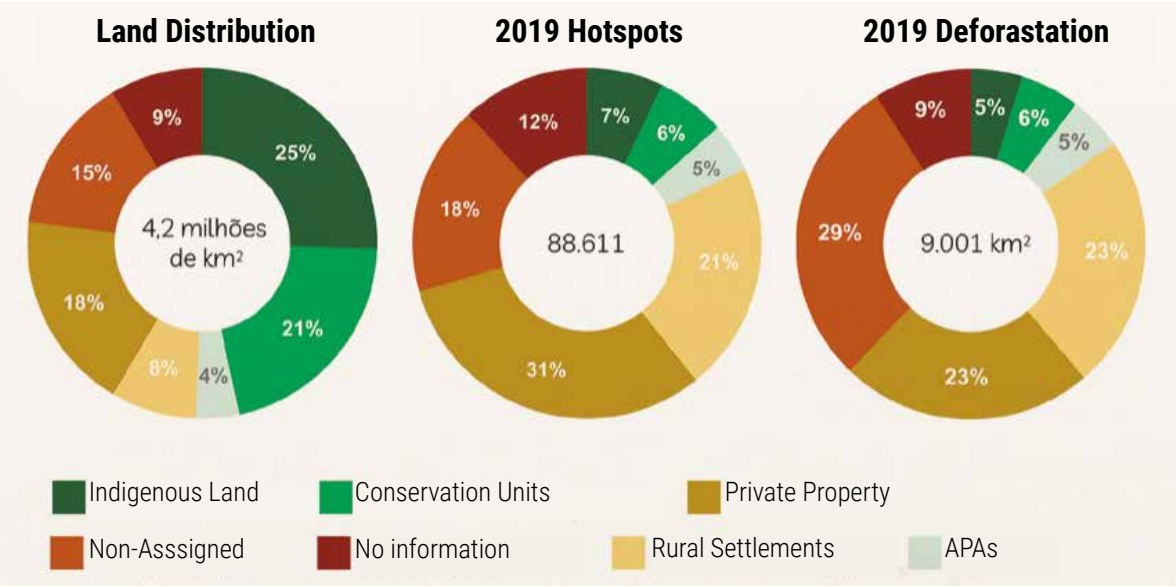


Source: IPAM (2019) apud Alencar et al. (2020, p. 6).

Likewise, it is inferred that in the same period analyzed, the highest incidence of deforestation occurred between the months of April to December and that the year 2019 had more than 9,000 km² of deforested area considering the accumulated months of the year considered, thus reaching a higher number than the years 2017 and 2018 (see Graph 2).

With the understanding of the data from the years 2017, 2018 and 2019 on the numbers of hot spots and on deforestation in the Amazon, it can be seen the numbers for the year 2019, as shown in the figure below

Figure 4 – Amazon hot spots and deforestation in 2019 by land category



Source: IPAM (2019) apud Alencar et al. (2020, p. 7).

Analyzing Figure 4 it is inferred that the 2019 INPE data show that only 18% of the 2019 hot spots occurred in TI (7%), in UC (6%), and in APA (5%); and that 16% of the deforestation of the same year were recorded in the same areas (TI - 5%, UC - 6% and APA - 5%), emphasizing that such areas together represent about 50% of the total area (4.2 million km²), i.e., the hot spots and deforestation of the year 2019 occurred with a higher incidence in private properties, rural settlements and in undesignated and uninformed areas.

In addition, experts on environmental issues relate the fires to deforestation, and according to Alencar et al. (2020, p. 1): "The 2019 fire season in the Amazon was clearly related to increased deforestation, not to a drier climate; [...]". Also, according to Alencar et al. (2020, p. 1) "the increase in deforestation in 2020, added to the vegetation felled in 2019 that did not burn, creates expectations of a new intense fire season; [...]".

Accumulated deforestation in the Legal Amazon in the last 10 months, from August 2019 to May 2020, is already 72% higher than that recorded in the same previous period, based on data from INPE's Real-Time Deforestation Detection[5] (Detecção do Desmatamento em Tempo Real – DETER) system (ESCOBAR, 2020). "All warning systems point to an upward trend," says the geographer Marcos Reis Rosa, a doctoral student at the School of Philosophy, Literature, and Human Sciences at USP and technical coordinator of the MAPBIOMAS project (ROSA, 2020 apud ESCOBAR, 2020). In total, 56,867 alerts were identified, validated,

5 The DETER operating system is a rapid alert survey of evidence of forest cover change in the Amazon and uses MODIS sensor data. It was developed as an alert system to support the inspection and control of illegal deforestation and forest degradation by IBAMA, detecting changes in forest cover with an area larger than 25 hectares (BRASIL, 2019b, p. 82). The PRODES operational system produces annual deforestation rates (BRASIL, 2019b, p. 78) and considers "deforestation" to be areas greater than 6.25 hectares, analyzing clearcutting deforestation processes that result in the complete removal of forest cover (BRASIL, 2019b, p. 80).

and refined throughout the country, resulting in 1,218,708 hectares (12,187 km²) of deforestation. Eighty-three percent of these alerts (63% of the area) are in the Amazon biome, with a total area of 770,000 hectares (MAPBIOMAS, 2020b).

Also, according to Escobar (2020), more than 99% of the almost 57 thousand alerts analyzed by the "MAPBIOMAS Alerta" project have some irregularity associated; either because the deforestation was done without legal authorization or because it advanced over some prohibited area, such as Conservation Units, Indigenous Lands, or Permanent Preservation Areas (Áreas de Preservação Permanente – APP).

Similarly, it can be seen in Table 1 below that comparing the first quarter of the years 2019 and 2020, it can be seen, in general (total values), a decrease in hot spots, but an increase in the deforested area. And, in particular, increased hot spots on private property (57%) and deforestation in undesignated areas (33%) in 2020 to the same period considered of 2019.

Table 1 – Numbers of hot spots and deforestation in the Amazon, broken down by land category, in the first quarter of 2019 and 2020.

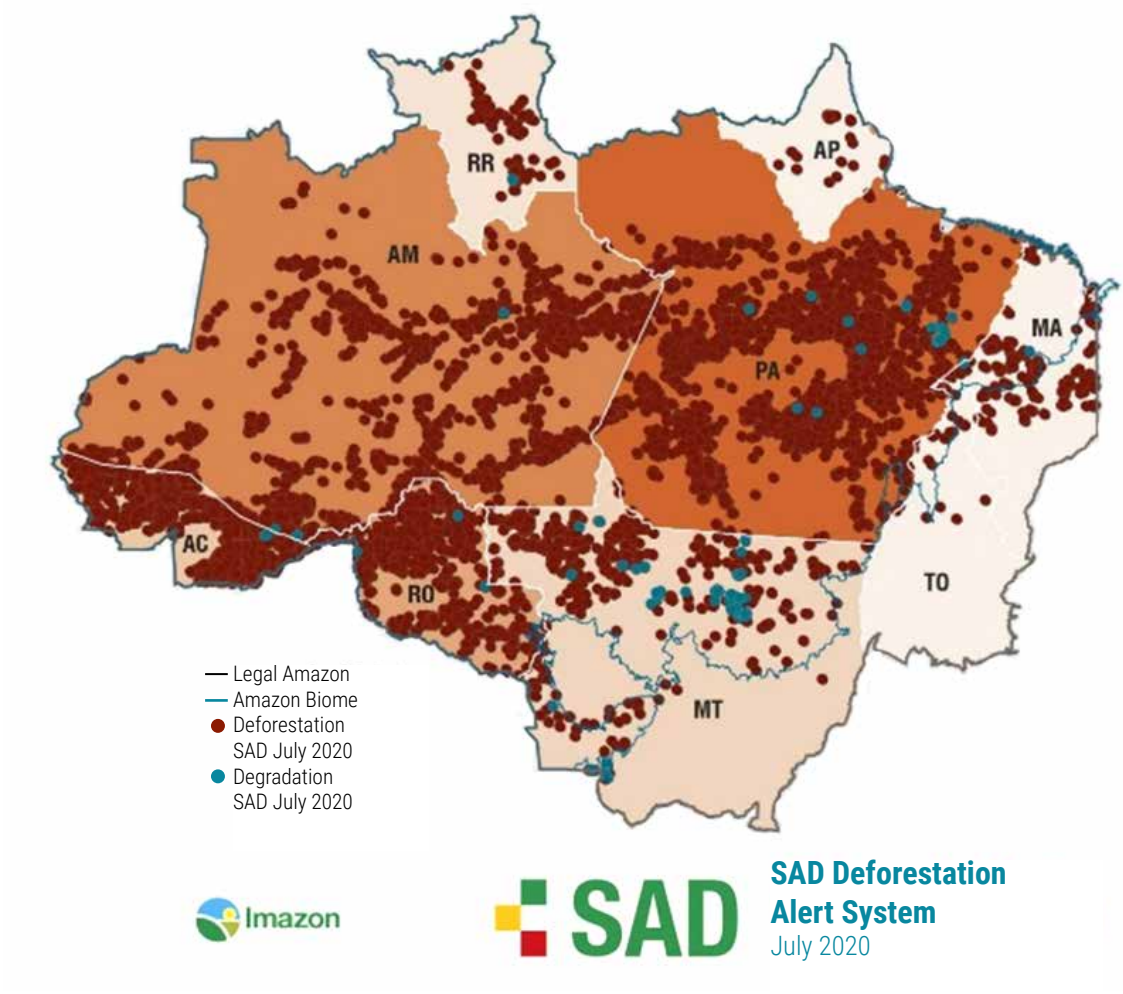
Land category	Hot spots Jan – Mar 2019	Hot spots Jan – Mar 2020	Deforestation Jan – Mar 2019	Deforestation Jan – Mar 2020
Indigenous Land	14%	17%	3%	2%
Conservation units	3%	1%	3%	2%
Permanent Preservation Areas	2%	1%	2%	3%
Private Properties	39%	57%	38%	30%
Settlements	20%	11%	24%	17%
Unassigned	17%	7%	22%	33%
No information	5%	6%	8%	13%
Total	6.169	4.445	511 km²	783 km²

Sources: The Author, based on IPAM (2019) apud Alencar et al. (2020, p. 8).

In the same line, aiming to analyze more data already released for the year 2020, the deforestation and degradation in the month of July 2020 in the Legal Amazon based on IMAZON's Deforestation Alert System (Sistema de Alerta de Desmatamento – SAD) can also be highlighted (see Map 2).

According to IMAZON's SAD (2020), in the period from August 2019 to July 2020, deforestation in the Legal Amazon had increased by 29% compared to the same previous period (from August 2018 to July 2019). In July 2020, specifically, SAD detected an 11% reduction in deforestation in the Legal Amazon compared to July 2019. However, there was a 110% increase in forest degradation, corresponding to 135 km². Also, the SAD pointed out that in July 2020, 59% of deforestation occurred in private areas or under various stages of ownership and the rest of the deforestation was recorded in Settlements (19%), UC (18%), and TI (4%).

Map 2 – Deforestation and Degradation in July 2020 in the Legal Amazon



Source: Adapted by Natã Lemos. Instituto do Homem e Meio Ambiente da Amazônia (2020).

Analyzing the 2019 data and comparing it with the 2020 data, which have already been released, it can be seen that in 2020 the hot spots and deforestation occurred with greater emphasis on private properties to the detriment of incidences in UC, TI, and APA.

Furthermore, according to IMAZON's SAD (2021), in February 2021, SAD detected a 74% increase in deforestation in the Legal Amazon compared to February 2020. This deforestation detected in February occurred in Pará (37%), Roraima (27%), Mato Grosso (13%), Amazonas (12%), Rondônia (6%), Maranhão (3%), Acre (1%), and Tocantins (1%). Likewise, there was a 38% increase in forest degradation, from 37 square kilometers in 2020 to 51 square kilometers in 2021. By February 2021, degradation was detected in Pará (71%), Mato Grosso (27%), and Roraima (2%). The SAD also pointed out that in February 2021, most (60%) of the deforestation occurred in private areas or under various stages of ownership and the rest of the deforestation was registered in Settlements (22%), Conservation Units (17%) and Indiginous Lands (1%).

Also, in order to facilitate the visualization of the various tools used for monitoring deforestation and fires in the Amazon, the author has consolidated national and international sources in Table 2.

Table 2 – Deforestation monitoring systems in the Amazon

Institution	App/Platform Mission/System	Observation/Reference (access on: Sep. 17, 2020 and Mar. 27, 2021)
Brazilian Federal Government	App "Guardiões da Amazônia".	It allows the sending of reports of environmentally damaging acts. https://www.gov.br/pt-br/apps/guardioes-da-amazonia
INPE	TerraBrasilis Web Platform.	http://terrabrasilis.dpi.inpe.br/app/map/deforestation
INPE	Missão Amazônia. It will provide remote sensing data (images) to observe and monitor deforestation especially in the Amazon region, and also the diverse agriculture throughout the country.	Amazonia 1 (AMZ 1) is the first Earth Observation satellite completely designed, integrated, tested and operated by Brazil. http://www.inpe.br/amazonia1/
INPE-EM	INPE – *Emission Model.*	It makes available spatially the annual estimates of greenhouse gas emissions from land cover change. http://inpe-em.ccst.inpe.br/en/home/
INPE	Programa Queimadas (includes APA — parks, forests, municipal, state and national biological reserves — and TI).	It allows the operational monitoring of active fires and forest fires detected by satellites, and the calculation and prediction of vegetation fire risk, as well as the mapping of burned area scars. https://queimadas.dgi.inpe.br/queimadas/portal/informacoes/apresentacao
IMAZON	Sistema de Alerta de Desmatamento (SAD).	Releases the Legal Amazon deforestation bulletin using (SAD) with support from the Gordon and Betty Moore Foundation and Norway's International Climate and Forest Initiative (NICFI) and The Norwegian Agency for Development Cooperation (Norad) https://imazon.org.br/categorias/sad-alerta/
Instituto Socioambiental (ISA)	Sistema de Indicação por Radar de Desmatamento na Bacia do Xingu (SIRAD X).	https://xingumais.org.br/siradx
Defense Ministry	Sistema integrado de alertas de desmatamento com radar orbital – SIPAMSAR (Radar de Abertura Sintética).	Centro Gestor e Operacional do Sistema de Proteção da Amazônia (CENSIPAM). http://www.sipam.gov.br/projeto-amazonia-sar-1/o-sistema-integrado-de-alertas-de-desmatamento-com-radar-orbital-sipamsar

Institution	App/Platform Mission/System	Observation/Reference (access on: Sep. 17, 2020 and Mar. 27, 2021)
Japan International Cooperation Agency	Forest Early Warning System in the Tropics (JJ-FAST).	Japan Aerospace Exploration Agency (JICA-JAXA). https://www.eorc.jaxa.jp/jjfast/jj_index.html
University of Maryland	Global Land Analysis and Discovery (GLAD). All Eyes on the Amazon.	https://glad.umd.edu/projects/all-eyes-amazon

Source: The Author based on IPAM (2019) apud Alencar et al. (2020, p. 8).

These tools have a high added value and allow the monitoring of deforestation and the survey of hot spots in the Amazon region in real-time, offering fundamental elements for the decision-making of the actors who work in synergy with the GLO operations.

It can be partially concluded that in the analyzed period, the hot spots and deforestation occurred less in PA, TI, and APA in relation to private areas or under different stages of ownership. Furthermore, it was observed that the aspect of degradation requires attention from the public authorities, considering the data from July 2020 and February 2021 of SAD/IMAZON, impacting the actions of governments to preserve the environment.

3 Environmental GLO in the legal Amazon

In the Legal Amazon, in the years 2019 and 2020, Environmental GLO Operations were adopted by the Federal Government in an "innovative" way, since this type of Military Operation is well known in society in cases of public security crisis[6] (DIAS; GOMES, 2018; SOUZA, 2020) when, in general, state governors request support from the Federal Government when they recognize that their means are unavailable, non-existent, or insufficient, according to constitutional and infra-constitutional legal support (paragraph 3 of Article 15 of LC 97/1999 (BRASIL, 1999), included in that law by LC 117/2004 (BRASIL, 2004b), PAIM; FRANCHI; FRANÇA, 2020).

"The acronym **GLO** refers to **Law and Order Guarantee** missions by the Armed Forces, which was the **strategy used by the government** in the year 2019 to **contain the advances of the fires** in the region" (ESCOBAR, 2020, n.p., emphasis added).

6 In the Amazon region, for example, it can be mentioned events that generated GLO Operations such as the strike of the Public Security Organs (Órgãos de Segurança Pública – OSP) in Maranhão and Rondônia, in Nov. and Dec. 2011 respectively. In this same scope of GLO, we cite Operation Tucuxi (Aug. 28 - Oct. 30, 2018), in Roraima, instated by Decree No. 9,483, Aug. 28, 2018 (PAIM; FRANCHI; FRANÇA, 2020, p. 149,150).

> "If we continue with the observed rates it **is expected that deforestation in 2020 will surpass that observed in 2019**; however, the effective implementation of the GLO may contain this advance in the coming months," says the researcher Luiz Aragão, head of INPE's Remote Sensing Division (ARAGÃO, 2020 apud ESCOBAR, 2020, emphasis added).

Thus, it can be observed that even with all the "satellite policing" apparatus, presented in the previous section, there are still few alerts that result in any legal punishment for violators, because of the various logistical and legal difficulties of prosecuting environmental crimes in Brazil. Furthermore, only a tiny portion of the fines imposed are effectively paid, generating a sense of impunity that serves as fuel for the continuation of deforestation (ESCOBAR, 2020).

"The action of the Armed Forces, in the guarantee of law and order, by initiative of any of the constitutional powers, will occur in accordance with the guidelines set forth in an act by the President of the Republic" (BRASIL, 1999), after exhausting the instruments destined to preserve public order and the safety of people and property, listed in article 144 of the Federal Constitution (FC) of 1988 (BRASIL, 2004a, p. 88), according to paragraph 2 of Article 15 of Complementary Law (LC) No. 97 of 1999 (BRASIL, 1999).

> Art. 144. **Public security**, a duty of the State, is exercised through the following agencies:
> I - Federal Police;
> II - Federal Highway Police;
> III - Federal Railway Police;
> IV - Civil Police;
> V - Military Police and **Fire Departmen**t (BRASIL, 2004a, p. 88, our emphasis).

In the case of Environmental GLO Operations in particular, and as mentioned above, it did not occur directly because of a public security crisis, but rather to preserve the environment of the Amazon region. Naturally, due to the dimensions and peculiar characteristics of the area, it would be impossible for the state fire departments to solve the environmental demands in question. Thus, Operations Verde Brasil 1 and 2, Environmental GLO, represented the solution adopted by the Federal Government to minimize such issues, taking into account the capillarity of the Military Organizations in the Legal Amazon (LIMA et al., 2017).

Operation Verde Brazil 1, from August 24 to October 24, 2019, in the states of the Legal Amazon (including border areas, Indigenous Lands, and federal environmental conservation units), supported by Decree No. 9,985, of August 23, 2019 (BRASIL, 2019a), defined preventive and repressive actions against environmental crimes; and survey and combat of fire outbreaks (ARAGÃO; SILVA JUNIOR; ANDERSON, 2020; PAIM; FRANCHI; FRANÇA, 2020).

In the same context as Operation Verde Brasil1, the Federal Government authorized Operation Verde Brasil 2 with similar characteristics. Published in the Federal Official Gazette through Decree No. 10,341, of May 6, 2020 (BRASIL, 2020a), providing for the employment of the Armed Forces in the Guarantee of Law and Order and in subsidiary actions in the Borderlands, Indigenous Lands, federal environmental conservation units, and other federal areas in the states of the Legal Amazon, in the initial period from May 11 to June 10, 2020 (ARAGÃO; SILVA JUNIOR; ANDERSON, 2020). On June 10, the Environmental GLO was renewed until July 10, through Decree No. 10,394. Likewise, on July 9, it was renewed by Decree No. 10,421 until November 6, 2020 (BRASIL, 2020b). And recently, on November 4, 2020, it was extended until April 30, 2021, by Decree No. 10,539 (BRASIL, 2020c). Operation Verde Brasil 2 aims to carry out preventive and repressive actions against environmental crimes, targeting illegal deforestation and fighting fires. It is worth noting that the operation's focus on illegal deforestation represents an increase over the first edition of the 2019 operation.

Another aspect to be analyzed in this article is what characterizes the GLO Operations, in the sense that they must be episodic, carried out in previously established areas and for a limited time, according to the Ministry of Defense.

> It is a military operation determined by the President of the Republic and conducted by the Armed Forces **episodically**, in a **previously established area** and **for a limited period of time**, which aims to preserve public order and the safety of people and property in situations of exhaustion of the instruments provided for in art. 144 of the Constitution or in other situations in which it is presumed possible to disturb order (BRASIL, 2015, p. 192, emphasis added).

Thus, when adopted in two consecutive years, it may cease to be episodic and become recurrent, like the GLO Operations aimed at public security itself, but more time will be needed for analysis in order to reach a conclusion. With regard to the area in which the Environmental GLO Operations encompassed, it is worth analyzing whether they would be too many and for legal security could be more punctual, noting that the region under study represents almost 60% of the national territory. In turn, the aspect that they must occur for a limited time should be considered especially in the case of Operation Verde Brasil 2, which has been taking place since May 11, 2020, and is scheduled to end on April 30, 2021, making up almost twelve months. In the case of Operation Verde Brasil 1, it lasted two months.

Furthermore, according to paragraph 5 of Article 15 of LC 97/1999, which was added to the aforementioned law by LC 117/2004, it is observed that GLO operations occur to a great extent in an interagency environment, that is, in collaboration with other law enforcement agencies:

> § 5º Once the employment of the Armed Forces in the **guarantee of law and order** is determined, the competent authority shall, by means of a formal act, transfer the operational control of the public security agencies necessary for the development of actions to the authority in charge of operations, which shall constitute an **operations coordination center, composed of representatives of the public agencies under its operational control** or with **similar interests** (BRASIL, 1999, emphasis added).

Thus, Environmental GLO occurs in the context of Agency Cooperation and Coordination Operations (Operações de Cooperação e Coordenação com Agências – OCCA), as this inter-agency environment is referred to within the Brazilian Army.

> They are **operations executed by elements of the Brazilian Army in support of agencies or institutions (governmental or not, military or civilian, public or private, national or international)**, generically defined as agencies [...]. They are intended to reconcile interests and **coordinate efforts** to achieve converging objectives or purposes that serve the common good. They seek to **avoid duplicity of actions, dispersion of resources, and divergence of solutions**, leading those involved to act with efficiency, effectiveness, efficacy, and lower costs (BRASIL, 2017b, p. 3-14, emphasis added).

Among the various governmental agencies which work in Cooperation and Coordination with the Army, in the context of Environmental GLO Operations, from the political to the operational and tactical level, we can mention the Brazilian Navy (Marinha do Brasil – MB), the Brazilian Air Force (FAB), the Federal Police (PF), the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) the National Center for Prevention and Fight Against Forest Fires (Prevfogo), the Chico Mendes Institute for Biodiversity Conservation (FUNAI), the National Institute for Colonization and Agrarian Reform (INCRA), the Federal Highway Police (PRF), the National Force, the Brazilian Intelligence Agency (ABIN) and the Operational and Management Center of the Amazon Protection System (Censipam). In addition to different agencies of the Federation Units and the municipalities, such as the Military Police, the Military Fire Brigade, the Civil Police, the Secretariats for the Environment and for State and Municipal Civil Defense and Protection. Each Agency mentioned above has specific responsibilities and attributions in its sphere of action, which, together with those of the Brazilian Army, interact in a synergistic manner, with the objective of mitigating threats to the environment, according to the Ministry of Defense in the book Defesa e Meio Ambiente: preparo com sustentabilidade (BRAZIL, 2017a).

Besides the aspects of LC 97/1999 already discussed in this section, it is also worth mentioning Subsection III of Article 17-A of this LC (text added to the aforementioned law by LC 117/2004), which lists the Army's mission as well:

> III – **to cooperate** with federal agencies, when necessary, in the repression of crimes with national and international repercussion, in the national territory, in the form of **logistical, intelligence, communications and instruction support** (BRASIL, 1999, n.p., emphasis added).

Such consideration increases the Army's relations with the countless actors of the inter-agency environment, given the legal support due to Operations (SOUZA, 2020). In the same way, the text of Decree nº 3.897, of 24th August 2001, ratifies the device described above:

> [...] provide **logistical, intelligence, communications and instruction support**, as well as **advice** to government agencies involved in **actions to ensure law and order**, including in combating transborder and **environmental crimes**, when determined (BRASIL, 2001, n.p., emphasis added).

In this way, the logistical difficulties arising from the dimensions of the Legal Amazon are minimized (ESCOBAR, 2020), and the agencies involved have the opportunity to increase their functional capabilities when supported by the Brazilian Army, whether in logistics, intelligence, communications, and training activities (SOUZA, 2020).

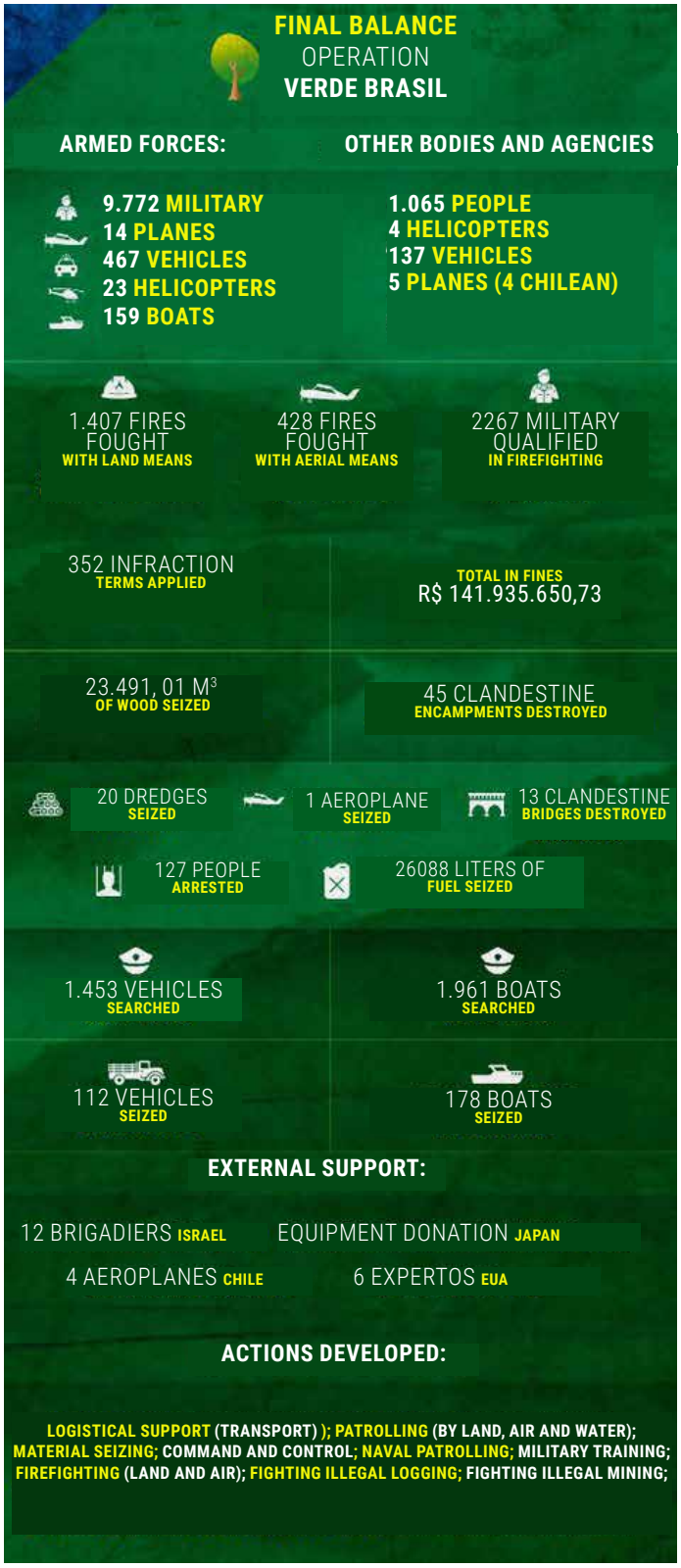
The Federal Government (2019) released the final balance sheet of the tangible results of Operation Verde Brasil 1, which can be analyzed by the data displayed in Infographic 2 below.

Taking into consideration the two months of Verde Brasil 1, it can be seen that the results were in fact positive, given the numbers presented as a result of the actions developed by national and foreign institutions, in addition to the number of fines that were applied, the cubic meters of wood seized, and the number of dredges, vehicles, and vessels seized. The Ministry of Defense (BRASIL, 2019) disclosed that in the first version of Operation Verde Brasil the amount of R$ 124,482,297.60 was spent, and that if compared with the amounts related to the results of the operation it is assessed that these expenses had a positive return for the preservation of the environment.

Likewise, the partial results of Operation Verde Brasil 2 were released, in order to assess the numerous tangible and intangible benefits for local populations. These results were published in a Note of clarification (BRASIL, 2020d) by the Social Communication Advisory of the Ministry of Defense, on June 29, 2020, when Verde Brasil 2 had just over a month of actions, and had already surpassed Verde Brasil 1 in the amount of fines to be paid.

> [...] the amount of **fines** imposed, as of June 27 **(R$206,082,204.00)**, had **already exceeded by three times the amount invested** in the Operation. [...]. A total of 10,404 inspections, patrols, inspections and searches were carried out, and 104 items of equipment such as mining motors, rafts, tractors, excavators, and vehicles, among others, were **rendered unusable**, in accordance with the legislation in force. Also **seized** were 163 boats, 187 vehicles, 139 kilos of marijuana, 218 kilos of cocaine base paste and 24,137 m^3 of wood. In addition, 31,880 hectares were **embargoed**, and 133 **arrests** were made (BRASIL, 2020d, n.p., emphasis added).

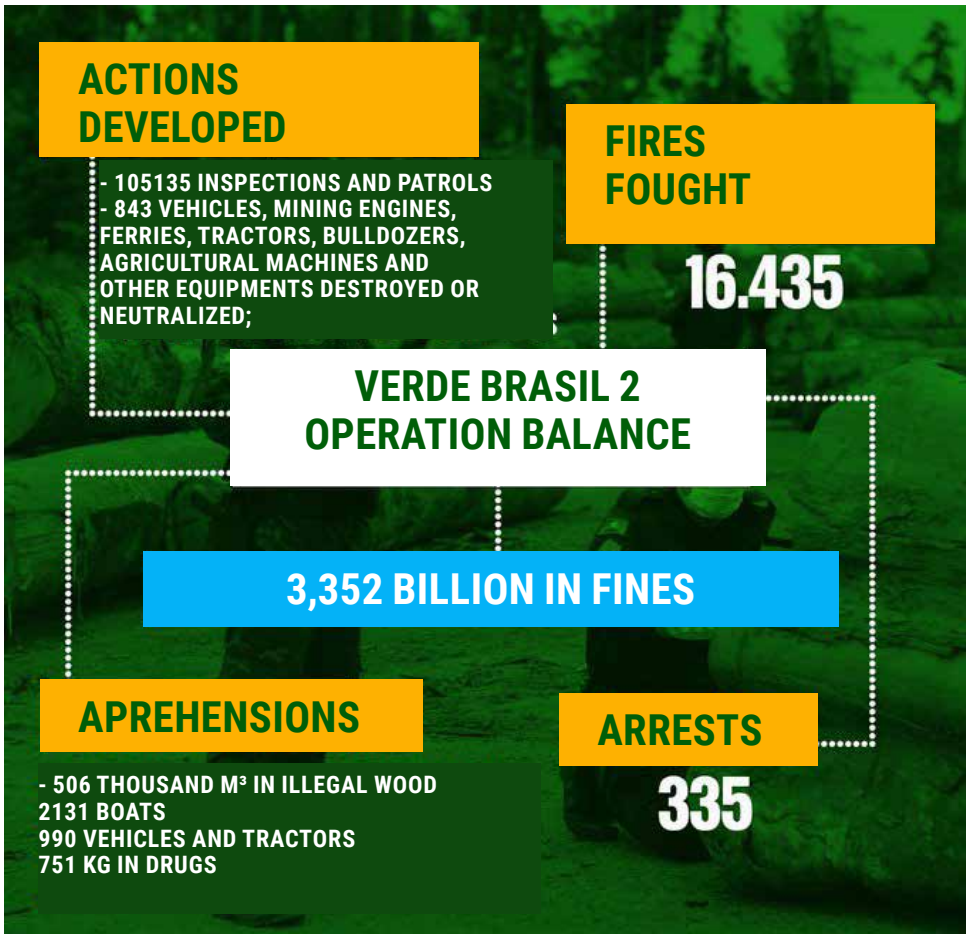
Infographic 2 – Results of Operation Verde Brasil 1 (2019)



Source: Federal Government (2019).

In May 2021, the final balance of the operation was released by the Army, as shown in Infographic 3, ratifying the reach of the actions in favor of environmental preservation.

Infographic 3 – Results of Operation Verde Brasil 2

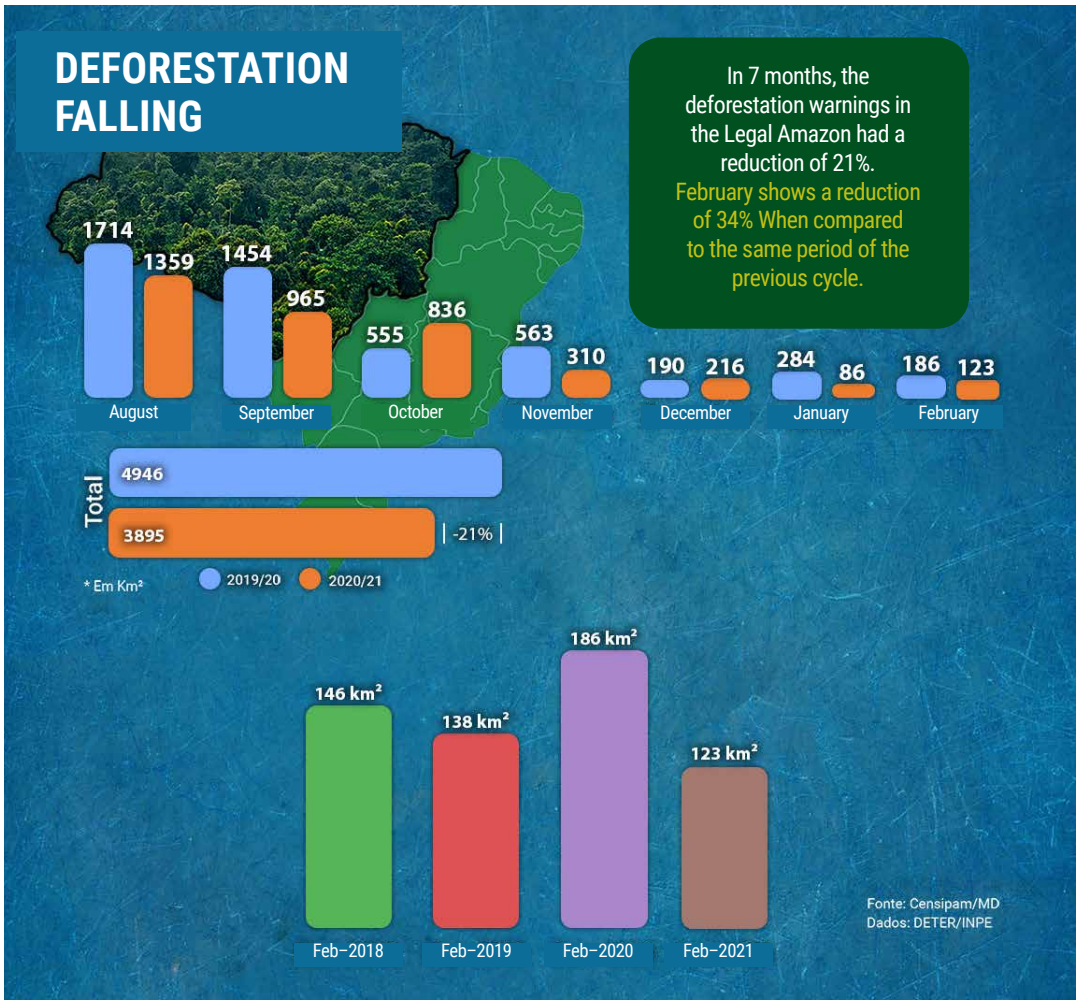


Source: Brasil, 2021a.

The results of Verde Brasil 2 are significant, such as the value of violations that exceeds 3.3 billion reais, which also allows us to infer that the problem of crimes against the environment is serious and requires constant governmental actions in the region. Likewise, it reveals that the preventive and repressive actions against environmental crimes, targeting illegal deforestation and fighting fire outbreaks contribute directly to the preservation of the Amazon biome, as shown in Infographic 4. It is worth mentioning that since the beginning of Operation Verde Brasil 2, the fight against the pandemic of the new coronavirus (WHO, 2020)[7], has been going on worldwide, but that even in the midst of the Covid-19 crisis, actions on behalf of the environment have not ceased to be carried out.

7 Em 11 mar. 2020, o diretor-geral da Organização Mundial da Saúde (OMS), Tedros Adhanom Ghebreyesus, anunciou, em Genebra, na Suíça, que a COVID-19, doença causada pelo novo coronavírus, é caracterizada como uma pandemia.

Infographic 4 – Evolution of deforestation (2019/20 and 21)



Source: Brasil (2021b).

The infographic shows the evolution of deforestation in the periods from August to February and in the transition of the years 2019/2020 (blue bars) and 2020/2021 (orange bars), highlighting that, in seven months, deforestation warnings in the Amazon had a 21% reduction. Besides registering that in the month of February 2021, there was a reduction of 34% compared to the same period in the year 2020.

Furthermore, the Operação Verde Brasil 2 *Hot Site*[8] consolidates several relevant information (news and videos) about the actions carried out by the involved actors, as well as their results, fulfilling the role of keeping society aware of the environmental problem in the Amazon region. Also, aiming to interact with all citizens, an application was created to be used on mobile or tablet devices: "Guardiões da Amazônia"[9]. Created in the context of Operation Verde Brasil 2,

8 Available at: http://www.coter.eb.mil.br/index.php/pagina-inicial-verde-brasil. Accessed on: Mar. 28, 2021.

9 Available at: https://www.17bdainfsl.eb.mil.br/guardioes/. Accessed on: Apr. 9, 2022.

in Rondônia, it has the support of the National Council of the Legal Amazon, whose motto is "Protecting and preserving the Amazon is developing Brazil"[10]. Through this application it is possible to register complaints of deforestation, fires, and illegal mining, as well as send geo-referenced photos that will be used by inspection agencies to curb such crimes. Furthermore, with the end of the Verde Brasil 2 Operation, the Federal Government has announced that the Amazon Plan 2021/2022 (BRASIL, 2021c), approved by Resolution No. 3 (April 9, 2021), establishes the guidelines for the continuity of enforcement actions and the fight against environmental and land crimes, mainly related to illegal deforestation and fires in the Legal Amazon.

Likewise, taking into consideration the importance of the theme and the growing studies on the Legal Amazon, it is worth clarifying that the Environmental GLO Operations differ from the Ágata Operations, Border Range Operations (PAIM; FRANCHI; FRANÇA, 2020), which have also been conducted by the Ministry of Defense in the Border Range (BRASIL, 1979; 2004a;) of the Legal Amazon and in other border regions of Brazil, since 2011. First because they occur specifically in border regions and second because they are geared to inhibit cross-border crimes, such as smuggling and drug trafficking (DONADIO; KUSSROW, 2016; LIMA et al., 2017). The Verde Brazil Operations are designed to carry out preventive and repressive actions against environmental crimes in the Legal Amazon, including the Borderland Strip.

Finally, it is concluded that the Environmental Law Enforcement Operations carried out in an inter-agency environment are efficient, given the relevant figures presented in this section, contributing to the preservation of the environment and strengthening the other existing institutions in the Amazon region.

4 Final considerations

Nowadays, the issue of environmental preservation is present in the national and international scenarios as a fundamental agenda, because this issue directly impacts social welfare.

In summary, throughout the work it was found that 2019 saw an increase in deforestation compared to 2017 and 2018. Also, the projection that 2020 would trend upward compared to 2019 was proven correct. Such data motivated state actions in the region, particularly materialized by Operations Verde Brasil 1 and 2, which, from the balances presented, allow us to infer that they contributed to the preservation of the Amazon forest.

Thus, the Environmental GLO conducted by the Armed Forces in the Legal Amazon favored the reduction of the rates of fires and deforestation in the Legal Amazon between the years 2019 and 2021, to the extent that they occurred in an inter-agency environment, seeking the necessary synergy to achieve cooperation and coordination among the various actors present. The means employed by the Armed Forces enhance the actions of partner agencies in combating hot spots and deforestation in such a way that logistical difficulties are minimized.

10 Available at: https://www.gov.br/planalto/pt-br/conheca-a-vice-presidencia/conselho-da-amazoniahttps://www.17bdainfsl.eb.mil.br/guardioes/. Accessed on: Apr. 9, 2022

The monitoring tools are important for the survey and analysis of hot spots and possible deforestation locations, including UC, APA and TI, providing accurate data for the actions of the agencies involved in Verde Brasil 1 and 2. Likewise, the adoption of Environmental GLO by the Federal Government presented itself as a viable solution, given the importance of the issue and the need for a prompt response to the Brazilian and international society.

The research highlights that IPAM lists that human action is a preponderant factor in triggering the third fundamental element of the "fire triangle" - the ignition source, which contributes to the occurrence of burnings and fires in the Amazon. Most of the time, it is above the adverse climatic conditions themselves of the intense heat and the large amount of combustible material existing in the region, which reveals the importance of environmental education in society, given the number of resources applied in preventive and repressive actions that guarantee the combat against the hot spots and illegal deforestation in the Amazon.

It is also proposed that the various national monitoring systems listed in Table 2 can be integrated, in order to foster greater unity of information and, consequently, optimize the actions of the competent bodies involved in Environmental GLO operations. Preventive and repressive actions against environmental crimes mitigate fire outbreaks and illegal deforestation, aiming at the preservation of the Amazon biome.

Throughout the work, several governmental websites were consulted to measure the results of the Environmental GLO operations and it was found that these data are released by the Ministry of the Environment, in a more generic way, and by the Ministry of Defense, including the official website of the Brazilian Army, in a more detailed way. Thus, it is suggested for further studies that the agencies supported by the Armed Forces should publicize the results obtained in their respective partnerships, with the aim of rectifying or ratifying the data already disclosed.

Finally, it can be concluded that the Brazilian State's actions, during the researched period, were relevant and contributed to the preservation of the Amazon biome, as well as strengthened the country's image in the concert of nations.

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The military-industrial complex and its foundations: geopolitics, development, and technological advance

El complejo industrial-militar y sus fundamentos: geopolítica, desarrollo y avance tecnológico

Abstract: The objective of this paper is to highlight the importance of the military-industrial complex for the process of economic development, as well as for the geopolitical strategy of countries that aspire to greater autonomy in the international system. In this regard, we will divide the article into two parts: in the first part, we will analyze the reasons for the development of a military-industrial complex and its importance for the great powers; in the second part, we will investigate the economic and technological contributions related to the defense economy; finally, in the third part we will briefly analyze the cases of the United States and China.

Keywords: Geopolitics; development; Military-Industrial Complex

Resumen: El objetivo de este trabajo es resaltar la importancia del complejo industrial-militar para el proceso de desarrollo económico, así como para la estrategia geopolítica de los países que aspiran a una mayr autonomía en el sistema internacional. En este sentido, dividimos el artículo en tres partes: en la primera trataremos de analizar las razones para el desarrollo de un complejo industrial-militar y su importancia para las grandes potencias; en la segunda parte, investigaremos acerca de las contribuciones económicas y tecnológicas vinculadas a la economía de defensa; por último, en la tercera parte haremos un breve análisis de los casos de Estados Unidos y China.

Palabras clave: Geopolítica; desarrollo; Complejo Industrial-Militar.

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1 Why develop a military-industrial complex?

The war played an important role in the development of states and military technological advancement. Historically, the great empires have benefited from wars and, modernly, colonialism and imperialism have been instruments of State enrichment that have allowed economic leaps in the benefited societies. Thus, the United Kingdom, France and the United States were largely rewarded for the use of force against their opponents (HOSSAIN-ZADEH, 2006).

The great world powers have always sought to develop military capabilities that would ensure their role in international relations. A preponderant aspect for the construction of sophisticated national means of defense is autonomy, or military independence. No power conceives the scenario of dependence on others, that is, all States that aspire to an elevation of their *status quo* enin the international system seek to build up arms production capabilities autonomously. It is undoubtedly necessary to understand that there is a transition period between dependence and autonomy, such as the Chinese case of the early 2000s or even the Indian one, which, with difficulties, has been striving to reduce the import of armaments.

As States underwent transformations in their military, technological and financial structures, the need for the development of sophisticated military apparatuses became pressing. With the explosion of wars and the "military revolutions"[1] – with special attention to the Industrial Revolution (MCNEILL, 1982) –, new techniques and degrees of technological complexity have created profound inequalities not only in the economic field, but especially in the military field. Being a great power[2] has come to mean having power of influence and domination in the most varied areas, however, it will be in the military sector that the difference will be more contrasting (CHIN, 2019). Today, a great power has a highly destructive military capability and a deterrent guarantee. The United States, Russia, France, the United Kingdom

1 Krepinevich on "*From cavalry to computer: the pattern of military revolution*" argues that there were at least ten major military revolutions, among which were those promoted by the Hundred Years' War, the Naval Revolution of the 19th century and the Nuclear Revolution of the second half of the 20th century. The author's central argument is that States that are capable of developing a military revolution tend to distance themselves from others and take different positions of power (KREPINEVICH, 1994). On the influences fostered by the Industrial Revolution in Military Affairs see: Zapotoczny (2006) and McNeill (1982).

2 Initially it is necessary to approach the concept of power itself. Here we use that of Max Weber who defines it as "the ability of an agent to impose one's own will in a social relationship, even if against the will of the other" (WEBER, 1922, p. 28). The realist theory of International Relations (IR) has a varied reading about power and its application and finding in the international system. There are different approaches within the realist school, such as Morgenthau's view that States reflect the impulsive and aggressive nature of man (MORGENTHAU, 2002), or that power units seek to secure a prominent place in the structure of the balance of power (WALTZ, 1979) or the interpretation that States seek the condition of hegemony in the international system, however, as such an objective is unlikely, the great powers transform the world into a stage of perpetual competition (MEARSHEIMER, 2001). For the latter author (John Mearsheimer) to be a great power means ultimately having the ability to militarily confront the strongest State in the international system. We believe that the strictly realistic view of IR does not fully translate the concept of "great power", as it focuses excessively on the military aspect. Thus, we prefer to draw on the contributions of International Political Economy and its realist/mercantilist interpretation of history and the international system. Authors such as Robert Gilpin (Global Political Economy), Paul Kennedy (*Global Political Economy*), and José L. Fiori (História, Estratégia e Desenvolvimento [History, Strategy and Development]) dialogue with the economy, that is, it is not only military power alone that counts to characterize the influence capacity of a world power, but also its economic strength as a lever for financing the war and the other States of the international system.

and China have sophisticated military-industrial complexes (MIC) that guarantee them a position in the privileged capitalist interstate system. The size of the State's power capacity in international relations should be measured by the ratio of its military, but equally, economic and political power. In fact, the MIC is an instrument of State power and a lever in the direction of global protagonism. It is not possible to accumulate power and wealth in the capitalist interstate system and guarantee influence over other States without the military, technological and economic means achieved with or from the MIC.

Another relevant element of the MIC is its impact on foreign policy. By being able to export armaments, countries usually also export services, technical assistance, military cooperation programs and, to some extent, imposes some degree of dependence on importers. An example of the dependence caused by cooperation agreements in defense and assistance is the one carried out between the United States and Brazil in 1952 (FLORES, 1982). This agreement lasted until its denunciation by the government of General Ernesto Geisel in 1977 and was based on the sale of used and often obsolete armaments at a more affordable price. The North Atlantic Treaty Organization (NATO) is also an example of creating a captive market to the American MIC (HARTLEY; BELIN, 2019).

Developing a military-industrial complex does not only mean having the capacity to manufacture armaments, but to master complex cycles of technology, create sophisticated conditions with the national economy and achieve internal and external market to have scale in production. Thus, the national innovation system of a large country ends up being deeply influenced by the issue of national security (NELSON, 1993). Other fundamental elements are geopolitics and international insertion. Having a sophisticated MIC means supporting autonomous and low-constraint international insertion.

Thus, an important dilemma is discussed among specialists of various strains: import armaments or develop internal capacity? In view of the historical geopolitical framework, there is no condition to achieve the degree of world power without the ability to produce sophisticated defense devices internally. As we discussed above, the instabilities inherent in the international system do not allow great powers to be dependent on others in any sector, much less in the sensitive field of defense and security.

Having a sophisticated military capability meant the main element of expanding imperial or State power in historical perspective. The countries that managed to develop the complex equation: threats and opportunities for expansion of power + economy (industry, financing the demand for cutting-edge weapons and R&D) + political stability, were able to influence or build the regional or international order in which they were or are present (KENNEDY, 1989). World powers tend to create difficulties and obstacles for peripheral countries or countries below the hierarchy of power that have pretensions to change their status in the international system. This fact poses a problem, which for some is insoluble: not every peripheral country can change its level on the scale of power. However, despite the fact that today the technological and financial difference between the great powers and peripheral countries is abysmal, history shows us that Rome was once periphery and became center, England was once periphery and became center, the United States was once periphery and today is at

the top of world power (COSTA, 2009). Therefore, through "founding insubordination" (GULLO, 2014), that is, from a geopolitical rebelliousness and daring, peripheral countries can break the restraints of access to power. In the case of India, it is important to note that the country was once center and, together with China, led the Asian and even world economy through the coveted manufactures and spices (NAYYAR, 2014).

A striking example of the performance of the great powers in the sense of vetoing access to peripheral countries in the development of cutting-edge military capabilities is the nuclear sector. If in the past, the veto was in the form of treaties in which the tonnage of ships or the number of warships allowed to the defeated in war was the rule, as in the case of Germany after World War I (CARR, 2001), with the advent of nuclear energy and its use for military purposes, it was decided to restrict it to a few countries. The central concern of governments with the right to military use of nuclear energy – the five permanent members of the UN Security Council, mainly – is that the process of enrichment of uranium and plutonium, either through the process of ultracentrifugation (as in the Brazilian case), or through the use of pressurized heavy-water reactor (used by India, Canada and others), for civilian purposes, can be directed at any time for military purposes (BUNN; SAGAN, 2014).

Thus, the United States and the Soviet Union led the process of creating the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) in 1968. Large peripheral countries, such as Brazil and India, reacted by declaring that such an attitude was, in addition to being hypocritical, harmful to World Peace by guaranteeing the most effective instrument of war – the atomic bomb – to few. This situation was denounced as a "freezing of world power" (ARAÚJO CASTRO, 1972). It is important to emphasize that there is a prediction of the extinction of nuclear weapons by the possessors, however, what is observed is that the States that have the "right" to develop atomic arsenals for military purposes have never applied a satisfactory reduction policy, much less the agreement to extinguish their stockpiles. This situation of maintenance of nuclear privilege encourages policies of autonomous affirmation by countries that were prevented from developing nuclear enrichment systems and suffered retaliation, such as Iran, or even those that did not adhere to non-proliferation treaties, such as India, Pakistan, Israel and North Korea, which defied the regime and developed nuclear capabilities for military purposes.

In addition to the NPT, the nuclear-armed countries, with the support of the United Nations and other States, pressed for the creation of an international non-proliferation regime[3] organized on the basis of a network of treaties, namely the aforementioned NPT, the *Missile Technology Control Regime* (MTCR)[4], *Comprehensive Nuclear Ban Test* (CTBC) and the *Nuclear Supliers Group* (NSG).

3 International regimes have different approaches according to the theory used. Our work is guided by realistic perception and, therefore, understands that international regimes are instruments of influence or even domination of the great powers over other States. For more information on the realistic approach to regimes see: Strange (1982) and Krasner (2012).

4 This regime is not directly aimed at non-proliferation, but reinforces it towards the use of long-range missiles with nuclear warheads.

It is salutary to understand that the non-proliferation regime is linked to the international security architecture that was put together throughout the Cold War. There was, then, a different bipolar international order with fewer rising States. Today, the global power structure has a number of emerging actors with broad military power, such as India, Pakistan, Israel and North Korea. These countries possess atomic artifacts and demonstrate the non-proliferation regime's failure to control access to nuclear energy for military purposes. Another relevant fact is the insecurity caused by the States themselves benefited by the pre-1968 NPT, such as the United States that generate instabilities in the world order due to unilateral actions as in the case of the invasion of Iraq in 2003, claiming that there were weapons of mass destruction (RAJAGOPALAN, 2018).

Another example very well used to restrict access to sensitive technologies or simply applied to combat competitors through the use of "law" or supposedly lawful mechanisms, are economic, commercial and or financial sanctions. This instrument was widely used by the United States during the Cold War; against Iraq (1991 and 2003), due to the Gulf War; Serbia, due to the war in the Balkans and widely used contemporaneously against Iran, Venezuela and China.

India also suffered from such retaliatory measures precisely because it dared to break the nuclear restriction of the NPT and explode its atomic bomb in 1974 (*POKHRAM I* tests). The Indian nuclear program began shortly after independence and was led by nuclear physicist Dr. Bhabha and had the decisive support of Prime Minister Nerhu. Initially developed with a peaceful purpose, the country's nuclear program took another turn after the conflict with China in 1962, and due to the unfair approach and guarantor of the privilege of the big five (USA, UK, France, USSR and China) to possess nuclear artifacts in the NPT negotiations in 1968 (SUBRAMANIAN, 1982). In 1998, the process of discussing the country's first nuclear doctrine began, in which the *No First Use* and *Second - Strike Capability* initiatives were established [5]. This strategy of using nuclear weapons is important in the scenario of discussions on non-proliferation, as it places India as a "politically correct" nuclear State, that is, without aggressive intentions of indiscriminate use (KANWAL, 2014).

There is yet another considerably relevant element in the relationship between world *status* and arms production, namely participation in conflicts (KINSELLA, 1998). As war was an integral part of the formation of States and vice versa (TILLY, 1996), the testing of armaments and the constant preparation for the conflict helped in the formatting of an industrial park aimed at military innovation that, in addition to benefiting the great powers with the most sophisticated defense equipment, also benefited them in the strategy of conquering markets for export.

5 The doctrine of "*no first use*" means that a nuclear power cannot use atomic weapons unless it has been attacked by nuclear artifacts and the "*Second - Strike Capability*" is the country's ability to use the nuclear attack as a response to the nuclear aggressor. More information in Siracusa (2008).

Indeed, as the military-technological complex became more and more sophisticated and the financing capabilities of war more difficult, few States were able to master productive defense systems that would guarantee them enough power to occupy the top of the world hierarchy. Thus, we insist with the question: is it possible for a peripheral country like India (or any other) to develop a military-industrial complex capable of offering defense solutions compatible with the country's global aspirations? At this time, we intend to highlight the advances in the military sector of the so-called traditional powers, but placing emphasis on the geopolitical factor. That is, our objective in this discussion is to illustrate the strategic component of the power and affirmation relationship with the development of critical military capabilities, either in the operational field or in the ability to design and manufacture defense devices.

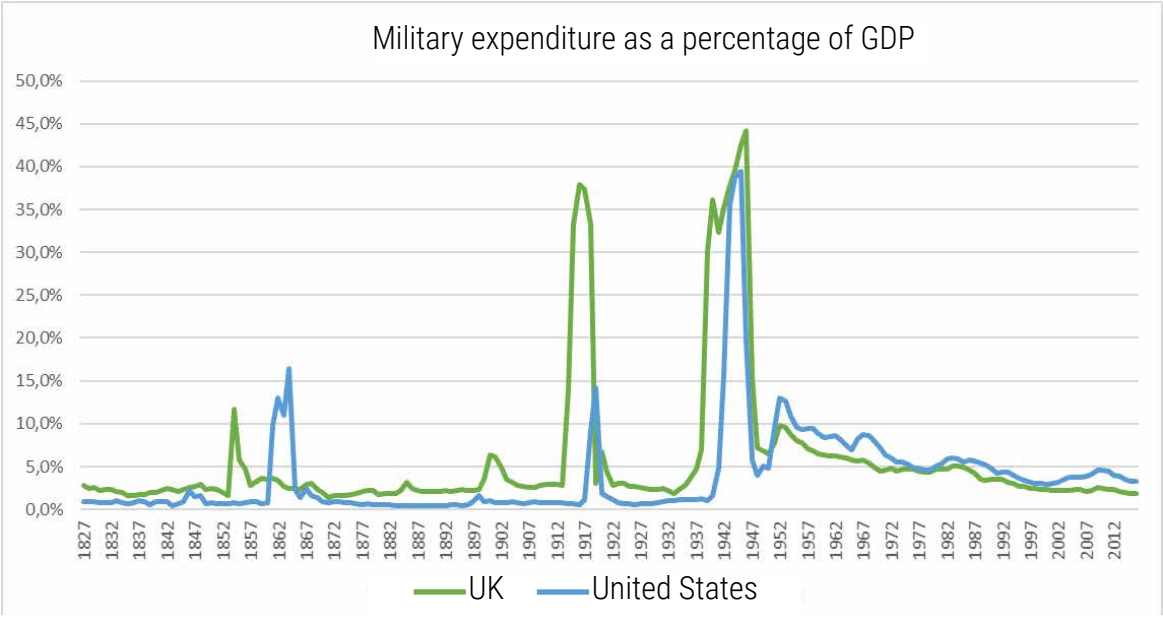
In fact, before analyzing the advances of the great powers in the field of development of productive and technological capacity aimed at defense and security, we will make a discussion that seems fundamental to us in the investigation about the military-industrial complex, which is the Defense Economy. This field of research seeks to analyze the relationship between military spending and economic growth, as well as the benefits or harms that come from this relationship.

2 Defense Economics: military spending and economic growth/development

In this topic, we will investigate the positive points (mainly) in the tax economy of military spending. Our goal is to discuss the main dilemmas and issues concerning the Defense Economy.

Historically, military spending increases when there are security dilemmas (HERZ, 1950) or conflicts. There were times when countries spent more than half their GDP on defense, such as Britain at the end of World War II, 52%/GDP (CHANTRIL, 2015), or Louis XIV's France in the 17th century, which had a budget average of 30% of GDP, however, rising to 57% during the war with the Netherlands in 1683 (BURNS, 1988; ELORANTA, 2005). Military spending, up to the social revolutions from the end of the 18th century, as well as with the creation of the mechanisms of control and transparency of the public budget, were quite broad. From then on, social spending was prioritized for the benefit of the majority of society and military spending became more controlled and "transparent".

Graph 1 – Share of military spending in the GDP of the United Kingdom and the United States of America between 1827-2012.



Fuente: Our World in Data (2016).

Thus, one of the most frequent discussions about defense spending concerns the *guns x butter* dilemma[6]. This dilemma has long been addressed by decision-makers, but above all by liberal (neoclassical) economists who tend not to perceive the strategic element involved in military spending, but only the accounting factor[7].

There is an interesting and well-established literature on defense economics that analyzes a series of schools and approaches on the issue, including those with an econometric profile (DUNNE; SMITH; WILLENBOCKEL, 2005). In addition to neoclassical authors, there are also those of Keynesian tradition who understand that military spending is positive, because through its multiplier effect they are able to stimulate aggregate demand and product growth (AMBROS, 2017).

In this sense, Pivetti (1992) defends the positive participation of the increase in military spending for the growth of the economy, since there would be an increase in aggregate demand pulled by military investments and expenditures. The author illustrates this relationship by analyzing the United States during the Cold War. In the two moments in which the US government increased military spending, 1947-1969 and the 1980s, there was a reduction in unemployment and economic growth.

6 In the past, there was a certain ease for politicians, kings and those responsible for the military budget to spend what was necessary for the strengthening of the State, however, with the advent of more representative governments, the dilemma reappeared with more vigor and imposed more democratic and transparent discussions. However, it is important to note that defense spending at the expense of social spending – or any increase in military spending seemingly without justification – affects developing countries that still need large sums of investment to carry out their structural change. For more information see: Garfinkel and Skaperdas (2007).

7 However, one of the greatest icons of economic liberalism, Adam Smith, understood the need for State interference in the economy when it came to national defense. For him, defense was a public good and therefore not liable to suffer the oscillations of the free market. More information in Smith (1983).

Another important element posed by Pivetti (1992) is that there would not be an opportunity cost in the issue of military spending and investments in other civilian sectors, since the former is a specific expenditure and, therefore, does not divert investment, but rather generates a new expenditure and stimulates the demand for new private investments. In addition, there would be the benefit of encouraging technological progress as a result of military spending, as well as a stimulus to private investment. There are, however, criticisms of the issue of "technical training diversion" from the market to the military sector. Nevertheless, Pivetti argues that the demand for specialized professionals tends to increase as the demand of the military sector for this manpower increases, as demonstrated in the American case of the arms race with the Soviet Union (USSR) during the Cold War. Finally, the author, as well as Sandler and Hartley (2007) and Mazzucato (2014), points out that military spending brings a contribution to the civilian sector through the *spin-off*, that is, the technological diffusion of the military sector to the market (PIVETTI, 1992).

Nevertheless, it is important to emphasize that the positive elements of military spending, as advocated by the aforementioned authors, will depend on the situation of each State analyzed. In particular, with regard to developing countries, Pivetti argues that, despite the general benefit of military spending as an aid to aggregate demand, one should investigate each particular case (PIVETTI, 1989). However, it is important to emphasize that there is research on the effects of military spending on the economic growth process of developing countries showing positive results. Benoit (1973) did a study with 44 emerging countries[8] between the years 1950 and 1965 and the result was that these countries, considering the "military burden", that is, a relative high military expenditure, achieved greater economic growth than those who spent relatively less (BENOIT, 1973).

McGuire (1995) advocates that economics can contribute to Defense and Security Studies on at least six points: 1) defense strategy and resource allocation; 2) analysis of deterrence; 3) economic alliance models; 4) national power, economic survival, and international trade – here the emphasis would be on protecting the National Defense Industry; 5) arms race and strategic interactions; 6) economic ecology and international conflicts. In this last point, the author uses the analysis of the demographic question (extinction and human survival) as an important element of security.

In addition to these points of contribution of economics to Defense and Security studies, McGuire argues that there are four levels of interdependence between areas. The first of these would be the question of the effectiveness of economic policies aimed at defense. The second is the national economy as a support and source of funds for security, as well as the use of the economy for the weakening of enemies, through sanctions, embargoes, financial advantages, that is, geoeconomics[9]. The third level of interdependence would be macro effects on national

8 Selected countries included India, Israel, China, Mexico, South Korea, Argentina and others.

9 SAccording to Blackwill and Harris (2016), geoeconomics is "the use of economic instruments to promote and defend national interests and produce beneficial geopolitical outcomes; and the effects of other nations' economic actions on a country's geopolitical goals" (BLACKWILL; HARRIS, 2016, p. 20, translated by the author). The strategic use of the economy as an instrument to achieve geopolitical ends is historical, many powers have done so and still do. Sanctions, blockades, loans with counterparts and so many other ways of using economic power as a weapon are present in the prescriptions of the most powerful nations. In this sense, the "modern geoeconomics" is necessarily linked to the use of traditional military power and diplomatic actions as an instrument of a country's foreign policy (BLACKWILL; HARRIS, 2016).

economies, such as economic stability, growth and prosperity. Finally, the fourth and final level is the economy as an explanation or source of the country's security problems. Examples of this would be: colonization (colonialism), distribution of wealth and all movements made by the State to ensure access to wealth (MCGUIRE, 1995).

There is a consensus that having a sophisticated military-industrial complex and state-of-the-art Armed Forces goes beyond geopolitical motivations. It is not enough just to have the will to be more powerful, it is necessary to create systematic conditions for the modernization of military power. This involves the decision to spend less on personnel and more on critical technologies – one of the problems that involves, above all, developing countries such as India and Brazil.

However, it is also known that there are emerging countries with greater international prominence and that need to accompany the great powers or simply develop deterrent devices that are costly.

Nonetheless, there are authors who argue that military expenditures are configured as burdens and, therefore, bring serious doubts about their contribution to national development and economic growth, because with military expenditures, important civilian investments would no longer be made (DUNNE, 1990; SEN, 1987; SMITH, 1977). For Sandler and Hartley (2007), however, defense spending brings considerable benefits to the development process, as they are positive in times of unemployment and economic crisis, generate *spillover* and *spin-off*s, can contribute to economic growth when focused on the construction of infrastructure and can generate an important sector of highly qualified human resources.

The benefits of military research and its *spillover* for the market was widely studied by Mariana Mazzucato who showed the numerous benefits of the constant policy of public investment in R&D in the Defense sector. It is through this initiative that devices such as *smartphones* and its components, such as the *touchscreen* or even the internet could, from the financing of military research, be widely used by the market and have become items of very high civilian consumption (MAZZUCATO, 2014). We could cite a huge list of inventions that derived from investments in defense, such as GPS, the microwave oven, superglues and many others from everyday use, such as razors and canned food (FROHLICH; COMEN; SUNESON, 2019).

Corroborating with the studies and positions of the aforementioned authors about the benefits of military spending for Economic Development, Ram (1994) reinforces the positive points of the *spin-off* and advocates that national defense spending promotes long-term economic growth, even if this is not the immediate goal. In addition to the long-term benefit, defense spending brings advantages such as the formation of human capital, advancement in infrastructure and technological progress.

However, despite the enormous contribution of the spillover of research in the defense sector – there is a myriad not yet spillovered and that, probably, will not be – for the market and its civilian use, the effectiveness of the final product cannot be credited only to its ability to be assimilated by the civil sector. The purpose of military research is to ensure, first of all, national defense and the possibility of maintaining or expanding the international power of the State.

The "Revolution in Military Affairs" (RAM)[10], a term that some defend, happens concomitantly with the most critical technological advances and needs to be understood as a strategic issue, as it completely alters the way of making war and seeks to create conditions to achieve victories in conflicts in a decisive way. As we commented in paragraphs above, the most developed powers are able to deepen the *gap* already quite large among advanced and backward with regard to military capabilities and everything indicates that this should be the rule, that is, the richest and most powerful countries should become even more capable of imposing their will on the least developed and dependent. Few states are able to do the technological-economic military *catch-up* and avoid domination and dependence.

However, it is of fundamental importance to reflect that technological military superiority is not enough to win the war – striking cases, such as the defeat of the United States in Vietnam and the difficulties of the same superpower in dominating the Afghan territory, are important findings of this – however, it is equally important to point out that the more means the country has to win the war – financial capacity, for example – the closer it will be to victory.

Our objective in this section is not to be guided by mathematical, econometric models or that analyze Defense Economics with an emphasis on cost-effectiveness. Most economists who study Defense leave aside the geopolitical element, that is, the strategic nexus that goes far beyond the accounting of spending itself. Even if we agree with the approaches to economics that meet the thesis that military spending is positive, we are not guided by such a line of thinking, since we understand that defense and security issues have always been the true pillars of the expansion of State power throughout history. For some defense economists – especially those of the neoclassical strain – war, and therefore conflicts, can be avoided if there is more transparency of information, after all *decision-takers* are rational agents capable of observing the effects of war under the lens of cost-benefit (BRITO; INTERLIGATOR, 1985; SÁNCHES-PAGÉS, 2004).

Although we agree that the economic element, such as the export of products and the financing of the military-industrial complex are important, it does not seem to be the main vector of stimulating the development of the National Military sector, but rather geopolitical threats and the need to strengthen the foundations of the expansion of power in the international system – or in the immediate space. It is necessary to make it very clear that our work is not only concerned with the macroeconomic or accounting aspects of defense, that is, we do not focus on budget disputes within the State – which we have already claimed to be a relevant factor – but whether there is the perception that the construction of a military-industrial complex is salutary for a State to establish itself as a world power. Thus, we go against the neoclassical perception of Brito and Interligator (1985) and Sánches-Pagés (2004) – and many others of the same approach – about the vision of war, because these are, first of all, politics by other

10 The term is not consensual in the specialized literature. There are authors who argue that there were "military revolutions" that completely changed "making war", such as Michael Roberts (2018). There are also those who understand that the technological changes of war take place in the "long-term" (BLACK, 1991). Our objective here, however, is to highlight the efforts in the direction of strengthening the strategic advantages aimed at the military field that guarantee conditions to win the war and or maintain the *status quo* in the hierarchy of world power. For more information on the topics see: Saint-Pierre and Gonçalves (2018) and Teixeira (2009).

means (CLAUSEWITZ, 2017) and the main definer of the hierarchy of power and wealth in the international system (FIORI, 2015). Therefore, there is a fundamental relationship between the economy and defense, not as a mere instrument of quantitative analysis of the costs and benefits of rational agents and their *trade-offs* about whether or not to invest in military power, but in understanding the economy as a pillar of the political and geopolitical strategy of the State in its struggle for survival and empowerment in the international system.

Before closing the section, it is important to emphasize the issue of technological advancement to overcome dependence in the military field. Indeed, it is worth mentioning an issue not always addressed by defense economists about developing countries, namely economic constraints. Few emerging states are able to break the shackles of technological dependence, often linked to intellectual property and the costs of developing sophisticated devices in the military sector. There is also, in spite of the problem of technological dependence mentioned, the issue of pressures suffered by developing countries to buy defense equipment from developed countries, see the recent case of Turkey that has been suffering pressures to apply sanctions by the United States due to the purchase of the S-400 anti-aircraft defense system from Russia (SELIGMAN, 2019). This reinforces the need for developing countries to build policies aimed at structural change in order to enable their productive systems to develop armaments and reduce dependence on the import of defense products from more advanced countries.

3. Military-industrial complex is power: a brief analysis of the cases of the United States and China

The United States

> "The basic innovations that shaped modern American technology after World War II (and quickly spread around the world as the jet plane, the transistor, fiber optics, nuclear energy, the computer, the internet) were conceived, developed and directed as a military enterprise" (SMITH apud MEDEIROS, 2004, p. 225).

Despite the military and economic advances of the 19th and early 20th centuries, it will be after WWII that the American economy and power will know a colossal advance. With the economic instruments built in the post-war period, such as the International Monetary Fund (IMF), the *General Agreement on Tariffs and Trade* (GATT) and the World Bank, the United States was able to accumulate considerable wealth and shape the international economic order according to its discretion (HOSSEIN-ZADEH, 2006).

This fabulous economic advance allowed the country an equal military expansion of an imperialist character, especially after the end of the Cold War. With a series of conflicts and military interventions – Gulf War, 1991; Serbia, 1999; Afghanistan, 2001; Iraq, 2003; Libya,

2011; Syria, 2013 – the United States has allied economy, production and sale of weapons and geopolitics like no other State so that its MIC has become the most complete and critical in the world. This relationship is called by Hossein-Zadeh "*The Political Economy of US Militarism*"and would have an imperialist form, the "militaristic" and "parasitic imperialism"[11] (HOSSEIN-ZADEH, p. 3, 2006). El imperialismo militar del país sería una especie de amplia distribución de la riqueza para los más ricos por medio del aumento del gasto militar y de la remuneración de las empresas que actúan en las guerras (HOSSEIN-ZADEH, 2006).

However, military spending and its instrumentalization via the "political economy of imperialism" is not consensual and faces a dispute between "factions". On one side there would be the armamentist *lobby*, nationalist and inciter of external conflicts, on the other the group of more neoliberal characteristics, which is not even a sponsor of the instabilities derived from military incursions, as they bring economic uncertainties to business. Thus, despite the more common perception that the United States acts internally in consensus in the decision-making process linked to conflicts, especially those in the Middle East, supposedly motivated by oil control, Hossein-Zadeh argues that there is a criticism on the part of American energy companies to the instabilities caused by the permanent military presence. Thus, there would be strong pressure from the militarist *lobby* for the country's external action in order to guarantee large financial returns to companies in the defense sector (HOSSEIN-ZADEH, 2006).

Indeed,

> [...] since the post-war period – and with the impetus of the Cold War – the role that militarism assumed in the construction of American International hegemony has been discussed. Since, by consolidating its military preponderance, the United States created an industrial demand that was responsible for boosting its domestic economy and fostering other productive sectors in times of crisis, stagnation or recession, making "continuous war" occupy a strategic role in the design of industrial policy and in the scientific and technological development of the country. Called the Military-Industrial Complex, this structure, which combines industrial demand with external military action, is for many authors the main responsible for the warming of the North American economy in periods of internal difficulties (MOREIRA JR, 2015, p. 27).

11 *Parasitic* because, according to the author, American militarism is inefficient and highly costly in economic terms. In the author's words: Historically, parasitic military imperialism has almost always evolved out of a higher stage of economic or classical imperialism: a prolonged reliance on military power for economic, territorial, or geopolitical gains gradually creates a dynamic out of which evolves a large standing military apparatus that tends to perpetuate itself — and develop into a bureaucratic military empire. Though military force in the economic sense of imperialism is usually a means for economic, territorial, or geopolitical gains, under parasitic military imperialism it becomes an end in itself (HOSSEIN-ZADEH, 2006, p. 3, translated by the author). Original source: Historically, parasitic military imperialism has almost always evolved out of a higher stage of economic or classical imperialism: a prolonged reliance on military power for economic, territorial, or geopolitical gains gradually creates a dynamic out of which evolves a large standing military apparatus that tends to perpetuate itself—and develop into a bureaucratic military empire. Though military force in the economic sense of imperialism is usually a means for economic, territorial, or geopolitical gains, under parasitic military imperialism it becomes an end in itself.

It can therefore be concluded that competition and rivalry, as with Germany (WWII) or the Soviet Union (Cold War) were striking elements of the advancement of the country's military technology.

In fact, the project *Manhatan* (atomic bomb), *Apollo* (space exploration) and *Strategic Defence Initiative* (known as "Star Wars") were examples of this. In this sense, the US National Defense Strategy of 2018 thus refers to the competition and threats of the "revisionists" Russia and China:

> The central challenge to U.S. prosperity and security is the reemergence of long-term, strategic competition by what the National Security Strategy classifies as revisionist powers. It is increasingly clear that China and Russia want to shape a world consistent with their authoritarian model – gaining veto authority over other nations' economic, diplomatic, and security decisions (EUA, 2018, p. 2) [12].

There has always been awareness on the part of American policy makers, and the manifest destiny[13] reinforces this, that the United States should be the great world reference (RESENDE, 2012). For such a project to become viable it was necessary to create a broad technological, economic and political base around the defense sector that would contribute to the progress and development of the country (MEDEIROS, 2004). In this sense, the US Department of Defense was, along with other federal agencies, such as the *Defense Advanced Research Projects Agency* (DARPA), or *National Research Council* (NRC) or yet the *National Aeronautics and Space Administration* (NASA) – in addition to a network of universities with research focused on the sector –, important to organize and induce modern technological innovation generating great benefits to the military leadership of the United States in the post-World War II. Thus,

> [...] the participation of the State through the so-called military Keynesianism is not restricted to the provision of resources to the research and development process and to government purchases and public contracts with weapons manufacturers, but presents itself as an articulation between public and private institutions that influenced the process of selection, diffusion and induction of modern technologies in the post-war period. All this under the commitment to maintain a strategic superiority over the opponent (MOREIRA JR., 2015, p. 34).

12 Original: The central challenge to U.S. prosperity and security is the reemergence of long-term, strategic competition by what the National Security Strategy classifies as revisionist powers. It is increasingly clear that China and Russia want to shape a world consistent with their authoritarian model – gaining veto authority over other nations' economic, diplomatic, and security decisions.

13 The term *Manifest Destiny* was initially coined by journalist John O'Sullivan, in 1845, and is based on the idea that the United States of America would have been blessed by God and, therefore, would have special rights to conquer territories and peoples. There is a strong Protestant religious influence in the term and practice, but there are also geopolitical and economic elements that would justify the expansion of American power to the west of the North American subcontinent. In this way, the domination over the natives and the taking over of their territory, as well as the conquest of part of the Mexican territory, were morally linked to manifest destiny. Subsequently, American imperialism was justified on the moral basis of the same principle. For more information about the term and its historical application see: Montjoy (2009) and Merk (1978).

In fact, strategic superiority is not only the result of State orders and inductions through military investments and expenditures, it is also necessary to create what Holley (1997) calls the "academic military-industrial complex". For the author it is necessary a system that can relate the best ideas to a doctrine and its strategic application. That is: "new weapons, when not accompanied by the corresponding doctrinal adjustments, are only several external additions to the Armed Forces Corps" (HOLLEY, 1997, p. 14, translated by the author).

In terms of share in the global armaments market, the country has 43 companies in the top-100 and 5 in the top-10. The country is the largest arms exporter, US$175 billion. According to SIPRI, in 2021, the country concentrated 39% of global sales. The main companies in the US defense sector – and also top-5 in the world – are: *Lockheed Martin, Boeing, Raytheon, Northrop Grumman* and *General Dynamics*. The defense budget of the United States in 2021 was US$778 billion – almost the same amount as the subsequent top 10 countries (SIPRI, 2021).

The MIC, in general, but the American in particular, is the most complete example of political-economic-military coordination of a global power project. The dynamics of this complex are highly sophisticated and have deep potential for spillover and *spin-off* – which proves the thesis defended by Mazzucato (2014), Block (2008) and others that the State is the great diffuser of innovation and development. The MIC cannot be detached from the national innovation system and in the case of the United States, the expansion of its economic and military power in the international system cannot be understood without interstate competition (arms race) and the development of its military-industrial complex.

It is in this sense that the *Interim National Security Strategic Guidence* – document that gives the main guidelines of U.S. policy for national security, while the *National Security Strategy* of the Biden administration was not disclosed – reinforces the link of the country's strategic objectives with the needs of investment in military R&D. The aforementioned document proposes a resumption of Washington's technological and economic prominence, given the loss of industrial competitiveness and innovation of the country to China and Russia. Thus, defense is explicitly cited as one of the pillars of ensuring the objectives of American power for the 21st century, as well as the maintenance of a large spending and investment budget (THE WHITE HOUSE, 2021).

China

China has been implementing a national development strategy since 1978 with the clear objective of transforming the country into one of the main forces of the international system. The government of Deng Xiaoping (1978-1992) announced the need to promote the national "Four Modernizations". The goal was to develop agriculture, defense, science/technology and industry as instruments to transform the country's economic and strategic structure. In fact, these measures of "opening up" China to foreign investment and international trade proved to be fundamental instruments of a national development project that, judging by its results, has been successful (JABBOUR; DANTAS, 2017).

In this sense, the development of a military-industrial complex – precipitously motivated to respond to threats and ensure autonomous international insertion – has transformed China into the third military force and the second largest defense budget in the world. Indeed, in 2019, Beijing released its Defense White Paper – *China's National Defense in The New Era* – official document that points out the main strategic objectives of the country for the 21st century. In addition to analyzing the international security landscape, the Chinese White Paper reiterates the mission of the country's Armed Forces and analyzes the needs for reform of military institutions. Another key point of the document is the relevance given to defense spending and the constant modernization of production and innovation capabilities in the military field in order to reach a global reference position by 2035 (HUI, 2019).

The country's strategic arsenal ranges from the ability to manufacture and launch intercontinental ballistic missiles, through sophisticated air defense systems (HQ-16), cyber warfare devices to fifth-generation attack fighters (J-20 and FC-31). Naval progress is equally extraordinary, the country is able to design and build a number of warships, such as frigates, destroyers, submarines (with nuclear propulsion) and aircraft carriers, such as the "Type 001A" (the project is to have 6 nuclear aircraft carriers by 2035). Today China has an ability to develop, produce and export state-of-the-art armaments (such as the hypersonic missile *Xingkong-2*), consolidating its position in the global military power hierarchy.

In the early 2000s, the Chinese military-industrial complex employed more than three million people – 300 thousand of them engineers alone – and has thousands of state-owned and private companies (BITZINGER, 2008). Today, there is a considerable technological advance and integration between the military and civilian sector in the country. Differently from what was seen in the first decades of communist China – which maintained a separation between sectors for numerous reasons, including economic backwardness and external threats – the progress achieved by the political effort to integrate the civil and military productive and technological system contributes for the dynamization of the Chinese economy and its development process (TREBAT; MEDEIROS, 2014).

To coordinate the policy of integration between the military and civil sectors, the *Comission of Science, Technology and Industry for National Defense* (COSTIND) was created in 1982. Its goal was to work with civilian agencies on technology transfer and *know-how* del sector militar. El efecto de tal política se puede notar en el cambio de la composición del sector de defensa que, en 1978, tenía solo el 8% de participación de empresas del sector civil, mientras que a fines de la década de 1980, dicha cifra aumentó al 70% (TREBAT; MEDEIROS, 2014).

Effectively, the advance towards the sophistication and modernization of the Chinese military-industrial complex was due to the political decision to increase military spending and to mirror the technological advances presented to the world by the United States during the Gulf War (1991). Advances in microelectronics and other items of critical technology, associated with the geopolitical changes of the 1990s, made China understand the need to adapt the people's Liberation Army to new ways of waging war and implement "military-industrial" reforms. Another factor that motivated the advancement and deepening of investments in military innovation was the US embargo on dual-use technologies exported to China, as well as the country's booming and constant economic growth (TREBAT; MEDEIROS, 2014).

In order to advance in the field of critical technologies, the Chinese government created Project 863 *High-Tech Research Program* focusing on information technology (IT), laser, biotechnology and other highly complex niches. A relevant aspect of the program is its link with universities, which receive funds for R&D focused on the military area (TREBAT; MEDEIROS, 2014)

China has become a major arms exporter. The country is among the five largest exporters in the world (SIPRI, 2021b). Its main customers are Pakistan, Bangladesh and Myanmar, as well as African and Middle Eastern countries. If NATO is a captive market and export platform for US defense products, the *Belt and Road Initiative* (BRI) has been a promising market for arms exports from China (SHAO, 2019). With regard to arms imports, Europe is the country's main partner with almost 99% of sales, with special emphasis on Russia with 68% (CSIS, 2019).

The main Chinese defense companies are: *Aviation Industry Corporation of China* (AVIC), *China South Industry Group* (CSIG), *China North Industry Group Corporation, China Aerospace Science and Industry Corporation, China Shipbuilding Industry Corporation, China Electronics Technology Group Corporation and China Aerospace Science and Technology Corporation* (ZHEN, 2018). A relevant fact of the Chinese MIC is that all large companies in the sector are state-owned.

In 2020, China managed to achieve an important place among the largest producers and exporters of defense equipment internationally. The *Aviation Industry Corp. of China* (AVIC), the company responsible for the fifth-generation J-20 fighter and the H-20 bomber aircraft, was, that year, the sixth largest arms exporter in the world; while the *China Electronics Tchnology Group Corp*. (CETC), the eighth, and the *China North Industries Group Corp*. (NORINCO), the ninth (SIPRI, 2021d).

Chinese defense spending/investment in 2020 was US$252 billion (13% of the world total) and the fifth largest arms exporter with 5.5% of the total (SIPRI, 2021). It is the world's second largest military budget and has been growing systematically. However, it is important to reinforce the jump in both spending and development of the Chinese MIC, in 1989 the country occupied only the twelfth world position with regard to military spending (TREBAT; MEDEIROS, 2014).

Despite the enormous progress in terms of technology and productive capacity – which can be seen as one of the few countries to provide the majority of military equipment to their Armed Forces (BOUTIN, 2017) – the Chinese MIC still cannot be compared to the American and even the Russian, as there are still some degrees lacking in the technological domain. Areas that require higher density and technological maturity, such as aerospace, still demand a *catch-up*. Another relevant aspect in this process of technical mismatch is the fact that Chinese armaments have not yet been widely tested in conflicts and therefore still lack a quality stamp when compared to the two military superpowers.

However, soon, China should become a country with complete independence in the military sector and compete with the United States and Russia for the most complete and sophisticated MIC *status* among nations, as this is the goal and the Chinese government has not been sparing efforts to reach it. In less than 40 years China's MIC has grown into one of the five most sophisticated and complete in the world. Considering the level of investment, training of human resources and geopolitical motivation, the country should not have great difficulties in materializing the goal of becoming a military superpower in the long term, if it manages to overcome the technological gaps that make the country need partners today in the supply of sensitive components, such as Russia.

In this sense, the proportional expenditure on R&D focused on the military sector in China, in 2014, was around 15 to 25% of GDP (TREBAT; MEDEIROS, 2014). Another relevant data on Chinese defense spending is personnel spending, which accounts for around 30.8% of the budget, with 28.1 remaining for training and maintenance and 41.1 for equipment (CSIS, 2019).

In short, despite the enormous technological advancement in the military sector and the fact that it is the world's largest economy (PPP – Purchasing Power Parity), China is still not on a par with the United States. The evolution of the production system and R&D is unquestionable, largely due to the abandonment of the Soviet-inspired model and adherence to an industrial-military organization inspired more by the American formula from the late 1970s onwards. Thus, seeking to deepen the military technological modernization, the *Medium to Long-Term National Science and Technological Development Plan* 2006-2020 was launched, focused on increasing endogenous innovation capacity (REPUBLIC OF CHINA, 2020).

Final considerations

In this article, we seek to analyze the importance of the military-industrial complex as a fundamental element of the geopolitical strategy of the State, especially of the one that has aspirations for world power. Thus, the discussion of the first session had the role of justifying the development of the military-industrial complex, reinforcing its historical importance for the international affirmation of the great world powers. In this sense, the discussion made in the second part aimed to investigate the positive economic elements, such as the *spin-off*, for the economic development and strategic innovation of the State. Finally, in the last part, our intention was to apply the concepts and contributions of the first two sessions. Thus, we analyze the cases of the United States and China, illustrating the importance of thinking strategically about the defense economy.

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Machiavelli and the importance of the national military power

Maquiavelo y la importancia del poder militar nacional

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Abstract: This work brings into consideration the teachings of Machiavelli regarding the consolidation of Nation-States. Under the hypothesis that the survival of the State would be attached to its capacity to provide its own defense by its own means, Machiavelli advocates that the creation of national armies formed by conscripts and promptly rejected the deployment of mercenaries, as well as rejected an army relying upon the aid from other States in the case of crisis or war, which were very common during his time. Nowadays, citizen armies became a reality, however the fast evolution of science, technology and innovation, as well as their consequences to the military expression of the national power, suggests that the existence of such armies no longer assure to any State the capacity to fully defend itself by its own means. This is true, particularly, for countries in which the processes of industrialization came late and that do not fully possess the knowledge required to develop critical and sensitive technologies, or those nations that operate with modest defense industry and, due to that, are heavily dependent upon other countries in regard to essential weaponry, weapon systems or other equipment's. Aware of the importance of such aspects for the Military Power, we present in this work the characteristics of the defense market, as well as some of the difficulties faced by countries under late industrialization. Moreover, we introduce proposals for the development of a national core for defense industry, such as the exploration of dual technologies and process optimization for the purchase of military systems and weaponry. The ideas explored within this essay should be seen as a warning to anyone tasked to formulate public policies that defend the reduction of personnel and financial resources directed to the development of armed forces and its national defense industrial core.

Keywords: Machiavelli; Defense Industrial Base; Military Expression of National Power; sovereignty; science; technology; innovation.

Resumen: En este ensayo traemos a consideración las enseñanzas de Maquiavelo, en particular con relación a la consolidación del Estado. Respaldado en la hipótesis de que la supervivencia del Estado estaría condicionada a la capacidad de él realizar su defensa por sus propios medios, Maquiavelo abogaba por la creación de ejércitos nacionales de conscriptos y refutaba perentoriamente el empleo de mercenarios y de recurrir a la ayuda de otros Estados en los momentos de crisis y de guerras, práctica habitual en su tiempo. En la actualidad, ejércitos formados por nacionales se han convertido en una realidad, pero la evolución vertiginosa de la ciencia, tecnología e innovación y las consecuencias de esa evolución en la Expresión Militar del Poder Nacional sugieren que la existencia de tales ejércitos no garantiza al Estado la condición de defenderse por sus propios medios, particularmente en países que han vivido procesos de industrialización tardío, que no dominan conocimientos esenciales para desarrollar tecnologías críticas y sensibles, que cuentan con modesta Base Industrial de Defensa (BID) y cuyas capacidades militares dependen esencialmente de armamentos, equipos y sistemas de empleo militar importados. Conscientes de la importancia de estos aspectos en la composición del Poder Militar, presentamos características del mercado de defensa, algunas dificultades enfrentadas por países de industrialización tardía y propuestas para el progreso del BID nacional, como la explotación de la dualidad tecnológica y la optimización de los procesos de obtención de sistemas y materiales de empleo militar. Las ideas exploradas en este ensayo sirven de alerta a los formuladores de políticas públicas que defienden la reducción de los efectivos y de los recursos financieros destinados al desarrollo de las Fuerzas Armadas y de la BID Nacional.

Palabras clave: Maquiavelo; Base Industrial de Defensa; Expresión Militar del Poder Nacional; soberanía; ciencia; tecnología; innovación.

1 Reflections on Machiavelli's thinking regarding the Art Of War

Machiavelli lived in a transitional age between the Middle and Modern Ages. In Europe, this was a period marked by great transformations, especially in Italy, where wars, betrayals, conspiracies and murders of members of the ruling class often occurred.

He took an active part in the political life of Florence, where he was born in 1469 and died in 1527 (RIDOLFI, 2003). At the age of 29, he took the role of Head of the Second Chancellery of the Republic of Florence, a position he held for more than 14 years. In this position, he dealt with internal and extraordinary affairs, among which were matters related to wars, and had the opportunity to get to know the main European states deeply, while participating in more than 20 diplomatic missions in which he represented his homeland. He was also a member of the council of the Ten of War, in which he focused on the practical tasks of organizing a military force.

In 1512, when the Medici resumed the rule of Florence, Machiavelli was removed from his office and went into exile. While in forced retreat, Machiavelli wrote his three great works: The Prince (1513), The Discourses on the First Decade of Titus Livius (1513-1521)[1] and The Art Of War (1519-1520).

His knowledge in history, especially of the Roman Empire, and his exceptional experience in the political, military and diplomatic fields supported these works whose contents transcended merely theoretical issues, but also had the pragmatic objective of offering ways to mitigate the impotence, decadence and fragility of the principalities of the Italian peninsula[2]. Although most prominent in The Art of War, the military question permeated these three important books by Machiavelli.

The originality, importance and depth of these works have raised Machiavelli to the status of founder of the Modern Political Science and his masterpiece, The Prince, is one of the most cited books in this area of human knowledge. Since he understood that conflicts are characteristic of a political nature, the military issue has become one of his main concerns and the object of consistent analysis. Despite this, his most complete work and in which he specifically addressed this subject, The Art of War, had no repercussions comparable to that achieved by his most famous work, in addition to having received criticism for not recognizing the revolutionary importance of artillery and firearms in general.

More than 500 years and a completely different historical context separate us from the time when Machiavelli produced his emblematic works in the early sixteenth century. However, this Florentine thinker continues to be analyzed, studied and quoted copiously, because his writings have captured aspects of human nature that endure despite the centuries elapsed. Undoubtedly, the main ideas of this sharp philosopher remain current.

According to Machiavelli's thought, military forces are essential for the formation and consolidation of the State. However, this empirical historian strongly warned, with inci-

1 The term “decade” in the title established in the Portuguese translation is imprecise, given that Machiavelli only comments on the first ten books of the History of Rome, by Titus Livius, composed of 142 books. Thus, the correct term would be "ten" and not "decade".

2 Rousseau disagrees with the majority by asserting that Machiavelli's intention was in reality to warn the people of atrocities that could be committed by tyrants.

sive argumentation based on historical facts, that such military forces should be composed of members recruited from among nationals. He thus peremptorily refuted the then customary practices of resorting to mercenary troops to promote the defense of the State, as well as to the absolute European monarchies for aid in their conflicts.

The Art Of War (MAQUIAVEL, 2006), analyzed the forms of recruitment, training, organization, planning and employment of troops made up of a kingdom's subjects, in addition to addressing financial, tactical, logistical and moral aspects of these troops. In this book, he defended the idea that the organization of its own military force is crucial for a city to ensure its independence and give vent to its political ambitions, in addition to serving as a powerful instrument for consolidating civic virtue. In fact, the role of the citizen in the defense of the State assumed special prominence in this work.

It should also be noted that Machiavelli devoted special attention to military training in peacetime, believing that one could compensate for the inexperience of the kingdom's subjects through it, instill discipline and develop the necessary capabilities to wage wars. Well-trained and disciplined subjects would greatly outperform those who made war their livelihood, even though the latter were more accustomed to military conflicts.

According to this pragmatic political thinker, those who made wars their business, the mercenaries, sought to prolong them and therefore did not fight with impetus or will. Since they did not strive for an ideal or belief, but only for financial compensation, they tended to be unfaithful, greedy, and, despite their bravery before their friends, often cowered before their enemies. Machiavelli supported these assertions through several examples of situations in which they offered no resistance to the enemy, did not seek the decisive battle, and betrayed their prince, changing sides for purely financial reasons. Thus, the expectations that were created in peacetime were usually frustrated during the war.

Also for financial reasons, mercenaries despised recent advances in the state of the art of military thought. For example, they despised the infantry, whose massive employment would entail increasing the number of troops and therefore the costs of long military campaigns. They prioritized cavalry, which was very fragile in the face of technological advances that occurred, especially at the end of the fifteenth century. They acted in this way to increase their profits and established a code of conduct aiming to strive for the reduction of risks, efforts and hardships in battles. Definitely, the relationship between the prince and the mercenaries was not dictated by trust and alignment of purposes, but by mistrust and conflicting interests. In short, for Machiavelli the princes who entrusted the security of the principalities to mercenary troops were doomed to failure, for no principality could be safe without having Forces of its own. According to Machiavelli, one of the first signs of weakness of the Roman Empire was the enlistment of the Goths in their phalanges.

The state of the art of military thought has accompanied scientific-technological progress over the past five centuries and has incorporated technological innovations and doctrinal advances that have completely transformed not only the face of the battlefield, but the very perception of the battlefield that has come to involve cities, critical infrastructures for the survival of a State, the electromagnetic spectrum, and the cyber and space fields. In this tuning fork, the

very will of a nation to defend itself, an essential aspect of Clausewitz's thinking, can be undermined without the use of conventional war weapons, but only by making use of cyber artifacts capable of promoting chaos in a country, through the denial of its capacity to generate and distribute electricity, gas and oil, in addition to the shutdown of Health Services, the financial sector, commercial transactions and of relevant defense systems.

Over the past five centuries, many seminal and visionary ideas of the Florentine thinker have been perfected, tested and become commonplace, as is the case with the adoption of national armies and the incorporation of conscripts. Despite this and the fact that there is no similarity between the current conjuncture and that experienced by Machiavelli, lessons drawn from history in this period suggest that the assertion remains current that a strong State must be able to carry out its defense by its own means. In fact, a State without Military Expression of strong and autonomous National Power is relegated to a marginal condition in international relations.

But how do we assess the capacity or strength of the Military Expression of National Power today? Certainly, in Machiavelli's time, military might depended essentially on numerous armies, well trained and aligned with the objectives of the principalities. However, in modern times, in spite of the importance of these elements, this power transcends aspects merely related to military personnel.

According to the National War College (2019, p. 109), the Military Expression of National Power is "the manifestation of a preponderantly military nature of National Power, which contributes to achieving and maintaining National Objectives" and whose most striking feature is the possibility or use of force in order to discourage possible threats (deterrence), neutralize or face them.

Certainly the Military Expression of National Power involves several elements, such as Military Doctrine and Strategy, Military Structure, Command and Control Capacity, Mobilization Capacity, Logistics Capacity, Education, Training and Readiness, Materials and Systems of Military Employment, Preparation and Employment, Human Resources and Scientific and Technological Capacity. However, the evolution of military conflicts shows a tendency of increasing importance of technological scientific capacity in the Military Expression of National Power, emblematic examples of this tendency can be extracted from the ongoing war between Russia and Ukraine.

Manifested not only by research and development activities of critical and sensitive technologies, but also by the technological and industrial readiness, particularly of the sector engaged in basic and applied research, research and development, production and modernization of military employment systems and materials, such as the enterprises that make up the country's Defense Industrial Base, the scientific, technological and national innovation capacity becomes a central element of the Ground Military Power. In short, the Sectoral System of Innovation (SSI) of defense becomes central to the development and support of military power.

The history of war conflicts, especially after the scientific revolution and the industrial revolution, suggests that States that rely on the scientific, technological and innovation capacity of third parties are doomed to failure, since they are unable to dissuade actions against their sovereignty and to promote their defense without weapons, defense systems and foreign

production capacity, thus being, in times of crisis, not only at the mercy of the existence of large financial resources, but above all geopolitical alignments that confer to them the condition of obtaining the supply of inputs in the quantity and quality necessary to sustain their Armed Forces in time of war.

In modern times, the State's ability to defend itself and to give vent to its political ambitions depends to a large extent on its strength in the scientific, technological and innovation fields, in short, on the efficiency of its Sectoral System of Defense Innovation. This system contributes to the development of a genuinely national doctrine and facilitates the preparation and employment of the Armed Forces, being an essential element for the success of the war effort.

2 Reflections of the SSI's ability in the Military Expression Of National Power

In the current stage of development of human society, and from the perspective of Machiavelli's thought, the ability of the State to defend its sovereignty, to achieve its national objectives and to give vent to its political and strategic ambitions with a reasonable degree of freedom of action depends, to a large extent, on the mastery of critical and sensitive technologies and the availability of a strong Defense Industrial Base capable of being mobilized to meet the needs of the country's Armed Forces.

Nowadays, vulnerabilities of the military expression of National Power have served as a stimulus to actions aimed at questioning, relativizing, or even vilifying the sovereignty of a nation, on the grounds of humanitarian and transnational problems such as environmental issues, transboundary crimes, climate issues and the lack of care for vital and scarce resources for an increasingly larger world population more demanding of vast quantities of resources. As foreseen by Machiavelli in the early sixteenth century, nowadays a strong State with military forces that appear to be incapable of defending its sovereignty and its interests in the concert of Nations is also not conceived.

The military expression of national power depends on inseparable factors such as doctrine, organizational structure, training, materials and systems of military employment, educational systems, personnel and infrastructure of the Armed Forces, as well as the ability to mobilize and other expressions of National Power (ESCOLA SUPERIOR DE GUERRA, 2019). Due to its transversality, the scientific-technological expression of National Power and, in particular, the National Defense Industrial Base (DIB), assumes a prominent role in the military expression of national power. It is up to this industrial sector the basic task of providing military employment systems and equipment in any situation, whether in peace or war. However, far beyond this, the DIB also contributes to the evolution of the doctrine of readiness and employment of the Armed Forces, since it develops specific systems, weapons and materials, according to operational and technical requirements established according to national physiographic conditions and military capabilities perceived as necessary for the Defense of the Nation.

Countries with small territorial dimensions and that have experienced a late industrialization process tend to find it difficult to develop an important industrial complex aimed at the military sector. The Defense market, marked by its protectionist characteristics, is domi-

nated by large *players* and is monopsonic, the State itself being the main buyer. In this area of the economy, supply to the domestic market is a prerequisite for enterprises to succeed in the foreign market. This is an important obstacle to the development of the sector in countries with modest and irregular demand. In addition, military employment products and systems employ high technology and, therefore, the military industry sector needs to be supported by advanced university and scientific-technological research and development centers. In this way, small countries that have a process of industrialization still in consolidation, usually resort to alliances with central countries to ensure their defense. However, even in countries with these characteristics, historical facts suggest caution in the face of the risk of conditioning the defense of sovereignty and vital interests to actions that depend on third parties.

Since its creation in 1948, Israel had good relations with France and found in that European country an important supplier of war supplies. From 1955, Israel began to receive fighter aircrafts from France, in addition to diversified equipment and modern armaments in large quantities. The alliance between these countries included a secret agreement aimed at the joint development of nuclear weapons and collaboration between national spy agencies. In April 1956, with the Suez Canal Crisis, relations between France and Israel were further strained and the supply of weapons from France to Israel was intensified.

In 1960, France undertook to supply Israel, over the course of ten years, with 200 AMX i3 tanks and 72 Mystère fighters. However, on June 2, 1967, three days before Israel launched a preemptive strike against Egypt and Syria, France ceased the supply of war material to Israel. Apparently, this decision was a reflection of changes in the geopolitical scenario that led to France's rapprochement with the Arab world, according to an article published at the time by a French newspaper: "The Gaullist France has no friends, only interests" (SENOR; SINGER, 2011). Let's face it, international relations are motivated by interests.

As a result of this strategic reorientation, the 200 AMX i3 tanks that would be supplied to Israel were sold to Libya and fifty fighters already paid for by Israel were sent to Syria, one of Israel's main enemies (SENOR; SINGER, 2011). The arms race in the Middle East was accelerating just as Israel was losing its main supplier of weapons. The French embargo of 1967 left Israel in an extremely vulnerable position at a critical time.

Faced with this emblematic episode, Israel made the strategic decision to no longer depend on another country to secure its own defense. It promoted accelerated and successful development in high-tech sectors, built an important global war industry and an exemplary model of technological transfer from the war sector to the conventional market (CUKIERMAN; ROUACH, 2019; SENOR; SINGER, 2011).

Strategic embargoes, like that suffered by Israel, and technological restrictions are generally practiced by the central countries, committed to maintaining the *status quo* and in defending their interests on the world geopolitical board (LONGO; MOREIRA, 2009). These actions represent clear indications not only of the importance of military power for the sovereignty of the State, but also of its Defense Industrial Base and scientific and technological deve-

lopment. It should be noted that these actions, which intensified after World War II, when the importance of Science, Technology and Innovation and industrial mobilization in war conflicts became evident (KENNEDY, 2014), they reached even higher heights with the end of the Cold War and the rise of non-State actors, transnational organized crime and terrorism, particularly with the attacks suffered by the USA on September 11, 2001.

Although legitimized by the pretext of having the purpose of containing new threats, technological curtailment initiatives greatly hinder the development of a vast list of important technologies for the generation of essential military capabilities autonomously, particularly in countries that have experienced a late industrialization process, even if there is no history of association with the threats that are intended to be inhibited by such curtailment policies.

2.1 Considerations on the Defense Market

The fall of the Berlin Wall in 1989, a milestone that started the easing of the bipolarization between the US and the USSR and the undeclared state of belligerence, impacted the reduction of defense budgets across the globe during the last decade of the twentieth century. As a result, there were bankruptcy and merger processes, but also portfolio diversification of the DIB companies, seeking to apply the technologies in the development of products for other markets as a way to overcome the reduction of the demands of the defense sector. Budgets would grow again after "September 11, 2001", with the attack on the Twin Towers, the outbreak of the war on terror and the growing commercial, technological and geopolitical rivalry between the US and China.

Since then, the global defense market has been growing, even in recent years, despite COVID-19 and the courtship of restrictive measures of movement and social distancing, remote work and stoppage of commercial activities, along with enormous operational challenges. Revenue is estimated to exceed US$550 billion in 2025, with a Compound Annual Growth Rate (*CAGR*) of approximately 5%.

These indicators suggest that the defense industry can represent a valuable component of the Economic Expression of National Power, however to infer about the characteristics of this market it is important to analyze the performance of companies operating in this sector. This analysis can also provide subsidies on trends or future-bearing facts, changes in the world geopolitical board, infer about the scientific and technological capacity in areas of military interest and point out the strength of the Military Expression of the National Power of the host countries of companies.

Several approaches could be adopted to evaluate the performance of companies in the defense sector, considering separately or jointly several indicators that allow to: perform quantitative or qualitative analysis of intangible intellectual property assets; understand the capacity of intellectual capital; measure the infrastructure of research and development (R&D) and fac-

tory park; and assess the product portfolio and contracts concluded between companies and the Armed Forces and public security agencies.

Having access to this list of variables would be unenforceable due to the notorious difficulty of accessing information covering industrial, business and even State secrets, in addition to being theoretically complex, due to the genuine difficulty of weighing so many indicators and thus defining an aggregate metric capable of faithfully reflecting reality. Faced with such a laborious and sophisticated problem, there is the possibility of analyzing and confronting the revenues of companies as an exceptional way to infer about the performance of those who work in the Defense Area. This simple approach makes it possible to carry out an exploratory study with some degree of assertiveness, insofar as it expresses, in a certain way, the innovation effort and competitiveness of companies and reflects public policies aimed at the sector.

In this matter, it is worth not only to consider the list of the 100 (one hundred) global companies in the defense sector with the highest turnover, elaborated annually since 2001 by the magazine Defense News, but also data provided by SIPRI (*Stockholm International Peace Research Institute*) about the 100 (one hundred) companies in the Defense market with the highest turnover.

According to these data, the total turnover of these companies reached the approximate amount of 200 billion US dollars in 2001 and exceeded the level of 500 billion in 2019, evidencing a significant increase, particularly if we consider the various economic crises that occurred in the period (DEFENSE..., 2020; FLEURANT et al., 2019; SIPRI, [2020?]). In this trajectory, there is a vertiginous growth in the revenues of these companies from 2015, adducing a vigorous recovery in investments in the defense sector after the retraction occurred with the fall of the Berlin Wall.

When analyzing in detail the information of SIPRI in the last two years, other important aspects are highlighted, such as the intense dynamics of change in the 100 (one hundred) companies with the highest turnover. These modifications go beyond significant classification variations, such as the one that occurred with EMBRAER, the only Brazilian company on the list, which moved from the 69th position in 2018 to the 84th position in 2019; they also cover significant changes in all companies. It is verified, for example, that 16 (sixteen) companies that are part of the 2018 list do not appear in the 2019 list.

This accentuated dynamic can highlight marked characteristics of the defense market, such as the inconstancy of acquisitions and the high amounts usually involved when contracts are concluded. In addition, it may reflect an unusual phenomenon: the inclusion of Chinese companies that until then were not considered because of the difficulty of access to information. The magazine, apparently, overcame this obstacle by associating with partners who succeeded in the endeavor.

It is observed that the 15 (fifteen) main countries on the list concentrate 91 companies and about 93% of the total turnover. The United States leads the ranking with 41 companies that together account for more than 50% of total revenues. In second place is China, with 8 (eight) companies, of which 6 (six) of them are among the 15 (fifteen) highest ranked, making up more than 20% of the total turnover of companies. Despite its powerful physiography, natural and mineral wealth and outstanding economy, Brazil does not integrate this relationship of countries that have an expressive Defense Industrial Base.

It should be noted that China's surprising performance does not necessarily mean a sudden advance of its defense sector, since, as previously reported, in previous years the data of this country were not considered in the magazine's rating. However, it undeniably signals a country with a strong Defense Industrial Base, certainly as a result of a major State policy, especially if we take into account the situation in which the People's Liberation Army of China stood until the end of the last century, considered by international observers and experts as a "scrap army" or "the largest military museum in the world" (CLIFF, 2020).

Considering the period from 2002 to 2018, SIPRI data demonstrate an interesting trend in the policies of companies operating in the Defense Market (FLEURANT et al., 2019; SIPRI, [2020?]): the importance of dealing with technological duality, in that they use their critical technologies to develop product portfolios not only for the defense market, but also for the conventional market.

According to SIPRI data (FLEURANT et al., 2019; SIPRI, [2020?]), in the aforementioned period, less than 10 companies, on the annual average, depended solely and exclusively on defense revenues, and these represented a small portion of the total revenues of companies operating in the defense sector. From 2006 to 2010 these companies earned, on average, around 2% of the total amount and after 2010 this share did not even reach 1% of the market, suggesting that this is a trend that is consolidating as a common practice of companies that work in the field of Defense

The sum of total revenues of the largest companies in the sector between 2002 and 2018, according to SIPRI data, reaches the figure of $20.2 trillion dollars, being $6.94 trillion, or 34.44%, arising exclusively from orders from the defense sector (FLEURANT et al., 2019; SIPRI, [2020?]). This evidence suggests that such companies are competitive in the conventional market and highlights the importance of exploring the duality of technologies and products. The ambivalence of the market allows that any reductions of exclusive acquisitions of the defense sector can be compensated by the common market, favoring sustainability, the maintenance of installed capacity and the stock of knowledge, essential to meet future demands. It is also observed that companies whose exclusive revenues from the defense market are greater than or equal to 70%, on average, contribute less than 20% of the total revenues of companies, while those with a percentage of less than 30% dominate more than 60% of this market. Therefore, taking as a reference the data released by SIPRI, the defense market is dominated by companies whose largest share of revenues comes from the conventional market.

Despite the fact that such figures show that the main companies in the defense market are competitive in the conventional market, the reverse path is not always successful, since the large players they seek to prevent neophytes from thriving and succeeding in the global defense market. In this sector, which involves the sovereignty of countries, economic forums and multilateral organizations exert little or no interference on the commercial practices adopted by companies and host countries.

2.2 Development of DIB in countries of late industrialization process

The data presented here indicate that, although initially focused on the domestic and monopsonic market, throughout the process of forming the current geopolitical map, the Defense Industrial Bases, developed a peculiar business model to meet not only the strategic and operational demands, but also the needs of the conventional market.

This may represent an auspicious strategy to be exploited by countries that cannot maintain a constant demand for defense systems and products and whose DIB companies have difficulties establishing themselves in the global defense market. A critical success factor of this strategy lies precisely in the perception that the defense and conventional markets have complementary characteristics and that many of the main technologies essential for the development of modern military capabilities are also of great commercial interest, particularly those that fall at the heart of the 4th Industrial Revolution (BRANCO et al., 2014; CASTRO, A., 2014; CASTRO, M. et al., 2014; GALDINO, 2019; SCHWAB, 2015; SILVA et al., 2014).

The strategic importance of the defense sector and the reflections of technological advances in military capabilities lead to the allocation of large resources for research activities, research and development and procurement of equipment, systems and armaments. Even if they are not constant and stable, even in the main countries of the defense sector (DALL'AGNOL, 2020), these resources create excellent business opportunities with the business environment. By verifying that the leading companies in the defense market are able to act strongly in the conventional market, which generates constant demands, but of smaller numbers, through the exploitation of technological duality, one can glimpse a strategy of insertion in the defense segment of companies capable of thriving without relying exclusively on state orders. This can contribute to the entry of new *players* in the DIB, to increase the competitiveness and, above all, the sustainability of the sector. Additionally, the dynamism required to meet the conventional market and the overcoming of the technological challenges imposed by the R&D orders from the defense sector contribute to the constant improvement of the technological capacity of companies. Finally, this finding relieves the pressure that falls on the State, showing that it is possible to develop the DIB without it having to be the exclusive buyer or even the main customer, responsible for the sustainability of national companies.

Although large budgets and government purchases are important drivers of the development and procurement of Military Employment Material Systems, the ongoing technological changes and empirical evidence point to emerging market niches and opportunities for new defense equipment suppliers, especially for technology-based companies that are independent of the supply of goods and services to the State (GALDINO, 2019).

The development of the ambivalence of companies bequeaths robustness, versatility and readiness to meet the high-tech demands of the Defense sector and the market in general. By adapting their business model to the dual political, economic and technological context, suppliers promote sustainability and business resilience in the face of commercial, budgetary or seasonal acquisitions common to Defense scenarios.

This paradigm creates insertion opportunities for technology-based companies operating in other market niches, generating value in the global chain of the defense industry and

favoring companies of the war industry, whose products or technologies meet the demands of the market in general.

The growing importance of new technologies of a dual nature in obtaining sophisticated military capabilities tends to increasingly intensify the participation of technology-based companies in the common market and in the Defense area, while strengthening the DIB and the conventional market and, consequently, the State, by reducing their technological dependence on areas of interest of National Defense (MESA, 2020).

Another fundamental aspect for the development of DIB in countries with late industrialization process is to seek to optimize the processes of obtaining military employment systems and materials, reconciling short, medium and long-term actions, prioritizing, when possible, the attainments by research and development process at the national level, to the detriment of imports.

The countries that develop their systems, equipment and weapons, or that adequately induce the technological development of the internal state of the art, make extensive use of national technical capabilities and establish a long-term vision in favor of strengthening the Military Expression of National Power. Investments in defense cooperate for technological overflow, that is, technical solutions originally conceived for a certain purpose achieve more comprehensive results, generating, among other assets, scientific knowledge, patents, trained professionals and new companies, which will serve as inputs for a new virtuous cycle. Thus, a synergistic procedure is generated, resulting in the strengthening of Military and Scientific-Technological Expressions of National Power. Israel is one of the most successful countries in this endeavor.

Countries that do not have an efficient State strategy to boost science, technology and innovation, especially in matters of military interest, conduct procurement processes prioritizing acquisition in the foreign market, to the detriment of their own development. Among the reasons for abdicating the internal technological development or restricting it, we can mention the urgency of time to preserve the operational capacity, since national R&D activities can cause budgetary, administrative and manufacturing delays that result in the unavailability of the product or its availability at a late time, after the needs of The Force.

In short, impact technology ventures should reconcile pressing operational needs with the strengthening of the national DIB, seeking to achieve a good compromise between international procurement and domestic RD&I, particularly with a view to increasing national content in critical areas without lengthening procurement schedules of products, systems and central weapons to maintain the operational capability of the Armed Forces. Studies show that an appropriate approach in this attempt consists in gathering information on the levels of technological maturity of possible national technology suppliers and taking this information in into account on the decision-making processes of the bodies in charge of acquisitions (FRANÇA JUNIOR; GALDINO, 2019, 2022).

The predominance of acquisitions in the international market should be avoided, as it contributes to the increase in the trade balance deficit and can cause invaluable losses in times of crisis, since the items purchased, or in use, do not always have parity with the version used in the country where the products are manufactured. This threat can be even more serious if the operation of imported products, systems or weapons is purposefully vulnerable to interference and the actions of adverse forces, or when such inputs, for geopolitical or commercial reasons, are denied at times of greatest need, which may, thus causing irreparable damage to the country and the achievement of its permanent national objectives (ESCOLA SUPERIOR DE GUERRA, 2019).

In spite of different dynamics of innovation of the countries and their different degrees of efficiency in the application of resources, the prominent States in technology show similarities, such as State policies that favor the continuity of budgets destined to the defense portfolio over years. As a result of these large investments, the stimulation of competitiveness and innovation, companies have been created in these countries whose productive capacities support national sovereignty and contribute to generating foreign exchange, as suggested by the significant resources earned by prominent companies in the Defense sector.

Essential to induce innovative projects, especially those directly related to National Defense, the mechanisms adopted by the State to benefit the DIB have few studies that characterize the multiple factors involved in their genesis or development. However, it is known that protagonists in this sector, such as the USA, England and Russia, supported their achievements in the main wars of the twentieth century in a powerful Defense industry and continued investments in education, science and technology, proving the importance of this triad for their peoples in the solution of conflicts.

It should also be noted that, in order to achieve the internal development of critical technologies of Defense interest, greater integration between government, Academia and the productive sector should be promoted, the stock of national knowledge should be expanded, the capacity to carry out R&D and the culture of innovation should be improved (AZEVEDO, 2018; BARBOSA; CALDEIRA, 2021). Without this, it is unlikely that a country will reduce its dependence on external suppliers. The sectoral Defense Innovation System interacts with and viscerally depends on the National Innovation System (SCHONS; PRADO FILHO; GALDINO, 2020).

3 Final Considerations

Statesmen, strategists and policy makers praise the value of freedom, democracy and sovereignty, recognizing that the preservation of this achievement depends on eternal vigilance and a National Defense capable of repelling current and future threats. The permanent state of alert is the price to pay for something so crucial. As Rui Barbosa summarizes: "An army can go 100 years without being employed, but it cannot go a minute without being prepared". This thinking underpins the feeling of self-preservation and national cohesion that should guide investments in defense. Although various sectors of National Power can be mobilized to act for the benefit of a country's sovereignty, it is the State's duty to orchestrate, obtain and integrate

the systems and materials of military employment in order to strengthen the military capabilities of its Armed Forces. Essential to the survival of States and dependent on technological innovations of high added value, the Defense Sector Drives scientific and technological development, mobilizing a billionaire market of companies that integrate the Defense Industrial Base, while fundamentally dependent on the very capacity of the scientific-technological expression of National Power and, in particular, the National Innovation System.

Machiavelli's teachings remain valid that a strong State must possess military forces capable of promoting its defense using its own means. As time passed, his conviction that a modern Republic could not be founded and maintained by relying solely on mercenaries and warlords (*condottieri*) and that only a conscript army, well trained and committed to the principality's objectives, could securing the independence of the Italian city-states proved farsighted.

In present times this condition refers, more than ever, to the need to develop National Science, Technology, Innovation and DIB as essential factors to raise the Military Expression of National Power to a prominent level in the concert of Nations. As discussed in this essay, the Scientific-Technological Expression influences the various constitutive elements of military capacity, such as doctrine, education, training, preparation and employment of Military Power, transcending more visible aspects of the domain of critical technologies and the supply of armaments, materials and military employment systems.

Machiavelli's teachings also serve as a warning regarding the vulnerabilities that may arise from the employment of private military companies in the modern world and the discussions or political positions that subsidize the reduction of budgets of the Armed Forces, imposing a reduction of their structures and personnel. Foreigners who exploit war as an instrument of trade may, for purely financial reasons or to serve the geopolitical and ideological interests of host countries, miss long-standing commitments made, and this usually tends to occur in times of greatest need and national crisis.

In this work, were also discussed characteristics of the defense market and, in particular, the difficulties imposed by technological curtailment and those naturally faced by countries that experienced late industrialization processes, especially in the sense of accumulating stock of knowledge and reaching the technological frontier in sophisticated areas, such as those that include the defense systems and products adopted by the Armed Forces. Ambivalence and acquisition processes were also discussed as mechanisms to be explored aiming at the progress of the National Defense Industrial Base.

In fact, it is necessary to adequately explore the technological duality in the DIB consolidation process of developing countries, which have modest budget resources to invest in the sector and which have experienced a late industrialization process. This strategy can both facilitate the search for resources in various ministries and funding bodies, and can represent a solution for the sustainability of companies operating in the military sector.

The defense of the Fatherland and National Sovereignty is indelible. No one will do our homework for us.

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