

Mapping the Defense Industrial Base: a comparative content analysis of the RARBID model

Mapeamento da Base Industrial de Defesa: análise de conteúdo comparada do modelo RARBID

Abstract: Prioritizing investments in science, technology, and innovation applied to defense products for military and/or dual use is essential to strengthening the Brazilian Defense Industry (BID) and the country's technological autonomy. Since 2021, the Annual Defense Industry Results Report (RARBID) has monitored the BID. This study reviewed other defense sector mapping models focusing on the objectives of the National Defense Industrial Base Policy (PNBID), to suggest improvements to the RARBID. It was found that the RARBID, although well-structured, presents gaps and areas for improvement that can be addressed by incorporating elements of the PNBID and international mapping models, especially regarding the assessment of the involvement between the Ministry of Defense and the BID, the analysis of the interaction between BID companies and the Armed Forces, and the mapping of access to financial resources, the labor market, research, and development.

Keywords: Defense Industrial Base; Sectoral Innovation and Production System; Mapping; RARBID; National Defense Industrial Base Policy.

Resumo: A priorização de investimentos em ciência, tecnologia e inovação aplicados a produtos de defesa de uso militar e/ou dual são essenciais ao fortalecimento da BID e à autonomia tecnológica do país. Desde 2021, o Relatório Anual de Resultados da Indústria de Defesa (RARBID) monitora a BID. Este estudo revisou outros modelos de mapeamento do setor de defesa à luz dos objetivos da Política Nacional da Base Industrial de Defesa (PNBID), para sugerir melhorias ao RARBID. Constatou-se que o RARBID, embora bem estruturado, apresenta lacunas e margens de aprimoramento que podem ser sanadas pela incorporação de elementos da PNBID e de modelos internacionais de mapeamento, especialmente em relação à avaliação do envolvimento entre o Ministério da Defesa e a BID, à análise da interação entre as empresas da BID e as Forças Armadas e ao mapeamento de acesso a recursos financeiros, mercado de trabalho, pesquisa e desenvolvimento.

Palavras-chave: Base Industrial de Defesa; mapeamento; RARBID; Política Nacional da Base Industrial de Defesa.

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1 INTRODUCTION

The defense industry is one of the most strategic industrial sectors for any state. Fostering the Defense Industrial Base (DIB) not only ensures national sovereignty but also promotes economic growth by generating direct and indirect jobs and developing dual-use products that benefit the civilian sector as well. The National Defense Policy states that the DIB is crucial in encouraging the prioritization of “investments in health, education, science, technology, and innovation applied to defense products for military and/or dual use, with the aim of strengthening the DIB and the country’s technological autonomy” (Brasil, 2020; our translation).

Monitoring the development of the defense sector is an essential activity of the Ministry of Defense (MD). The current stage of technological development in this sector in developed countries tends to widen the gap with Brazil’s defense industry, especially in relation to production in the United States, China, Russia, the United Kingdom, and France. Thus, it is necessary to identify what should be measured so that public policies for the sector can better track the evolution of the national DIB and propose actions capable of reversing this trend, which hinders Brazilian sovereignty (Couinho, 2018; Dalbosco; Cortinhas, 2024; Moreira, 2011).

As a joint initiative between the MD and the Ministry of the Economy (ME), and in alignment with the National Defense Policy, the Interministerial Ordinance MD/ME No. 4,866 of November 30, 2021, proposed a monitoring model for the country’s defense industry via the Annual Defense Industry Results Report (*Relatório Annual dos Resultados da Base Industrial de Defesa – RARBID*). Issued annually, this report aims to support the implementation of policies directed at mapping the DIB¹ (Defesa [...], 2023).

Thus, the general objective of this article is to assess the RARBID in light of the requirements established in Brazil’s major political and strategic documents. Comparing it with other experiences and DIB mapping models aids in identifying potential improvements in performance indicators and data collection methods to strengthen the independence of Brazil’s DIB without hindering the capacity to keep pace with the high-tech systems of developed countries.

The RARBID was proposed in 2021 as a federal, interministerial public policy. Thus, any improvement in its data collection process directly benefits the Brazilian Ministries of Defense and Economy by enabling timely and accurate assessments of the sector’s development needs.

At the academic level, this study also contributes to understanding national and international realities in the field of National Defense, particularly concerning security and development. Studies on the DIB fall within this scope, as its mapping is directly linked to improving the country’s defense industrial capacity.

To analyze DIB mapping through the RARBID, the authors consulted various documents and compared their content with the RARBID’s topics and questions. Notably, data on the Brazilian defense market were drawn from The Military Balance and other reports

1 No sanctions have yet been established for companies that fail to complete the RARBID annually, although doing so is mandatory for those seeking to obtain the designation and privileges of Defense Companies or Strategic Defense Companies, as well as to register their products as Defense Products or Strategic Defense Products.

from the Stockholm International Peace Research Institute (SIPRI, [202-]; SIPRI Arms [...], [202-]; SIPRI Military [...], [202-]; The SIPRI [...], 2023), as well as reports and studies from the Institute for Applied Economic Research (IPEA) (Andrade; Franco, 2016; Leske, A. C., 2016; Negrete, 2016; Squeff, 2016), bulletins from the Brazilian Association of Defense and Security Materials Industries (Abimde, 2015, 2024; Defesa [...], 2021a), the national defense industry's legal and regulatory framework (Bem vindo [...], [202-]; Brasil, 2008, 2018, 2020, 2021, 2022; Defesa [...], 2021b; Produtos [...], [202-]), and the broader academic literature. The content analysis of the theoretical framework followed the principles of scientific methodology (Elo; Kyngäs, 2008; Guest; MacQueen; Namey, 2012; Mayring, 2014, 2022; Nassehi; Esmaeili; Varaei, 2016).

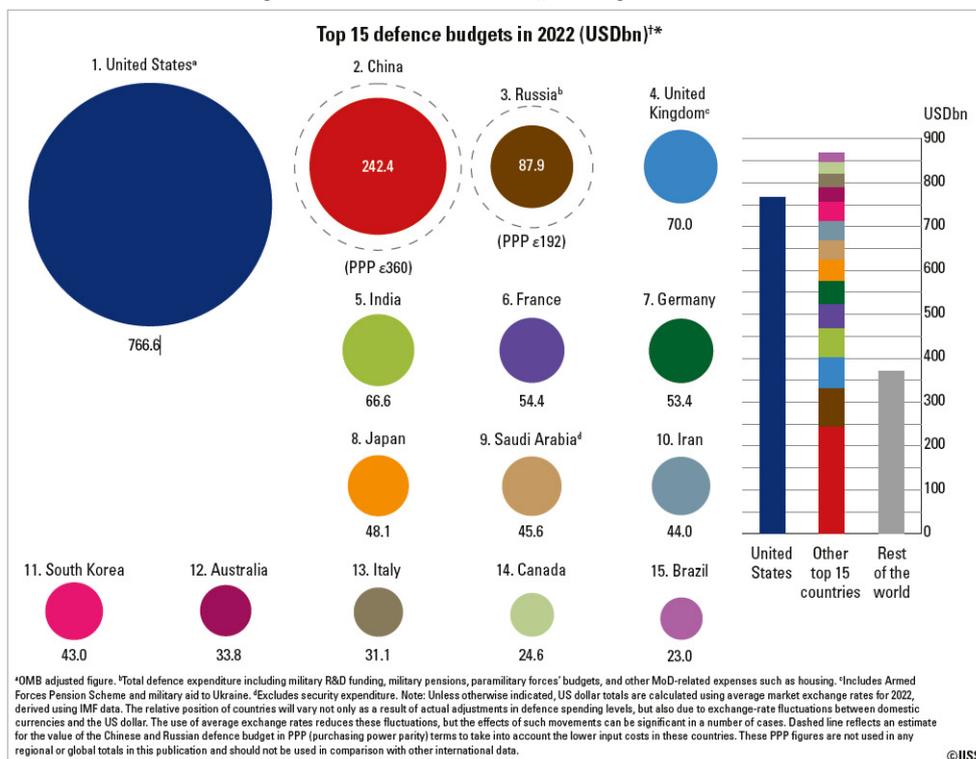
2 CURRENT LIMITS OF BRAZIL'S DEFENSE INDUSTRIAL POLICY

The Brazilian National Defense Industrial Base Policy (*Política Nacional da Base Industrial de Defesa – PNBID*) was recently published through Decree No. 11,169 of August 10, 2022, with the goal of ensuring the competitiveness and autonomy of the Defense Industrial Base (DIB) in strategic technologies essential to national defense. The PNBID established six objectives, summarized as follows: i) to stimulate knowledge production and the generation of intellectual property by institutions engaged in research, development, and innovation in defense-related goods and services; ii) to promote the integration of science, technology, and innovation activities as drivers of the DIB's productive development; iii) to encourage ongoing training of human resources for the DIB; iv) to reduce external dependence on defense goods and services; v) to improve the technological quality of defense goods and services produced and developed in the country; and vi) to increase the DIB's competitiveness to expand exports of domestically developed and produced defense goods and services (Brasil, 2022).

However, initiatives focused on nationalizing the defense industry are not new. The National Defense Policy (PDN), approved by Decree No. 5,484 of June 30, 2005, already mentioned the “defense industry” in three passages, highlighting the importance of its development to “reduce technological dependence and overcome unilateral restrictions on access to sensitive technologies,” including “mastering dual-use technologies [...] to achieve a secure and predictable supply of defense materials and services” (Brasil, 2005; our translation). The National Defense Strategy (END), approved by Decree No. 6,703 of December 18, 2008, also set forth the objective of strengthening the sector, prioritizing human resource training and mastery of national technology (Brasil, 2008). In 2011, Provisional Measure No. 544, later converted into Law No. 12,598 of March 22, 2012, sought to stimulate the defense industry by establishing special rules for procurement, contracting, and the development of defense products and systems, as well as by introducing tax incentives through the Special Tax Regime for the Defense Industry (RETID) (Brasil, 2012). Nevertheless, Brazil's DIB still falls short of meeting the innovation and production requirements needed to ensure sustainable autonomy and to modernize the country's arsenal in line with the world's most advanced defense products.

In the Brazilian context, the defense industry faces a range of challenges. In absolute terms, the country ranks 15th worldwide and 1st in Latin America in defense spending, according to the latest edition of *The Military Balance (2024)* (Figures 1 and 2). However, the DIB remains dependent on systems and components involving advanced embedded technology. This dependence arises from the complexity and high cost of producing and maintaining such equipment. Import reliance is also tied to the need to modernize the Armed Forces to keep pace with the technological standards of developed nations, as local production at the current stage of DIB development would require substantial time for research, development, and manufacturing, in addition to resources exceeding the historical level of the defense budget (Andrade; Franco, 2016).

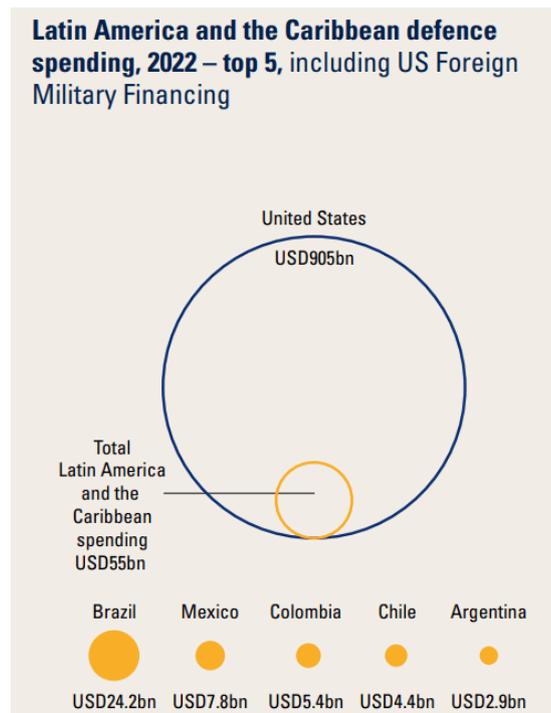
Figure 1 – Brazil’s defense spending worldwide



Legends: ^aOMB adjusted figure. ^bTotal defense expenditure including military R&D funding, military pensions, paramilitary forces' budgets, and other MOD-related expenses such as housing. ^cIncludes Armed Forces Pension Scheme and military aid to Ukraine. ^dExcludes security expenditure. Note: Unless otherwise indicated, US dollar totals are calculated using average market exchange rates for 2022, derived using IMF data. The relative position of countries will vary not only as a result of actual adjustments in defence spending levels, but also due to exchange-rate fluctuations between domestic currencies and the US dollar. The use of average exchange rates reduces these fluctuations, but the effects of such movements can be significant in a number of cases. Dashed line reflects an estimate for the value of the Chinese and Russian defence budget in PPP (purchasing power parity) terms to take into account the lower input costs in these countries. These PPP figures are not used in any regional or global totals in this publication and should not be used in comparison with other international data.

Source: The Military Balance ([202-]).

Figure 2 – Brazil’s defense spending in Latin America



Source: The Military Balance ([202-]).

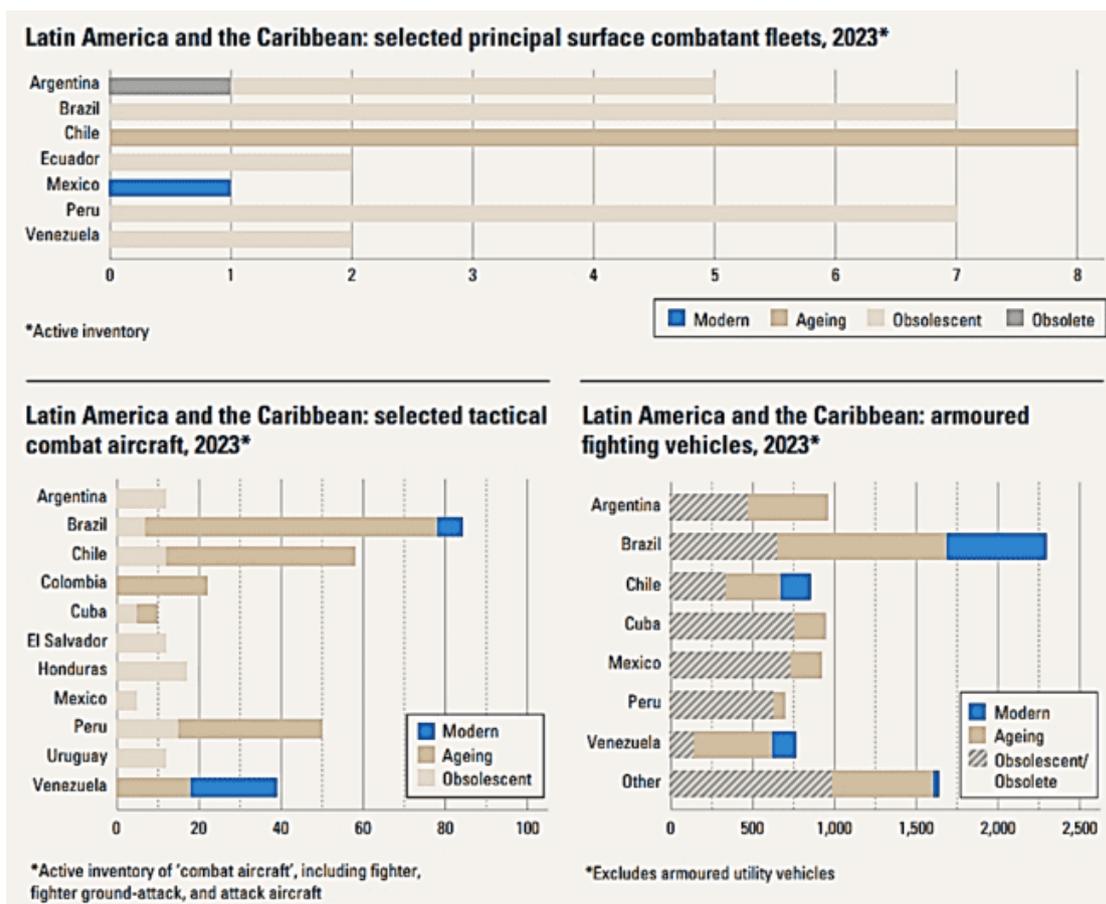
Although Brazil’s military spending is significant within South America, in absolute terms the country’s defense sector still depends on foreign technology to develop many high value-added components. The KC-390 aircraft, a national project by Embraer, illustrates this point: its integrated propulsion system is manufactured by International Aero Engines, a joint venture that brings together major aircraft engine manufacturers, including Pratt & Whitney, Pratt & Whitney Aero Engines International (a wholly owned subsidiary of Pratt & Whitney), Japan’s Aero Engine Corporation, and MTU Aero Engines. The Brazilian company has a portfolio of 190 clients in 80 countries and exports the same V2500 engine used in the KC-390 for the current Airbus A320 family (Company, [20--]). In the case of Gabbiano T20 tactical radars, supply was provided by the Italian company Selex ES, part of the Finmeccanica group (Finmeccanica, 2015).

This context highlights Brazil’s growing dependence on high technology components as the country moves further away from the capacity to generate patents in this field. Evidence in the literature shows that such concerns within the military sector—particularly the Brazilian Navy—date back to the late 1960s, as expressed in the 1967 Master Plan (Pivatto Junior, 2024), and became more pronounced in the 1980s. The Navy’s Technical Directorates, Arsenal, domestic shipyards, national and foreign suppliers of systems, equipment, and materials, as well as universities, were involved in the effort (Freitas, 2007). This plan highlighted an autonomist and industrializing mindset that became firmly established during the 1970s, coinciding with the political distancing between Brazil and the United States and breaking a cycle of close relations that had intensified in the 1940s. According to Freitas (2007; our translation), “to nationalize

is to establish or develop within the country the knowledge and means for design, innovation, production, support, and operation. It is the necessary path to greatness.” This strategy of pursuing a more autonomous international position—supported by the restructuring and expansion of Brazil’s military industry as a whole and the development of specific technologies in the naval sector—was also shared by leading naval authors of the period, regarded as “the main figures of this new school of thought”: Armando Amorim Ferreira Vidigal and Mario Cesar Flores (Pivatto Junior, 2024).

Another concerning issue, beyond the nationalization of high-technology components, relates to the obsolescence of the defense arsenal. The Military Balance ([202-]) illustrated this issue in Figure 3, which compares the size and level of development of naval, armored, and aircraft assets among Latin American countries. Although it represents only three systems among the many that equip the Armed Forces, this comparison aids contextualize the current state of Brazil’s DIB.

Figure 3 – Comparison of defense arsenals in Latin America



Source: The Military Balance ([202-]).

From a positive perspective, it is worth noting that the development of the Tamandaré-class frigates anticipates that the first vessel is to contain over 30% local content, increasing to more

than 40% for future ships. The USD 2 billion contract for four vessels was awarded in 2020 to the Águas Azuis Consortium, a joint venture between Germany's Thyssenkrupp Marine Systems, Embraer, and Brazil's Atech. The vessels will be based on TKMS's MEKO A100 design and adapted to Brazilian requirements, being built entirely in Brazil.

The Military Balance also highlights Brazil's cooperation ties with France, Sweden, and the United States, emphasizing that the country has a well-developed DIB capable of designing and manufacturing land, naval, and air systems. Brazilian aerospace companies such as Avibras and Embraer are also exporters, and local companies are involved in the Integrated Border Monitoring System (SISFRON) (The military [...], [202-]).

For public policies to be effective, policymakers must conduct monitoring, evaluation, and control activities via continuous examination of processes and impacts, measuring variables to track outcomes (Brasil, 2018). Effective public policies require detailed diagnosis so that resulting strategic actions can achieve the desired effects (Freitas, 2016, Vergel-Tovar *et al.*, 2022). The need to "measure to manage" was adapted to public administration through quality management practices, which are also applicable to public policy (Helmold, 2021; Sioutou *et al.*, 2022). The same applies to the defense sector, in which mapping the companies that comprise the DIB is essential (Kent, 2022, Settanni *et al.*, 2017).

3 CONTEXT OF THE MAPPING OF THE BRAZILIAN DIB

In addition to the RARBID, other earlier initiatives deserve attention. In 2016, within the scope of strengthening the national defense industry, the Brazilian Agency for Industrial Development (ABDI), in partnership with the Institute for Applied Economic Research (IPEA) and with support from the Ministry of Defense (MD), carried out an extensive and detailed mapping of the DIB (Negrete, 2016). This initiative aimed to contribute to academic studies on the sector, as well as to the data provided by representative entities and associations, such as the Brazilian Association of Defense and Security Material Industries (*Associação Brasileira das Indústrias de Material de Defesa e Segurança* – ABIMDE) and the Brazilian Aerospace Industries Association (AIAB). It consolidated information about the defense production chain, including smaller companies that receive less visibility than those linked to trade associations.

IPEA's final report is a comprehensive work exceeding 700 pages and provides a detailed study of the Brazilian DIB up to 2015. Nationally, the systems segment recorded a 21% increase in the number of companies (from 82 to 100) and a 78% increase in the number of employees from 2005 to 2011 (from 9,108 to 16,229). Most companies were located in the Southeast (73%), followed by the South (16%), with the remaining regions together accounting for 11%. This concentration reflects the greater availability of skilled labor, suppliers, and logistical infrastructure in those two regions. Moreover, 73% of the companies depended on their defense contracts to maintain their workforce (Negrete, 2016).

ABIMDE also conducts DIB mapping activities in Brazil, with more than 200 member companies. In 2014, Brazil's Defense and Security Complex generated BRL 202 billion, equivalent to 3.7% of the previous year's Gross Domestic Product (GDP),

according to the 2015 report prepared by the Economic Research Institute Foundation (FIPE) (ABIMDE, 2015).

In 2021, the Brazilian National Bank for Economic and Social Development (BNDES) estimated that the sector employed more than 1 million workers and comprised over 1,100 companies, most of which were micro, small, and medium-sized enterprises. These companies accounted for approximately 285,000 direct and 850,000 indirect jobs—offering wages higher than the average in the manufacturing industry—and generated around BRL 200 billion in the national economy, representing about 4% of GDP. According to BNDES, the DIB had exported an average of USD 1 billion per year, with studies indicating an export potential of up to USD 5 billion per year (BNDES [...], 2021).

Also in 2021, DIB exports reached a record high of USD 1.5 billion, although the high exchange rate—an average of BRL 5.50 per USD—may have been a decisive factor in this significant increase, as there was no record of a considerable rise in sales volume or new contracts (Defesa [...], 2021b).

In 2023, the Brazilian National Confederation of Industry (CNI) published a significant research report on the challenges faced by Brazil's defense and security industry (CNI, 2023). Among its key findings were the challenges related to technological dependence on foreign countries, which must be overcome for Brazil to master the full production cycle and reduce permanent dependence on external expertise. The report also highlighted the difficulties in research and development investment, focusing on innovation and cutting-edge defense technologies, along with budgetary constraints that limit the industry's capacity to modernize and expand its potential. Dependence on imported components and technologies poses additional challenges in terms of supply chain vulnerabilities and potential disruptions.

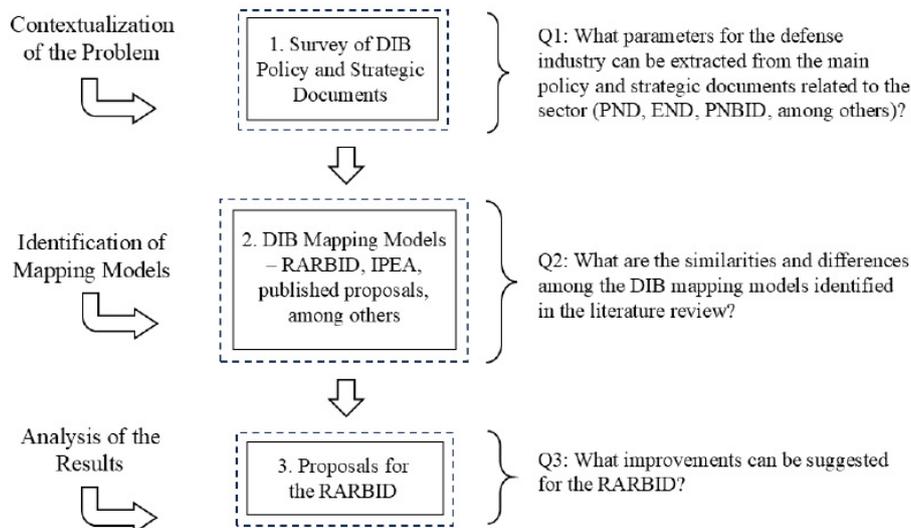
State industry federations also engage in mapping the defense sector. The Federation of Industries of the State of Rio de Janeiro (FIRJAN), for example, conducts this work, which, according to the Ministry of Defense data, is the second state with the largest number of Strategic Defense Companies (SDCs) and Defense Companies (DCs) in the country. On the Brazilian government's open data portal, the Ministry of Defense provides information on the number of SDCs, DCs, Strategic Defense Products, and Defense Products registered by state and by company. São Paulo leads with 66 companies holding these designations, followed by Rio de Janeiro with 23, Santa Catarina with 15, and Rio Grande do Sul with 13 (Produtos [...], [202-]).

4 METHODOLOGY

Figure 4 summarizes the methodology adopted to achieve the objectives of this research. The contextualization of the issue involves Stage 1, which analyzes the current situation of the DIB, highlighting the challenges of nationalizing high-technology systems while maintaining the capacity to match the technological level of systems equipping the arsenals of developed countries. In this stage, the necessary documents are collected to identify

parameters described explicitly or implicitly in the country's political-strategic guidelines and related documents. This stage corresponds to Research Question 1.

Figure 4 – Proposed methodological framework



Source: Elaborated by the authors.

Stage 2 identifies existing DIB mapping models and their similarities and differences, as addressed in Research Question 2. Finally, the results were analyzed in terms of content to suggest potential improvements to the RARBID, corresponding to Research Question 3.

Qualitative Content Analysis (QCA), or Thematic Analysis, is one of the most commonly used methods for analyzing qualitative data (Guest; MacQueen; Namey, 2012; Kuckartz, 2019; Mayring, 2014; Schreier, 2024). QCA can be applied to qualitative or quantitative data, either inductively or deductively. When prior knowledge about a phenomenon is insufficient or fragmented, the inductive approach is recommended. Deductive content analysis is used when the analytical structure is operationalized based on prior knowledge and the aim of the study is to test a theory (Elo; Kyngäs, 2008). A deductive approach is grounded in an existing theory or model and thus moves from the general to the specific (Nassehi; Esmaili; Varaei, 2017). This deductive approach is suitable for the RARBID model, as it involves content analysis based on the previous version of the model and other existing ones, with the goal of generating an improved version.

5 RESULTS

The results show that although the RARBID² is well structured, it can still be improved in light of the objectives of the PNBID and other defense industry mapping models. A comparative

² RARBID was described in Article 3 of the Interministerial Ordinance of its creation as the “guiding object of DCs and SDCs assessments” to “serve as a basis for the issuance of opinions on products by the Armed Forces” (Brasil, 2021, our translation).

table of the RARBID topics against other models is available as supplementary material to this article, with open access (Gavião, 2024). The findings of this study are presented according to the RARBID questionnaire's sections: technology and production, trade, labor market, research and development, and other aspects.

This comparative framework guided the analysis of new items for inclusion in the RARBID, identifying advances and gaps that could be addressed in future updates of the questionnaire. Moreover, the analysis of the current RARBID model can generate information and inputs suitable for meeting the objectives established in the PNBID. By comparing different questionnaire models designed for mapping defense industries and other relevant industrial sectors, this study aims to enrich and enhance one of the fundamental instruments for the development of the defense sector in Brazil.

It is important to note that the RARBID itself, established at the end of 2021, may be considered a direct fulfillment of the objectives stated in Article 8 of the PNBID, which addresses the coordinated involvement between the Ministry of Defense (MD) and the Defense Industrial Base (DIB) in assessing the sector's needs, with the aim of developing new defense technologies and products. This foundational goal of coordinated involvement between the MD and the DIB, as set forth in the PNBID, is also consistent with Malerba's (2002) concept of the Sectoral System of Innovation. National companies and institutions, such as ministries, are crucial agents within a sectoral system, and their coordinated interactions are a key factor in the sector's dynamics and development—from policymaking, regulation, and financing incentives to infrastructure investments and international agreements for the transfer of strategic technologies.

The annual questionnaire, institutionalized by the MD itself and aimed at the continuous mapping of one of the most strategic industrial sectors for national defense, serves as an important tool for building trust between the industry and the federal government, represented by the ministry. Considering that the sector is governed by confidentiality and industrial secrecy contracts involving sensitive information—including those relevant to national sovereignty—the RARBID represents a commendable initiative to foster closer ties and strengthen trust between the public and private sectors.

Nonetheless, this study identified a significant gap not addressed by the RARBID: the questionnaire does not seek to investigate or understand the level of involvement between DIB companies and the MD itself. That is, even though the RARBID serves as an instrument of interaction between these actors, it remains a relatively recent initiative. Therefore, measuring the degree of proximity perceived by industry stakeholders in their relationship with the MD could provide valuable insights into whether, beyond the annual questionnaire, mechanisms of engagement, dialogue, and coordination between the DIB and the MD are effectively in place and perceived as such by business leaders. Identifying whether companies have, are aware of, or regularly interact with ministry focal points assigned to their sector could be an additional feature to include in the RARBID questionnaire, especially to guide initiatives that foster closer relationships and build trust with DIB companies.

The degree of interaction and coordinated involvement between the MD and DIB was absent from the joint ABDI/IPEA mapping questionnaire—the largest and most recent

of its kind published to date. That questionnaire did not assess DIB companies' perceptions of contact, proximity, or levels of trust in their relationships with the ministry responsible for the sector. However, IPEA's mapping stood out among the models analyzed here for exploring the DIB's challenges in establishing interaction and cooperation with Science and Technology Institutes (STI), higher education institutions (HEI), and even with other defense companies.

By contrast, the evaluation of coordinated involvement between the MD and the DIB was addressed in other industrial mapping models reviewed in this study, such as those by Soare and Pothier (2021) and Cheung (2021). Soare and Pothier (2021) view the expansion of political-level engagement with the private defense sector and organizational development as key governance factors for promoting defense innovation in countries such as the United States, the United Kingdom, France, and China. Cheung (2021), in turn, classifies this engagement as one of the so-called "catalyst factors," described as "sparks that ignite" the sectoral ecosystem—occurring at the highest and most influential levels of the defense industry—without which the system would be severely compromised in its capacity to generate innovations in defense goods or services, as envisaged in the PNBID. In this context, leadership support from the MD plays a crucial role in its relationship with industry, whether through visits, inspections, or the allocation of resources.

Another important topic established by the PNBID—the coordinated involvement between the Armed Forces and the DIB for identifying defense sector needs and developing technologies—is also not thoroughly addressed by either the RARBID or the IPEA model. Both only partially map whether DIB companies hold contracts with the Armed Forces and what percentage of their revenue derives from them. This represents an area of high potential for further investigation, particularly concerning defense product testing. In addition to identifying interactions between companies and the Armed Forces, it is necessary to assess the extent of such collaboration, as Soare and Pothier (2021) described in their concept of "lab-to-battlefield innovation implementation plans/pathways." This factor was identified by the authors as one of the key drivers of defense sector development in the United States and France.

From this point, the study followed the thematic group structure used by the RARBID to proceed with the comparative analysis of mapping models, as previously noted.

5.1 Technology and production

The PNBID stipulates that, within the theme of technology and production, the main objectives of the national DIB are to "reduce external dependence on defense goods and services, including those whose intellectual property remains of foreign origin, even if they are produced domestically," and to "improve the technological quality of defense goods and services produced and developed in the country." This area also includes the generation of intellectual property for defense goods and services (Brasil, 2022; our translation).

The RARBID is successful in satisfactorily mapping the indicators that will guide the fulfillment of the PNBID's objectives related to technology and production. It measures the Technology Readiness Level (TRL) of Defense Products and Strategic Defense Products developed by companies, classified into basic, intermediate, or advanced technological maturity levels, as previously discussed. Moreover, it monitors the technological cycle of products according to radical, conceptual, and incremental degrees of innovation (TRL 1 to 3) and innovative, contemporary, and ostensive technological cycles (TRL 4 to 9). Still within TRL 4 to 9, the RARBID annually monitors both the productive and logistical availability of products, based on scenarios of dependence, restriction, or productive autonomy, to enable the conception of Defense Products and Strategic Defense Products by companies in the sector.

The only gap identified is that the RARBID does not directly map patent registration by DIB companies, which represents an opportunity for improvement in the questionnaire. Moreover, the approach adopted by the IPEA model—focused on mapping the main difficulties perceived by industry actors across multiple dimensions—could also be a valuable addition to the RARBID, providing important inputs for the formulation of public policies targeting the DIB. In this regard, as with the IPEA model, the RARBID could explore issues such as the main difficulties in acquiring inputs or even in maintaining operations within the defense sector. Within this topic, the RARBID monitors the main national and international suppliers of components, raw materials, or technology for each Defense Product or Strategic Defense Product produced, but it could take a further step toward understanding whether difficulties exist in these processes and what they may be.

5.2 Trade

Within the theme of trade, the RARBID also satisfactorily meets most of the PNBID's objectives, although there are relevant gaps that can be addressed. Regarding general information, such as the existence of subsidiaries, foreign participation in corporate capital, or revenue composition by sector of activity (defense, security, or others), both the Ministry of Defense (MD) questionnaire and the IPEA model cover this topic. The models by Soare and Pothier (2021) and Cheung (2021), however, adopt a distinct approach in their mappings, where such information is not among the indicators used to identify drivers of defense sector development.

According to this study's assessment, the RARBID partially fulfills the mapping of indicators that would support initiatives to enhance the competitiveness of the DIB in expanding exports of defense goods and services produced or developed in Brazil. The current questionnaire maps the export profile of companies, which may serve as input for public policy design in this regard. However, these data alone do not meet Objective VI of the PNBID. We therefore consider that the IPEA model introduces important additions that could improve and deepen the information provided to the MD via the RARBID and better guide public policies aimed at stimulating trade and enhancing the competitiveness of the national DIB.

The IPEA model seeks to map the main pain points, barriers, and challenges faced by BID companies across various dimensions. From a trade perspective, the model includes a section

devoted to export difficulties for Defense Products and Strategic Defense Products that could be incorporated into the Ministry of Defense questionnaire. Notably, the RARBID already maps, in the field of international trade in defense products, the restrictive practices applied by other countries to the trade of Defense Products and Strategic Defense Products manufactured by Brazilian companies, as well as the predominant forms of competition in the markets in which they operate.

Nevertheless, the IPEA model also stands out for incorporating the monitoring of issues related to trade promotion, from which the RARBID could benefit. Regarding Article 9 of the PNBID, only the IPEA questionnaire, among the models examined, maps the relationship of the DIB with initiatives for promoting defense goods and services produced and developed in Brazil, as well as their inclusion in federal export support programs. The RARBID does not map the participation of the DIB in trade-promotion initiatives in Brazil or abroad, nor those promoted by government entities such as the MD or the Brazilian Trade and Investment Promotion Agency (*Agência Brasileira de Promoção de Exportações e Investimentos* – ApexBrasil) at international defense fairs. From March 2022 to March 2024, a cooperation agreement between ABIMDE and ApexBrasil established a sectoral trade-promotion project called Brazil Defense. The incorporation of questions addressing the sector's integration with such initiatives could provide important insights for the MD to monitor success rates (based on new markets opened, contracts signed, cooperation memoranda, among others) or identify gaps for further expanding the competitive international presence of the national defense industry with federal government support.

In financial terms, Article 10 of the PNBID addresses access to public or private financial resources, reimbursable or non-reimbursable, as well as access to economic grants. Both the IPEA and Cheung (2021) models assign great importance to this variable. Cheung (2021) defines it as an “input factor,” that is, a material, financial, or technological element directed toward the innovation process within the defense industry. Although such resources may also originate internally, from the companies' own funds, the author recognizes that most come from external sources, such as state or private budgetary resources (from banks or investors, for instance).

The RARBID currently maps the Brazilian DIB's access to non-reimbursable public financial resources (which do not require repayment, such as economic grants) and reimbursable ones (which are loans with reduced rates that must be repaid by the beneficiary companies). However, a gap remains regarding the mapping of access to private reimbursable financial resources—that is, loans obtained from private banks and financial institutions that involve repayment with charges. The current RARBID questionnaire monitors whether Brazilian DIB companies are using governmental or non-governmental resources to invest in research and development (R&D) in the defense area. In both cases, the mapping covers only which project receives such funding, the financing institution, the starting year, and the percentage of these resources relative to the total project investment.

Especially in the defense sector, access to private financial resources tends to be more difficult, as private financial institutions often view the sector as highly risky. In the United Kingdom, the UK Export Finance (UKEF) is the governmental export credit agency that

ensures no export of British defense products fails due to lack of access to financial resources or insurance from private entities, recognizing that the defense sector faces limited appetite for risk from potential private financiers (Peterson; Downie, 2024). Similarly, the US Department of Defense has the Office of Strategic Capital (OSC), which provides financial instruments enabling capital providers to invest in critical technologies that would otherwise be less attractive because of high capital costs, excessively long repayment or liquidity periods, or overly risky technical challenges (Scarazzato; Lipson, 2023).

In Brazil, Article 10 of the PNBID already provides, in the area of financing and guarantees, that the MD and the Ministry of Economy shall act jointly to “propose measures aimed at expanding financing and guarantees for the production and development of defense goods and services by the DIB” through access to financial resources (public or private, reimbursable or non-reimbursable), grants, and export support (Brasil, 2022; our translation). In this sense, paragraph 2 of Article 10 establishes the MD’s responsibility, in coordination with the Ministry of Economy, in identifying new resources; suggesting appropriate conditions for the granting of financial assistance for loans; proposing criteria to public banks and other financial institutions for the creation of credit lines; and proposing the alignment of domestic financial charges with those of the international market to finance the export of defense products and services by the Brazilian DIB. In this regard, the RARBID would benefit from adopting the approach used in the IPEA model for access to financial resources (Brasil, 2021; Negrete, 2016). In three items of the mapping questionnaire, the difficulties faced by Brazilian defense companies in obtaining public or private financing or tax incentives are examined. None of the other models presented here have explored this type of dynamic, which directly affects the performance, competitiveness, and completion of DIB projects.

In terms of forms of competition in the international market, the RARBID has the potential to assist in identifying the main factors that affect the performance of different segments in external competition. The questionnaire includes important information, such as whether competition is primarily based on price, product differentiation, availability of technical assistance, distribution channels, or even trade promotion. Strategic segments can benefit from analyzing these results, helping the MD and the federal government focus on targeted measures capable of positively impacting the competitiveness of Brazil’s defense sector in the international market.

The mapping of the DIB conducted by ABDI/IPEA identified that, among the main difficulties related to the international market, were industrial protection in destination countries (78%), unfavorable exchange rates (69%), and domestic bureaucracy (66%) (Leske; Santos, 2020). The RARBID, in turn, also monitors the occurrence of restrictive practices affecting trade in defense products manufactured by Brazilian companies, which makes a significant contribution to understanding the sector’s dynamics and how to support the national industry in positioning itself in foreign markets.

In the field of supply chains, the RARBID satisfactorily maps suppliers, inputs, and raw materials acquired by the DIB domestically or internationally. A possible improvement

would be to include the mapping of the main difficulties encountered in acquiring inputs in the domestic market, such as the lack of suppliers capable of providing inputs, raw materials, or components that meet required specifications; price competitiveness compared to international suppliers; or other factors. Such mapping could be useful for analyzing which segments of the Brazilian market could be encouraged to integrate into the defense sectoral system and increase its autonomy—one of the objectives of the PNBID.

Concluding the trade section, the mapping of access to special tax regimes or fiscal incentives The RARBID maps the accreditations and the extent to which the DIB makes use of the Special Taxation Regime for the Defense Industry (RETID), specifically, as well as any other regimes or incentives adopted and the reasons for their selection. The issue of taxation aimed at ensuring the competitiveness of the national defense industry is addressed in Articles 11 and 12 of the PNBID (Brasil, 2021, 2022).

5.3 Labor Market

The third objective of the PNBID focuses on encouraging the continuous training of human resources for the national defense industry. This factor is considered key in all mapping models discussed here. Cheung (2021) defines it as one of the input factors and highlights characteristics of the workforce, such as quantity and quality (training and qualifications) of personnel working especially in innovation processes within the industry. Soare and Pothier (2021) also classify tailored programs for recruiting, retaining, and training human resources as an important factor to be monitored and recognize its partial influence on defense innovation processes in the United States.

The ABDI/IPEA mapping conducted in 2017 found that the percentage of workers with higher education across different segments of Brazil's DIB was well above the national average. While some segments reach 48%, on average, DIB personnel with higher education represent 27.3%; whereas the national average, according to the Brazilian Institute of Geography and Statistics (IBGE), is only 15% of the total workforce (Leske; Santos, 2020). The study also examined the main difficulties faced by defense companies in recruiting and retaining human resources, such as a shortage of qualified labor in relevant areas, high salary demands, labor laws and regulations, and even issues related to company location, transportation, or the absence of career development plans. Regarding investments in workforce development, the mapping included challenges such as high training costs, lack of time for courses and training, lack of available courses or training centers in relevant areas, absence of public incentives, lack of interest among professionals, and others.

In this regard, the RARBID is currently limited to mapping the workforce—whether internal or outsourced—by operational segment, number of employees on the payroll, classification as a micro, small, medium, or large enterprise, and the percentage distribution of employees by education level. Thus, the current setting of the MD's questionnaire is outdated in its potential to provide decision-makers with inputs for initiatives aimed at fulfilling the objectives outlined in the PNBID. Adopting a more comprehensive approach, such as that used in the ABDI/IPEA

model, would be an improvement to the RARBID for mapping the labor market within the national defense industry.

5.4 Research and development

The production of knowledge in research, development, and innovation of defense goods and services, as well as the generation of intellectual property resulting from it, are part of the primary objective that the PNBID seeks to achieve. This is also a common point among all mapping models, which agree that these are key factors to be mapped in any DIB.

Cheung (2021) classifies certain input, institutional, and organizational factors as inherent components of the defense innovation process; among them are the direct encouragement of military organizations or the Ministry of Defense (MD), civil-military integration between researchers and military personnel, an organizational culture oriented toward innovation, and specific plans and strategies designed for that purpose.

Soare and Pothier (2021) offer a more in-depth approach to the organizational characteristics that enable efficient research and development management. Among the aspects assessed are the existence of a management system for unsuccessful research projects, and a culture described as “fail small, fail fast,” which stimulates the innovation process by recognizing that failure can be an outcome—normalizing it while emphasizing that learning must occur quickly, enabling prompt corrections and more effective new forms of innovation. The existence of internal processes aimed at self-assessment and at incorporating lessons learned from both successful and unsuccessful innovations is relevant within an organizational framework that fosters openness to new ideas and a culture of innovation. Another important factor is the combination of incremental and disruptive innovations within companies’ innovation dynamics. Moreover, the preparation of practical implementation plans for transferring innovations from the laboratory to the battlefield also plays a decisive role in this model, particularly in the case of the defense industries of the United States (US) and France. Additional aspects include political and ministerial responsibility for directing attention toward recognizing the importance of innovation in the defense sector, which proved significant in the US case.

The ABDI/IPEA model also examined research and development in detail. The questionnaire addresses aspects such as the types of innovation carried out by companies (product, process, organizational, or marketing), access to public financing and tax incentives for innovation and the difficulties in obtaining them (high interest rates, short repayment terms, low credit volume, etc.), partnerships with higher education institutions (HEIs) and science and technology institutions (STIs), and the challenges in establishing such partnerships (including disputes over intellectual property rights, bureaucracy, research timelines, low reliability, or inadequate funding). As previously noted, a key strength of this model lies in its mapping of the difficulties and barriers faced by defense companies within the dynamics of the sectoral system.

In this regard, the RARBID adopts a model that lacks sufficient depth, given the importance of innovation in the defense sector for the competitiveness of the Brazilian DIB. Simply monitoring whether a company invests in R&D activities, the amounts invested and their percentage relative to gross annual revenue, or whether activities are conducted by in-house staff

or outsourced entities, as well as whether governmental or non-governmental funds are used, is insufficient to address such a crucial topic. The RARBID also maps, as does the ABDI/IPEA questionnaire, whether companies benefit from any offset projects with the Armed Forces. Here, the IPEA model once again takes the opportunity to identify possible challenges in conducting offset projects with foreign companies and in establishing agreements and partnerships with other defense companies. Regarding quality certifications, such as ISO, AS, and RBQA, which are already mapped by the RARBID, improvements could be made based on the IPEA model by additionally mapping the main challenges faced in obtaining them, to facilitate and promote their adoption.

Finally, the RARBID also records whether DIB companies have expanded or modernized their production facilities in the previous fiscal year, the reasons for such investment (technological updates, increased demand, etc.), and the source of financing (own capital, loans, etc.). An important enhancement to the questionnaire, once again based on the IPEA model, would be to map the existence of plans for expansion or improvement of production capacity within a given time frame—such as the next five years (expansion of facilities and machinery, increase in workforce, etc.). Therefore, in each cycle, the Ministry could assess whether the planned actions have been or are being effectively implemented and, if not, identify the obstacles faced to enable targeted interventions.

5.5 Other aspects

This section of the RARBID includes a “space reserved for companies to provide criticism, comments, and/or suggestions” (Brasil, 2021; our translation). Opening this channel for company feedback is an important, albeit basic, initiative and deserves recognition. It could be used as an additional space for the Ministry to incorporate seasonal questions, which can be removed or modified annually, enabling greater flexibility in the questionnaire and enabling the inclusion of specific topics of interest to decision-makers that can generate insights to guide public initiatives to stimulate the Brazilian DIB.

6 CONCLUSION: PROPOSALS FOR THE RARBID

This study analyzed the RARBID in light of the PNBID and national and international industrial mapping models, in order to propose improvements that could contribute to the development of the Brazilian defense sector. The results obtained indicate that, although the RARBID represents a significant initiative for mapping and monitoring the DIB, there are still gaps that, if addressed, could considerably enhance the instrument’s effectiveness.

The analysis of the different models’ content revealed that the RARBID, in its early years, already presented a robust structure capable of mapping critical indicators for the DIB. However, the study identified the need to expand the questionnaire’s scope to include variables that could provide a more comprehensive and detailed view of the sector. It also found that the RARBID does not fully reflect the objectives of the PNBID, particularly regarding the coordinated

involvement between the MD and the DIB and the analysis of the interaction between DIB companies and the Armed Forces.

Moreover, the questionnaire shows gaps in mapping aspects such as access to financial resources, the defense sector labor market, research and development, and defense product exports. The proposed additions to the RARBID are summarized in Table 1.

Table 1 – Proposal for Including New Topics in the RARBID

RARBID Section	Subject	Proposed new questions
Preamble	Degree of interaction between the company and the Ministry of Defense	<ul style="list-style-type: none"> - Does the company have, or is it aware of, a MD department or representative serving as its focal point for communications with the Ministry? How often does the company interact with MD focal points? For example: weekly, biweekly, monthly, bimonthly, quarterly, every four months, or more. - How does the company assess the ease and effectiveness of communication with the MD? For example: excellent, good, fair, poor, or very poor. - What are the main challenges in the company’s interaction with the MD? For example: absence of a focal point; delays in establishing contact; delays in resolving demands; lack of sectoral/segment knowledge within the Ministry; other (specify); no difficulties.
Technology and Production	Patent registration	- Has the company registered any national and/or international patents in the last two fiscal years? If yes, provide the product description, whether the patent is national or international, and the registration details.
	Identification of dual-use products	- Indicate which of the company’s products and services have dual use and to what extent.
Trade	Participation in contracts with the Armed Forces	- What percentage of the company’s contracts in the last fiscal year involved the Armed Forces? None (0%); up to 20%; 21%–50%; 51%–80%; 81%–100%. (the original scale—“up to 20%; 20%–50%; 50%–80%; 80%–100%”—was revised for clearer percentage definition, without repetition.)
	Interaction/contact with the Armed Forces	<ul style="list-style-type: none"> - How often does the company interact with the branch of the Armed Forces to which it supplies any type of Defense Product or Strategic Defense Product? For example: weekly, biweekly, monthly, bimonthly, quarterly, every four months, or more. - Did the company participate in any meetings with the Armed Forces in the last fiscal year regarding the identification of needs in the defense segment or sector for technology development and related matters? - What are the main challenges faced by the company in its interaction with the Armed Forces? For example: absence of an appropriate interlocutor/focal point; delays in establishing contact; delays in resolving demands; lack of sector/segment knowledge within the branch; other (specify); no difficulties.
	Difficulties in commercial exchange with the Armed Forces	<ul style="list-style-type: none"> - What are the main challenges faced by the company in selling to the Armed Forces? For example: outdated procurement budgets; strict specifications; bureaucratic bidding procedures; complex acquisition processes; delayed payments; insufficient production capacity; need for working capital; foreign competition; difficulties obtaining inputs; other (specify). - What are the main challenges faced by the company in exporting its defense products? For example: noncompetitive pricing; trade barriers; lack of financing; lack of government support for trade promotion; export bureaucracy; high logistical costs/difficulties; need for working capital; high taxes; unfavorable exchange rate; difficulty obtaining inputs; insufficient production capacity; external political barriers; other (specify). - What are the main challenges in obtaining inputs/components/services? For example: few available suppliers; absence of suitable suppliers in Brazil; import bureaucracy; long delivery times; high taxes; unfavorable exchange rate; inadequate logistics infrastructure; tax complexity; high prices; difficulty obtaining supplies on a large scale; failure to meet product specifications; other (specify).
	Product marketing and promotion	- Did the company participate in any trade promotion activities in the last fiscal year? If yes, indicate whether it was an independent initiative or a government/MD initiative through ApexBrasil, and specify whether any trade agreement, memorandum of understanding, or preliminary discussions were established, or whether no commercial progress was made.

Continues...

Table 1 – Continuation

RARBID Section	Subject	Proposed new questions
Trade	Tax incentives	- What are the main challenges faced by the company in obtaining tax incentives? For example: insufficient information; difficulty understanding tax legislation; risk in reporting to the Federal Revenue Service; risks related to expenditures and depreciation amortization; legal uncertainty; risks related to deductible IRPJ and CSLL expenses; project misalignment with incentive laws; variation in laws, percentages, and calculation bases; excessive bureaucracy; poor coordination within company departments; other (specify).
	Survival in the defense market	- What are the main challenges faced by the company in maintaining its position in the Defense Product (PRODE) and Strategic Defense Product (PED) markets? For example: insufficient demand; seasonal demand; dependence on government purchases; lack of qualified personnel; contract breaches by the State; few incentives; difficulty obtaining financing; difficulty in trade promotion; rapid technological change in the sector; lack of required certifications; difficulties accessing foreign markets; competition with foreign companies; other (specify).
Labor market	Recruitment and retention	- What are the main challenges faced by the company in recruiting and retaining human resources? For example: shortage of qualified professionals; high salary demands; labor laws and regulations; company headquarters/plant location; competition with the civilian market; difficulty finding/recruiting candidates; lack of career development plans; other (specify).
	Specialization and professional development	- What are the main challenges faced by the company in training and developing its workforce? For example: high costs; lack of time for courses and training; limited availability of training centers; employee disinterest; lack of public incentives; labor laws and regulations; other (specify).
Research and Development (R&D)	Gross revenue allocated to R&D	- What percentage of the company's annual gross revenue was allocated to R&D activities? 0–10%; 11%–20%; 21%–30%; above 31%. (the original scale—“0–10%; 10%–20%; 20%–30%; above 30%”—was revised for clearer percentage definition, without repetition.)
	R&D personnel	- Are R&D activities conducted by company employees? If yes, specify the number of employees involved, project description, and start year. If not, provide project details, including description, partnering entity, and start year.
	Partnerships with STIs and HEIs	- What are the main challenges faced by the company in establishing partnerships with science and technology institutions (STIs) and higher education institutions (HEIs) for R&D? For example: disputes over intellectual property rights; communication difficulties; bureaucracy; geographic distance; inadequate STI/HEI staff; insufficient funding; conflicting research timelines; low reliability of partners; other (specify).
	Quality certifications in R&D	- What are the main challenges faced by the company in obtaining quality certifications? For example: limited employee engagement; resistance to documentation; lack of familiarity with standards; resistance to change/adaptation; excessive time required for awareness; misunderstanding of requirements; excessive bureaucracy; lack of investment resources; lack of interest; absence of a quality culture; other (specify).
	Expansion or improvement of production capacity	- Does the company have plans to expand or improve production capacity in the next fiscal year? If yes, specify the area: workforce increase; plant expansion; acquisition of new machinery; acquisition of new production technologies; other (specify).
	R&D financing	- What are the main challenges faced by the company in obtaining R&D financing? For example: difficulties accessing the banking system; lack of credibility of new companies; high interest rates; short repayment terms; difficulty obtaining documentation; low credit volume; insufficient information; difficulty preparing business plans; company listed in Cadin/Serasa; company insolvency; lack of government support for credit access; other (specify). - Is the company aware of and/or up to date with the various public and private financing opportunities available domestically and abroad for its projects?

This study identifies several opportunities for future research. For example, a direct survey could be conducted with DIB companies to investigate their reception of the RARBID's implementation, any difficulties encountered in completing and submitting it, and whether the

report has demonstrated any effectiveness to date—such as improvements resulting from its adoption, including in the company’s relationship with the MD. Another possible research avenue would be to explore private financing mechanisms for the DIB, including barriers and facilitators to accessing financial resources, thus providing a clearer understanding of the challenges faced by companies in the sector.

Additionally, it would be relevant to analyze the impact of public policies that promote technological innovation in the defense sector, as well as the interaction among different actors within the Sectoral Innovation System, offering new perspectives for developing effective strategies to enhance the competitiveness and sustainability of the DIB.

Finally, the implementation of longitudinal studies to monitor changes within the DIB over time is also recommended, in order to assess the effectiveness of implemented policies and adjust them as needed to meet the dynamic demands of the defense sector.

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