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Evaluation of innovation and technology transfer programs in the defense sector: an analysis of Brazilian strategic documents

Evaluación de programas de innovación y transferencia de tecnología en el sector de defensa: análisis de documentos estratégicos brasileños

Abstract: This article analyzes evaluation methodologies applied to innovation and technology transfer in the defense sector, based on national and international strategic documents. It adopts a qualitative approach grounded in interpretive document analysis and thematic clustering, which grouped materials into three axes: small business support programs, Brazilian public policies, and global evaluation practices. The results show that the effectiveness of Science, Technology, and Innovation (ST&I) policies depends on integrating evaluation, institutional learning, and interagency governance. Methodological gaps were identified in measuring long-term impacts and in developing multidimensional and adaptive indicators. The study concludes that consolidating a national technological evaluation system is essential to strengthen the Defense Industrial Base and sustain Brazil's technological sovereignty.

Keywords: Public policy evaluation; Technology transfer; Defense innovation; Thematic clustering; Technological performance indicators.

Resumen: Este artículo tiene como objetivo analizar las metodologías de evaluación aplicadas a la innovación y la transferencia de tecnología en el sector de defensa a partir de documentos estratégicos nacionales e internacionales. Se utiliza un enfoque cualitativo, basado en el análisis documental interpretativo y la clusterización temática, que reunió los materiales en tres ejes: programas de apoyo a las pequeñas empresas, políticas públicas brasileñas y prácticas de evaluación global. Los resultados demuestran que la eficacia de las políticas de Ciencia, Tecnología e Innovación (CT&I) depende de la integración entre la evaluación, el aprendizaje institucional y la gobernanza interinstitucional. Se identificaron brechas metodológicas en la medición de impactos a largo plazo y la necesidad de indicadores multidimensionales y adaptativos. Se concluye que la consolidación de un sistema nacional de evaluación tecnológica es esencial para fortalecer la Base Industrial de Defensa y sostener la soberanía tecnológica brasileña.

Palabras clave: Evaluación de políticas públicas; Transferencia de tecnología; Innovación en defensa; Clusterización temática; Indicadores de desempeño tecnológico.

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1 INTRODUCTION

International trade of defense products is a key pillar of the global geopolitical and economic landscape, representing a strategic sector that encompasses the production and transfer of advanced military technologies (Correa; Urbina, 2021). This complex international market significantly influences global security and strategic alliances (Carvalho; Montenegro, 2021). Such influence is often driven by economic factors, as observed in the relationship between war, military power, and economic dynamics (Matos, 2018).

The sector is currently undergoing a transition period marked by disruptive innovations that are transforming defense companies into more efficient and collaborative organizations, although the adoption of a strong intellectual property culture remains a persistent challenge (Bellais; Fiott, 2017; Bellais; Guichard, 2006; Blom; Castellacci; Fevolden, 2014; Dombrowski; Gholz, 2009).

In this context, Commercial, Industrial, and Technological Compensation Agreements (offsets) have emerged as essential compensatory mechanisms, especially for developing economies seeking to enhance their industrial and technological capabilities (Silva, 2019). However, the debate surrounding the effectiveness and economic rationale of defense policies, including offsets, remains intense and often polarized, with contrasting views among critics and proponents (Fevolden; Tvetbråten, 2016).

In the United States, despite ongoing criticism, offsets remain a well-established practice and are evaluated annually by the Bureau of Industry and Security (BIS), an agency of the U.S. Department of Commerce, which publishes reports on their impacts on defense trade (Estados Unidos da América, 2018). In Brazil, the supervision of Offset Agreements by the Brazilian Air Force Command (COMAER) reflects an effort to align these practices with the National Defense Strategy (NDS) and national innovation policies. Nevertheless, the lack of consistent innovation indicators reveals gaps in the monitoring and evaluation of outcomes (Brasil, 2020a; 2020b).

The evaluation of innovation and technology transfer programs therefore represents a central methodological challenge for the management of public defense policies. As noted by Correa and Urbina (2021), innovation should be understood as a systemic and interactive process that depends on cooperation among scientific, industrial, and governmental institutions. From this perspective, the evaluation of innovation policies requires methodological tools capable of measuring not only tangible outcomes, but also long-term impacts and externalities associated with technological learning.

Bozeman and Sarewitz (2011) argue that the effectiveness of an innovation policy should be evaluated across multiple dimensions—technical, economic, and social—rather than being limited to performance metrics alone. Arnold *et al*. (2018) further emphasize that the evaluation of complex policies, such as innovation and defense, requires approaches that consider uncertainty, feedback, and the adaptive nature of innovation systems. In Brazil, the lack of established methodologies and a robust analytical framework for evaluating technology transfer and offset programs compromises the ability to feed lessons learned back into the policy-making cycle and to support the strategic management of the Defense Industrial Base (DIB).

Thus, this study aims to analyze the evaluation approaches applied to innovation and technology transfer in the defense sector, considering both national strategic guidelines and the

international evaluation frameworks. This investigation is based on a documentary analysis of policies and strategic reports and is structured around a thematic clustering approach that groups documents into categories representing global evaluation trends.

The study seeks to identify methodological patterns, conceptual gaps, and opportunities for improving the evaluation of innovation and technology transfer policies applicable to the Brazilian defense sector. Ultimately, it aims to contribute to strengthening the analytical and institutional framework of the DIB by providing a critical reflection on current evaluation models and their implications for national technological sovereignty.

2 METHODOLOGY

This study is classified as applied research with a qualitative approach and an exploratory-descriptive design, aimed at understanding and critically analyzing evaluation methods applicable to innovation and technology transfer in the defense sector. The research seeks to integrate theoretical and empirical perspectives by combining the bibliographic review and documentary analysis within a single investigation framework.

2.1 Methodological approach and design

The methodological strategy adopted is based on a combination of qualitative methods design for the analysis of complex policies and is structured around three complementary components:

a. a structured literature review, which enabled the identification of the main theoretical frameworks related to the evaluation of innovation policies, technology transfer, and technological offset programs;
a. a documentary analysis, aimed at interpreting strategic guidelines, regulations, and technical reports produced by national and international institutions; and
a. thematic clustering, a qualitative classification technique used to organize documents according to conceptual, methodological, and contextual similarities.

The clustering procedure adopted follows the logic of thematic content analysis proposed by Bardin (2016), in which categories emerge from semantic and conceptual regularities identified within the corpus. This technique was applied in an interpretative rather than statistical manner in order to understand patterns of approach, terminologies, and evaluation structures across different institutional contexts. In this regard, clustering served as an analytical systematization tool that enabled the identification of convergences, gaps, and contrasts among Science, Technology, and Innovation (ST&I) evaluation models.

The adoption of this procedure is justified by the heterogeneity of the empirical material, composed of documents of different types (strategic, regulatory, and methodological) and origins (national and international). Such diversity would limit the effectiveness of a comparative analysis based solely on quantitative methods, making it necessary to employ a structured interpretative framework capable of identifying conceptual relationships among policies, methodologies, and evaluation instruments.

Accordingly, the analytical process was conducted in four stages: (i) exploratory reading and initial coding of the documents; (ii) identification of common thematic axes; (iii) classification of documents according to scope, purpose, and evaluation methodology; and (iv) comparative interpretation across clusters. This process resulted in the definition of three interpretative clusters representing distinct assessment approaches:

1. Evaluation of programs targeting small businesses – encompasses empirical studies and reports that examine interventions designed to promote innovation among micro and small enterprises, with emphasis on the Small Business Innovation Research Program in Japan and the document Evaluation Revisited: Improving the Quality of Evaluative Practice by Embracing Complexity.
2. Public policies and national planning instruments – includes Brazilian strategic documents, such as the NDS, Normative Ordinance No. 61/GM-MD, and the Multi-Year Plan Indicators Manual, which provide the institutional framework for national technology offset and innovation policies.
3. Global organizations and established R&D practices – comprises internationally recognized reference documents, including reports published by the National Science Foundation (NSF), the Organisation for Economic Co-operation and Development (OECD), and the U.S. Department of Energy (DOE), which present advanced methodologies for measuring and evaluating Research and Development (R&D).

Table 1 summarizes the classification of the analyzed documents according to the type and category of each group, highlighting the alignment between the empirical material and the proposed analytical framework. This methodological structure enabled a systematic comparison of different evaluation practices and the identification of opportunities for improvement within the Brazilian defense and innovation context.

Table 1 – Classification of the analyzed documents

Clusters	Type of document	Title
1	Small Business Programs	Evaluation of the Small Business Innovation Research Program in Japan
		Evaluation Revisited Improving the Quality of Evaluative Practice by Embracing Complexity
2	Public Policies	*Estratégia Nacional de Defesa (END)* [National Defense Strategy (NDS)]
		Normative Ordinance No. 61/GM-MD
		Multi-year Plan Indicators Manual
3	Global Organizations/ United States	Science and Engineering Indicators – National Science Foundation (NSF)
		Measuring Innovation – A New Perspective – Organisation for Economic Co-operation and Development (OECD)
		[Overview of Evaluation Methods for R&D Programs]

Source: Prepared by the authors (2024).

2.2 Selection and documentary corpus

For the sample, we purposively selected strategic documents that are recognized in the literature and by institutional organizations. The selection was based on three criteria:

a. thematic relevance, encompassing policies and programs directly related to innovation evaluation and technology transfer;
b. institutional representativeness, including guidelines issued by governments, multilateral organizations, and funding agencies; and
c. methodological scope, contemplating documents with different types of evaluation instruments.

Eight key documents were analyzed, as presented in Table 1. These include national policy documents—such as the NDS (Brasil, 2020a), Normative Ordinance No. 61/GM-MD (Brasil, 2018), and the Multi-Year Plan Indicators Manual (Brasil, 2020c)—as well as major international reference reports, including Science and Engineering Indicators (NSF, 2024), Measuring Innovation: A New Perspective (OECD, 2010), and Overview of Evaluation Methods for R&D Programs (DOE, 2012).

2.3 Analysis procedures

The analysis was conducted in three successive stages:

1. Exploratory reading and preliminary coding, aimed at identifying recurring concepts and evaluation categories (efficiency, impact, learning, and innovation).
2. Thematic categorization according to similarity, grouping documents according to their evaluation focus and analytical scale.
3. Interpretative synthesis and triangulation, articulating the empirical findings with the theoretical framework, particularly the contributions of Arnold *et al*. (2018) and Figueiredo (2015), who emphasize the need for multidimensional and adaptive approaches to the evaluation of complex policies.

The triangulation of theory, practice, and public policy enhanced the study's analytical validity and argumentative coherence, enabling a comparative interpretation of evaluation strategies and their implications for innovation management in the defense sector.

2.4 Relevance and limitations

The originality of this approach lies in the integration of documentary analysis and thematic clustering applied to a set of strategic policies and reports that have rarely been examined from the perspective of innovation evaluation in the defense sector. However, qualitative analysis has well-known limitations regarding the generalization of its findings. Nevertheless, its interpretative strength lies in its ability to generate comparative and structuring insights for future empirical evaluations and the development of indicators.

3 RESULTS AND DISCUSSION

This section presents the analysis and interpretation of the data obtained from the adopted methodological approach. The investigation focused on the evaluation of impacts in ST&I programs and was structured around a thematic clustering approach that organized the

analyzed documents into three interpretative groups. Each cluster represents a distinct dimension of evaluation practices, allowing us to understand the convergences, specificities, and limitations of the models applied to innovation and technology transfer.

The clustering technique was employed as an interpretative tool grounded in content analysis (Bardin, 2016), enabling the grouping of documents according to conceptual similarities, evaluation objectives, and the methodological instruments used. This organization favored the development of a comparative perspective between established international experiences and national normative frameworks, highlighting patterns of governance, performance metrics, and challenges in measuring long-term impacts.

3.1 *Cluster* 1 – Evaluation of programs applied to small businesses

3.1.1 Evaluation of the Small Business Innovation Research Program in Japan

The first cluster encompasses studies on innovation support programs for small and medium-sized enterprises, with emphasis on the report Evaluation of the Small Business Innovation Research Program in Japan and the document Evaluation Revisited: Improving the Quality of Evaluative Practice by Embracing Complexity. These studies stem from the tradition of technological innovation programs targeting small businesses, initiated in the United States with the Small Business Innovation Research (SBIR) established in 1982, which is considered one of the most influential models for promoting applied research and competitiveness in strategic sectors (Inoue; Yamaguchi, 2017).

According to Froehlich (2016) and Souza *et al.* (2023), the effectiveness of innovation programs is directly associated with their ability to promote organizational learning and strengthen technological ecosystems, moving beyond a narrow focus on short-term outcomes.

In the Japanese case, the results of the SBIR program indicated no statistically significant differences in sales, patent generation, and employment between beneficiary and non-beneficiary companies. These findings, derived from econometric analyses, suggest that although investment in R&D occurred, the immediate effects on the competitiveness of companies were limited (Inoue; Yamaguchi, 2017).

However, the study reveals relevant qualitative impacts, such as the strengthening of managerial capacities and the development of cooperative networks between companies and universities. These intangible outcomes, often overlooked in traditional evaluation approaches, reinforce the importance of complementary performance metrics capable of capturing the medium- and long-term effects of innovation, aligning with the argument of Bogers, Chesbrough, and Moedas (2018) regarding the need to consider non-measurable outputs in open innovation processes.

Among the challenges observed in the Japanese SBIR are: (i) limited knowledge transfer between universities and companies; (ii) institutional fragmentation among ministries and agencies; and (iii) absence of specialized scientific evaluators in the project selection process, which reduces the originality of funded proposals.

These weaknesses have been partially addressed by other Japanese innovation support programs, such as ERATO[1] and COI-NEXT[2], both administered by the Japan Science and Technology Agency (JST), which prioritize cross-sector collaboration and breakthrough innovations aimed at sustainability and carbon neutrality (JST, [198-?]; [*ca.* 2020]).

The temporal analysis (2006–2010) coincides with a period of economic stagnation in Japan, during which the traditional industrial model showed signs of exhaustion and the transition toward a knowledge-based economy became imperative. This change reflects the Triple Helix concept (Etzkowitz; Leydesdorff, 2000), in which interactions among government, universities, and the productive sector constitute the core foundation of innovation policies.

Therefore, the study reinforces the argument that the structural effects of innovation policies transcend immediate outcomes and are better understood in the light of a systemic and longitudinal evaluation perspective. This understanding is particularly relevant to the Brazilian context, in which technology offset programs and dual-use R&D projects require monitoring instruments that capture cumulative impacts related to learning processes and strengthening of the DIB.

In summary, although the Japanese SBIR presents modest quantitative results (Inoue; Yamaguchi, 2017), it reveals significant intangible effects, such as the enhancement of technological capacities, the promotion of an innovative culture, and the creation of inter-institutional cooperation networks. These findings converge with the guidelines established by the NDS and Normative Ordinance No. 61/GM-MD, which reinforce the importance of continuously measuring R&D impacts and developing indicators capable of reflecting the multidimensional nature of innovation (Brasil, 2020a; 2018).

3.1.2 Evaluation Revisited: Improving the Quality of Evaluative Practice by Embracing Complexity

The report summarizes the discussions and presentations from the international conference that sought to rethink the methodologies used to evaluate innovation and development programs, placing them in the context of a global measurement agenda based on complexity. The event's deliberations were disseminated in several international evaluation meetings held between 2010 and 2011, expanding the circulation of the findings and methods discussed (Guijt *et al.*, 2011).

During the conference, a consensus emerged that the evaluation of the effectiveness of innovation programs for small businesses must go beyond traditional metrics by adopting approaches that combine quantitative and qualitative methods. This methodological integration allows us to capture the multifaceted nature of innovation by considering both immediate and long-term impacts.

The conference also emphasized the importance of incorporating ethical values and diverse stakeholder perspectives, recognizing that evaluation must go beyond measuring outcomes to include dimensions of empowerment and social justice. A notable example is the methodology employed by Oxfam America, which employs inclusive indicators aimed at the sustainable

1 Exploratory Research for Advanced Technology (ERATO).

2 Program on Open Innovation Platform for Industry-Academia Co-Creation (COI-NEXT).

empowerment of beneficiary communities, reinforcing the role of evaluation as a tool for social transformation and not just accountability.

The objectives of the report included:

- summarizing key concepts discussed during the event;
- reflecting on the applicability of the insights generated;
- evaluating the conference by means of participatory methods; and
- analyzing the adequacy of the evaluation techniques employed.

The section entitled *General Discussion Overview* further explores the importance of a systemic and integrated approach to evaluation, emphasizing collective learning and stakeholder engagement. The use of participatory tools, such as voting procedures and SurveyMonkey questionnaires, evidenced participants' support for the adoption of collaborative evaluation practices centered on organizational learning (Versiani; Oribe; Rezende, 2013).

The study highlights the predominance of qualitative methods, the sequential structure of the techniques employed, and the values that guided the evaluation process. This methodological choice reflects the challenge of measuring complex systemic changes that are often not captured by conventional performance metrics (Almeida; Silva, 2025). Furthermore, the report highlights the difficulty of ensuring continuous funding for program components that generate indirect returns and of developing specific skills to manage interorganizational learning processes.

Finally, the document warns that simplistic management approaches, which prioritize immediate results and avoid risks, may restrict innovation. Such approaches tend to perpetuate traditional practices, which, according to the authors, undermine the evolution of evaluation systems and institutional learning, especially in contexts of innovation policies in developing countries.

In summary, the Evaluation Revisited report reinforces that evaluating is learning: a process that requires flexibility, dialogue among stakeholders, and acknowledgement of systemic interdependencies. This perspective aligns with the approach adopted in this study by advocating multidimensional and adaptive evaluation models for assessing the outcomes of innovation and technology transfer programs, especially those associated with the NDS and Brazil's technology offset policy.

3.2 *Cluster* 2 – Evaluation of Public Policy Documents

The analysis of the second cluster focused on documents related to the formulation and management of Brazilian public policies, specifically the NDS, Normative Ordinance No. 61/GM-MD, and the Multi-year Plan Indicators Manual (PPA 2020–2023). These instruments constitute the legal and institutional framework that guides innovation and technology transfer policy in the defense sector, reflecting the Brazilian State's effort to establish governance and evaluation mechanisms aimed at ensuring technological autonomy and long-term industrial sustainability (Brasil, 2018; 2020a; 2020c).

The 2020 version of the NDS reaffirms science, technology, and innovation as pillars of national sovereignty. The document associates the strengthening of the DIB with the ability to absorb, adapt, and generate strategic knowledge, emphasizing that technological mastery is essential to reduce external dependencies. In this context, the Strategic Defense Actions (*Ações*

Estratégicas de Defesa – AEDs)—particularly AED-45, AED-46, and AED-47—establish operational guidelines aimed, respectively, at:

a. expanding defense product exports;
b. incorporating national content into strategic systems; and
c. negotiating and implementing Technological, Industrial, and Commercial Compensation Agreements (offsets).

These actions consolidate the technological dimension of defense by integrating security objectives with economic development goals (Brasil, 2020a).

Normative Ordinance No. 61/GM-MD/2018, which establishes the Defense Technological, Industrial, and Commercial Compensation Policy (PComTIC Defense), translates this strategic vision into an operational regulatory instrument. The document establishes principles of technological reciprocity, shared responsibility, and results evaluation, linking the fulfillment of offset commitments to the technological maturity of national companies. It also introduces the concept of progressive technological capacity building, according to which projects must generate not only immediate compensatory benefits but also cumulative learning and technological diffusion within the DIB. This perspective aligns with Porter's (1990) approach, which associates enhanced competitiveness with firms' capacity for continuous innovation.

However, the comparative analysis between PComICT Defense and international practices reveals methodological gaps in the monitoring and evaluation of technological compensation agreements. Although the regulation establishes the mandatory use of performance indicators, the absence of standardized metrics and an institutional feedback framework limits the assessment of the long-term effects of defense innovation policies. This challenge is also emphasized by Figueiredo (2015), who argues that the effectiveness of ST&I policies depends on the institutionalization of evaluation systems that combine methodological rigor with practical usefulness.

The PPA 2020–2023 Indicators Manual highlights the importance of technical and consistent criteria for the design and monitoring of public policy indicators. The document emphasizes that metrics should demonstrate validity, reliability, usefulness, and data availability, reinforcing the need for instruments capable of translating qualitative results into quantitative evidence (Brasil, 2020c). This guideline aligns with the perspective of Furubo, Rist, and Sandahl (2002), according to which evaluation should be understood as a systematic process of generating knowledge that supports public management and decision-making.

Despite these institutional advances, challenges remain regarding the integration of Defense and Innovation evaluation systems. The lack of interoperability among databases, combined with fragmentation among implementing agencies (Ministry of Defense; Ministry of Science, Technology and Innovation; and COMAER), hinders the consolidation of a holistic understanding of the impacts of the policies implemented. This gap is consistent with the diagnosis presented by Bozeman and Sarewitz (2011), who identify the absence of systemic indicators as one of the main obstacles to the evaluation of science and technology policies in emerging countries.

From a methodological perspective, the NDS, PComTIC Defense, and the PPA 2020–2023 present normative complementarity but evaluative asymmetry. While the NDS establishes long-term

strategic guidelines, Ordinance No. 61 operationalizes the offset policy, and the PPA provides the monitoring instrument. However, this triad lacks empirical *ex post* evaluation mechanisms capable of feeding evidence on the effectiveness of defense innovation programs back into the decision-making process.

To address this limitation, the adoption of multidimensional indicators is recommended, capable of capturing both tangible outcomes (contract volume, training hours, and technology absorption rates) and intangible outcomes (levels of organizational learning, technological autonomy, and knowledge diffusion). This recommendation aligns with the OECD's (2010) guidelines in Measuring Innovation, which advocate the development of hybrid metrics—both quantitative and qualitative—to assess the structural effects of innovation and its contribution to sustainable development.

Therefore, the convergence among the three instruments analyzed (END, PComTIC Defense, and the PPA) reveals the emergence of a Brazilian defense innovation policy model that remains under development but is guided by principles of technological sovereignty, interinstitutional integration, and evidence-based evaluation. However, its effectiveness will depend on the establishment of continuous monitoring systems and institutional analytical capabilities capable of feeding policies with performance, learning, and impact data.

In summary, the public policy cluster demonstrates that Brazil possesses a promising strategic framework but still lacks a mature evaluation system capable of translating the discourse of innovation into measurable and sustainable practices. The consolidation of such a system requires aligning the normative framework with an evaluation culture, strengthening the relationship between planning, implementation, and institutional learning—principles that are central to improving the technology offset policy and enhancing the competitive positioning of the DIB in the international scenario.

3.3 *Clusters* 3 – Evaluation of Global/U.S.-Based Organizations

The third cluster covers documents produced by **international organizations and U.S. governmental agencies** responsible for establishing references **in the evaluation of ST&I policies**. The analysis of this group serves a dual purpose: (i) to identify established models of measurement and technological governance; and (ii) to examine their applicability to the Brazilian context, particularly within the scope of defense policies and technology offset programs.

The methodological approach employed followed the logic of interpretive documentary analysis, combined with thematic clustering (Bardin, 2016). Thus, the reports produced by the NSF, OECD, and DOE were examined not merely as descriptive sources, but as epistemic artifacts, that is, instruments that embody conceptions of evaluation, performance metrics, and public policy perspectives. This approach allowed us to understand the different evaluative rationalities underlying each institution: the scientific (NSF), the normative (OECD), and the operational (DOE).

3.3.1 Science and Engineering Indicators – National Science Foundation (NSF)

The Science and Engineering Indicators report (NSF, 2024) represents one of the most influential sources for global ST&I monitoring. Unlike purely statistical studies, its structure

reflects a systemic evaluation model that considers the interdependence among scientific output, public investment, human capital, and international collaboration. This model is grounded in the approach proposed by Sábato and Botana (1968) and later developed by Freeman (1987) and Lundvall (1992), recognizing that technological performance results from interactions among the State, universities, and firms—the foundation of the National Innovation System (NIS) concept.

The analysis of the document reveals profound structural changes in the global landscape of Science and Engineering (S&E). Traditional performance metrics, based on publications and R&D expenditures, have been complemented by qualitative indicators related to collaboration flows, technological expertise, and knowledge diffusion. This methodological advancement demonstrates a transition from a descriptive evaluation model to an interpretative and relational one.

The phenomenon of emerging countries catching up with S&E signals a multipolar reconfiguration of technological power, particularly exemplified by China, which has demonstrated significant growth in science education and R&D investment, indicating a global redistribution of high-tech skills. This trend reinforces the relevance of longitudinal and comparative indicators, which are essential for understanding the long-term impacts of innovation policies—a gap that remains evident in Brazilian methodologies.

The evidence presented by the NSF corroborates the need for high-quality data and international comparability. This issue is particularly relevant to the context of the NDS, which lacks systematic mechanisms for collecting and integrating information on innovation, technological productivity, and industrial maturity. The use of integrated indicators—combining R&D outcomes, publications, patents, and inter-institutional cooperation—could strengthen the empirical basis for evaluating technology offset programs in Brazil, as suggested by Figueiredo (2015) and Porter (1990).

3.3.2 Measuring Innovation – A New Perspective (OECD)

The report *Measuring Innovation: A New Perspective* (OECD, 2010) represents a conceptual milestone in the evolution of innovation measurement. The OECD argues that the evaluation of public policies should not be restricted to input–output measures but should also encompass learning processes, cooperation, and social impacts—a perspective consistent with Edquist's (2005) approach, which understands innovation systems *as policy frameworks*.

The OECD introduces the notion of a "measurement agenda for innovation," which seeks to align statistical systems with the strategic objectives of each country. This agenda reinforces the idea that measuring innovation is a strategic and political task rather than merely a technical one: indicators define what governments perceive as success. This perspective echoes Godin's (2016) critique that the history of scientific measurement reflects ideologies regarding progress and development.

Methodologically, the report proposes a multidimensional evaluation model that integrates quantitative and qualitative data. The focus lies on developing open and interoperable data infrastructures capable of enabling robust comparative analyses between advanced and emerging economies. Such principles could be adapted to Brazil by means of a national ST&I indicator policy for the defense sector, capable of connecting the databases of the Ministry of Defense, the Ministry of Science, Technology and Innovation, and the Ministry of Development, Industry, and Foreign Trade.

The OECD's proposal converges with the recommendations of the Oslo Manual (2018) by suggesting that the success of innovation depends on interactions among actors and institutional learning. The document also recognizes existing methodological limitations, such as the underestimation of regional effects and the difficulty of measuring positive externalities (*spillovers*), advocating a transition towards dynamic and adaptable indicators.

In summary, the OECD report reinforces the need for countries to adopt continuous and reflexive evaluation approaches, in which measurement is not an end in itself but an instrument to improve policies and align incentives. This perspective is especially relevant for Brazil, where the technology offset policy still lacks a systematic and interinstitutional evaluation system.

3.3.3 Overview of Evaluation Methods for R&D Programs – U.S. Department of Energy (DOE)

The document *Overview of Evaluation Methods for R&D Programs* (DOE, 2012) synthesizes methodologies applicable to the evaluation of Research and Development programs, providing an operational and pragmatic perspective on technology evaluation. Unlike the NSF and OECD reports, which adopt a normative and strategic orientation, the DOE report follows an instrumental approach focused on the practical application of evaluation methods to support funding decisions and project prioritization.

The report recognizes that R&D programs generate multi-scale effects—direct, indirect, and diffuse—therefore, no single method is sufficient to measure them. Thus, it advocates the use of a mixed-methods approach, combining quantitative techniques (econometric analyses and cost-benefit analysis) with qualitative approaches (peer review, case studies, and network analyses). This perspective is consistent with Scriven's (1991) paradigm, which argues that the validity of evaluation depends on the triangulation of multiple sources and perspectives.

The DOE also introduces the concept of spillover analysis, aimed at measuring the indirect effects of innovation, such as knowledge diffusion, capability development, and the stimulation of related sectors. This technique is particularly relevant for evaluating technology offset programs, in which outcomes may extend beyond the scope of the original project, generating diffuse benefits for the national economy.

Among the identified limitations, the scarcity of longitudinal data and the difficulty of isolating variables in complex R&D programs stand out. To address these challenges, the DOE recommends the establishment of integrated and iterative data systems that enable continuous updates and cross-validation, a practice that remains incipient in Brazil but is essential for improving the evaluation of ST&I policies in the defense sector.

The model proposed by the DOE provides a valuable methodological reference for the design of monitoring systems for PComTIC Defense, emphasizing the balance among technical rigor, institutional learning, and adaptability. When applied to the Brazilian context, this framework would support the consolidation of a systematic and prospective evaluation culture, transforming the assessment of *offsets* programs into an instrument for continuous innovation and not just contractual control.

3.3.4 Interpretative synthesis of Cluster 3

The triangulation of the NSF, OECD, and DOE reports reveals that international innovation evaluation practices converge toward an integrative and adaptive logic, in which indicators not only measure outcomes but also guide learning and policy formulation. These reports move beyond the traditional measurement-oriented approach by incorporating epistemological, ethical, and political dimensions.

In the Brazilian context, incorporating these lessons could enhance the evaluative maturity of defense policy, transforming the document clustering approach into an instrument for critical reflection and the generation of original knowledge, capable of proposing a national model for the evaluation of dual innovation—simultaneously technological and strategic.

4 FINAL CONSIDERATIONS

This study sought to understand how different approaches and evaluation instruments for innovation and technology transfer can contribute to improving the PComTIC Defesa and strengthening the Brazilian DIB. The analysis was structured around three complementary clusters—programs applied to small businesses, national public policies, and global organizations—enabling the identification of patterns, gaps, and opportunities for methodological convergence between international and domestic practices.

From a theoretical and methodological perspective, the research adopts a qualitative and interpretive approach, grounded in systematic documentary analysis and thematic clustering (Bardin, 2016). This strategy proved appropriate for addressing the complex and multidimensional nature of innovation policies, enabling not only the synthesis of evidence but also the reconstruction of epistemological connections among documents, actors, and contexts. Unlike purely descriptive studies, this analysis proposes a comparative model of evaluative rationalities—scientific, normative, and operational—derived from the analyzed documents and associated, respectively, with the reports produced by the NSF, OECD, and DOE.

The results obtained demonstrate that technological sovereignty constitutes a central pillar of national defense strategies and that the sustainability of the DIB depends on the State's ability to integrate innovation support, technology transfer, and evidence-based evaluation. This perspective aligns with Figueiredo's (2015) argument that technological development is a cumulative and systemic process sustained by continuous interactions among government, universities, and industry—the Triple Helix of innovation (Etzkowitz; Leydesdorff, 2000).

The documentary analysis demonstrated that international reports, such as Evaluation of the Small Business Innovation Research Program in Japan and Overview of Evaluation Methods for R&D Programs, provide relevant conceptual and methodological insights for improving Brazilian evaluation practices. In particular, three central dimensions stand out:

1. Institutional capacities and organizational learning, which are essential for transforming offset compensatory measures into lasting technological assets.

2. Long-term indicators and qualitative metrics capable of capturing learning effects, collaboration, and knowledge diffusion.
3. Participatory and ethical evaluation, incorporating multiple stakeholder perspectives and strengthening the transparency of public policies.

These dimensions reinforce that defense innovation should not be understood as an isolated outcome but rather as a systemic and evolutionary process whose effectiveness depends on the integration of normative instruments, measurement mechanisms, and interinstitutional governance practices. This conception is consistent with the principle of adaptive public policies (Almeida; Silva, 2025), according to which evaluation should be a continuous learning process, adjusted to the technological and geopolitical transformations shaping the global strategic environment.

Table 2 presents a synthesis of the main insights derived from the analyzed documents, highlighting the contributions of each source to the development of indicators and evaluation practices applicable to the defense sector.

Table 2 – Insights observed in the analyzed documents

Document	Insights observed
Evaluation of the Small Business Innovation Research Program in Japan	Strengthening of technical and managerial capacities of the companies revealed in the documents analyzed.
Evaluation Revisited Improving the Quality of Evaluative Practice by Embracing Complexity	Indicators developed to capture long-term benefits from investments in intellectual capital and organizational innovation are emphasized.
Estratégia Nacional de Defesa (END) [National Defense Strategy (NDS)]	The approach of documents regarding immediate impacts and long--term consequences is notorious.
Normative Ordinance No. 61/GM-MD	The emphasis on the importance of ethical values and consideration of perspectives of diverse stakeholders is clearly valued.
Manual de Indicadores do Plano Plurianual [Multi-year Plan Indicators Manual]	Documents establish a classification of countervailing measures, differentiating technological, industrial, and commercial measures.
Science and Engineering Indicators – National Science Foundation (NSF)	The precepts for prospecting, negotiating, implementing, monitoring, and controlling projects are outlined.
Measuring Innovation – A New Perspective – Organization for Economic Co-operation and Development (OECD)	The construction of indicators is based on the needs of decision-makers, a crucial aspect identified. The regional impact and contributions to scientific and technological innovation policies.
Visão Geral dos Métodos de Avaliação para Programas de P&D [Overview of Evaluation Methods for R&D Programs]	The significance of indicators, and their maintenance over time, is a key point discussed.

Source: Prepared by the authors (2024).

The joint analysis of the documents revealed that the effectiveness of defense ST&I policies depends on three structural conditions:

a. the institutionalization of a permanent evaluation system with technological, economic, and social performance indicators;
b. integration between civilian and military institutions to ensure coherence and continuity in innovation policies; and

c. intertemporal organizational learning based on empirical data and periodic performance reviews.

The results further demonstrate that well-designed policies, when supported by robust evaluation systems, can generate positive externalities (spillovers) both in the civilian economy and within the DIB. This finding reinforces the importance of adopting measurement approaches that extend beyond the boundaries of offset agreements, incorporating dimensions of open innovation, sustainability, and social impact (Bogers, Chesbrough; Moedas, 2018).

In summary, this research demonstrates that the evaluation of innovation and technology transfer programs should be multidimensional, adaptive, and integrated into the public policy cycle.

The interpretive clustering approach proposed in this study—by bringing together different evaluation traditions within a comparative perspective—represents an original methodological contribution, offering a framework for critical analysis that combines analytical rigor with practical applicability in the context of defense policies.

Thus, we conclude that advancing defense innovation policy requires the consolidation of a national technological evaluation system capable of generating reliable evidence, supporting strategic decision-making, and sustaining Brazilian technological sovereignty. This is a necessary condition for the country to move from a logic of contractual compensation toward a sustainable innovation strategy guided by learning, cooperation, and the development of national capabilities.

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