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A review on defense innovation: from *spin-off* to[1] *spin-in*[2,3]

Uma revisão sobre a inovação em defesa: do spin-off ao spin-in

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RESUMO: As inovações para fins de defesa estão entre aquelas consideradas de alto nível tecnológico. Os investimentos públicos em P&D são, historicamente, associados ao desenvolvimento de importantes tecnologias, as quais impactaram positivamente a economia. Contudo, após a Guerra Fria, as tensões mundiais se apresentaram em menor proporção. Os investimentos se reduziram, assim como a performance das empresas ligadas à defesa. A indústria de defesa não é mais a precursora de novas tecnologias. Nesse contexto é requerida uma atualização nas reflexões sobre a inovação em defesa.
PALAVRAS-CHAVE: Inovação; transbordamentos; defesa.

ABSTRACT: Historically, investments in innovation for military purposes have been presented as having a positive impact on economy development as whole. In this vein, the end of the Cold War is presented as an inflection point. The reduction in the number of international conflicts would have negatively affected investments in defense-related products, as the former was considered the driver of the latter. It argues that the decision of whether investing in the military or the civil sectors as the driver of economic development depends first and foremost on historic and socio-economic contexts in which decisions are taken.
KEYWORDS: Innovation; defense; spin-off; spin-in.
JEL Classification: O3.

[1] The economic studies about defense normally used the term *Spin-off* to characterize the occurrence of situations in which the product or a civil technology were originated on products or technologies developed initially to military purposes.

[2] Similarly, the term *Spin-in* is normally used when products or civil technologies make feasible new products or military technologies. Throughout the text, the term "overflow" is used in the same context to remit to these expressions.

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INTRODUCTION

The technological innovation was one of the main players on the Second World War, which had impacted all economy. Projects elaborated during this period include the atomic bomb, microelectronics (semiconductors), aeronautic sector, nuclear energy, informatics, among others (Rutan, 2006; Dosi, 1984; Mowery and Langlois, 1996). Next, the existent tension during the Cold War period had continued to motivate high levels of investments in R&D for projects with military purposes. According to Gansler (2011), such behavior from the North American government was based on the idea that the construction of big weaponry systems would be very expensive, then the investments should address the technological improvement that would ensure the country's forefront as well. The projects were developed by private companies, in partnership with laboratories and military research centers, subsidizes by non-reimbursable public financy, with alocation of significant qualified human resources, under the guidelines of the Armed Forces needs (Freeman; Soete, 1982; Dosi, 1984). These projects influenced the appearance of new technological paradigms; their impacts were called "overflows" or *spin-off*, as they were conceived to military purposes, but their application unfolded in many economic sectors. The overflows created significant debates about its positive aspects, in terms of improvements, and negatives, considering the costs.

However, the fall of the Berlin Wall represented to many the promise of an age that would be characterized by the decrease of tensions and great international conflicts. Against this feeling of reduction of the external threats, it is reasonable the occurrence of reduction in the spending directed to defense, particularly in the United States and in the European countries (Hartley and Sandler, 2005; Mallik, 2004). Changes in the political and socioeconomic contexts brings with it empiric and theorist changes.

The current work starts at the premise that the conditions under which the process of innovation in defense tends to be radical or disruptive, depending on the economic, politic and social context of any country[4]. Besides, it is believed that the innovation cannot be observed by the linear perspective, so the systemic perspective will be maintained, as developed by Freeman (1982, 1995), Nelson (1993, 1996) and Lundvall (1992). Those referred authors analyze the innovation as a systemic process, with certain diversity of economic agents and planned or unplanned actions, capable of enhance the technological progress. Such perspective is based on the concept of National Innovation Systems, which approaches the interactions among government, companies, educational, researching, and financing institutes, and other agents, in the area of technological development, considering the historical and cultural specificities of each country and region (Albuquerque, 1996; Cassiolato; Lastres, 2005).

[4] In this article, such premise is analyzed through the review of the international literature. It's important to be aware that it basically reflects the experiences in developed countries.

By using the examples of countries like the United States, the potential overflows are pointed as one of the factors that justified rises in the military expenses in Brazil as well. However, the specificities of these States or even the way in which this process has evolved on developed countries mostly are not properly considered, so the possibility of success of the presented purposes is disabled. The review of the topic intends to introduce elements that contribute to more suitable reflections in Brazil. Therefore, the objective of this work is to discuss the dynamic about the defense innovation that began in World War II, in a way that could be possible to contribute with the debates on this question through a proper contextualization. In real terms, two aspects will be prioritized: the innovative effort in the area of defense, and the relevance of technological overflows, starting in the 1940s.

In order to meet the proposed objective, this article is organized as follows: on the next section some specificities in the innovative process to defense purposes are presented, highlighting the influence of the main agents composing the system of innovation in this area. The third section discuss questions about the technological 'overflows' in the defense area, starting with the contextualization about the conditions to its occurrence, in particular on the Cold War, when there is a change of political and budgeting priorities in this area. Finally, some considerations are delivered, including the possible implications to this debate in Brazil.

CHARACTERISTICS OF THE SCIENTIFICALLY, TECHNOLOGICAL AND INNOVATIVE PROCESS IN THE DEFENSE AREA

The military innovation based on Science and Technology (S&T) can assume many forms. The results may range from the intangible individual knowledge – tangible results skills under the form of scientific reports and others publications –, to the creation of new investigation equipment, and final goods methods and production (Hagelin, 2004). In order to identify these results, the activities of Research and Development (R&D) are used – not just by the defense area – as an indicator of innovative and technological effort. Such measure is also adopted by the Frascati Manual of OECD.

However, it is observed that, in the case of the defense, the delimitation of the activities of R&D may vary according to the specificities in each study. The Stockholm International Peace Research Institute (SIPRI), for example, works with the definition of the military Research and Development (R&D) from the perception of who does the research. Thus, if the research is originated in a private institute, it is civil; the military R&D would be that developed in military laboratories and centers of research. To Molas-Gallart (1999) and Hagelin (2004) the possibility of the responsible not being a defense agency, but a private company, should be considered as well, in order to identify the existence of a public funding with military purposes, and thus keep the focus on the purposes of the R&D. Following this argument, the activities of technological development to military and national defense purposes are considered as military R&D.

According to Bellais (2013), while the military abilities always play an important role in defense matters, a new paradigm focused on technological questions gained significant relevancy during the 1940s. This model was reinforced along the Cold War and have been remained after 1991 till actual days, in a way that the technology-based defense is yet considered the best approach to solve the challenges of security in leader countries. The focus on the technologic research aims to avoid "surprises" that may compromise national security, what makes the performance in the scientific and technological areas fundamental (Saunders et al., 1995).

Relationship between technological development and national defense goes through the recognition of the importance of the interaction between technological and military innovation. While changes on nature of war may result in the usage of new technologies, this also can generate changes on military doctrines, operational and organizational concepts, also changing the character and conduct of military operations (Longo, 2007, 2009; Turner, 2000). In these terms, for example, Dombrowski and Gholz (2006) note that even on cases that the available technologies were similar, the differential on the choices were the practices and doctrines been used. This fact revels the importance of reflecting about the difficulties of training all the military contingent to the application of new technologies, which request time and new ways of management, with the intention of ensuring more practical efficiency.

In this scope, Tattar (2009) also analizes the correlation between innovative capacity and military performance and observes that this influence can be dynamic, but also decreasing. The new technologies would tend to lose your power of impact by spreading through knowledge transference and doctrinal updates, even more as the improvements became more sophisticated and complex. For this reason, this author, as Biddle (2005), concerns in emphasize that, although exists a contribution; in fact it's hard to measure how the innovation can contribute to success or victory in combat. When innovations in technologies, tactics, operations or strategies generate effects on the battle camp, other factors like strategic surprise, leadership, tactic and geography invariably, also play important roles (Tattar, 2009; Biddle, 2005).

In context of defense innovation, suppliers must deal with the specificities of the applicants. The demand process for innovation requests that the companies know about the functionings of the military institutions, as well as developing good political relationship, in order to provide the adequate care of the client's needs, which includes knowing the applicability of the ordered technology. This information can many times be attributed to specific sectors of the companies, it also includes hiring of reserved military that know the functioning of public and military institutions, being able to ensure higher efficiency in the interactions, which are needed to succeed in the innovative process (Dombrowski and Gholz, 2006). This way, the maintenance of actual suppliers can be of the behalf of both parts. On the requester's point of view, keeping familiar suppliers can be useful when old systems are kept and the incremental innovations can keep them in activity for a longer

time. However for the companies, there are lesser political and learning costs (Markowski et al., 2010).

On the other hand, Dombrowski and Gholz (2009) emphasize that new companies that are more willing to develop radical innovations, cannot adequate themselves to the political relationship required in the military acquisitions or may not be seen as reliable by the buyers, making the companies already familiar as more viable, despite the possible accommodation in the search for innovations. Thereby, the starters would have space only in areas in which there was no traditional supplier. Thus, to Hasik (2008), by choosing the suppliers, the government is not only determining which will be the developed technologies, but also which companies will have more chances to be commercially successful.

The search for technological innovations in defense area is also influenced by the perception of external threats, as observed, for example, in relation to the progress achieved by the United States during the Cold War, in response to the Sovietic behavior (Murray, 2001). However, if the insecurity feeling is reduced, the tendency it is the progressive reducing of this investments, as occurred in the same country during the 1990s, for example (Murray, 2001). In this situation, defense companies started to engage in convincing the military leaders that they understood the requirements to new defense systems, and that they had technical ability to develop the innovative equipment, in an effort to maintain the demand.

In general, the political influence of the companies that work in the defense area leads to focusing on marketing actions, not only through the relationships with the Armed Forces, by previously identifying clients for new products, but also by applying politic pressure, action known as lobby. Lobby interferes in the acquisition of new technologies and the efficiency of the choice, because those companies already known and/or with better relationships are indicated. This can result in the acquisition of known technologies and a few incremental innovations of low impact, while potential new starters, which may have more impetus searching truly new technologies, can be removed of the innovative process (Dombrowski and Gholz, 2006).

The fact that the government, mainly the Armed Forces, is the financier and main consumer of the ordered projects allows the allocation of public resources to projects of R&D, according to the country's military needs, which are defined by the Armed Forces, as affirmed by Hagelim (2004, p. 288):

> S&T-based military innovation can take many forms, but pursuing it generally implies deliberate, long-term support for basic and applied research and technology development by defense ministries, military R&D and/or acquisition organizations, and armed forces. Such support may be extended to individual scientists or select projects and take the form of, for instance, direct financial support, exchange programs, shared facilities and joint research programs, or it may involve the military in "centers of excellence". Thus, S&T-based military innovation implies an increasing involvement of non-military participants in military innova-

> tion, such as universities and other public and private organizations as well as commercial business enterprises. Since such S&T activities are not defined as military activities, military support, participation and sharing of results are normally not complicated by military security restrictions.

This enforces the perception that R&D or even R&T (Research and Technology, as mentioned) require the interaction among the research institutions, the government, the Armed Forces (AF) and the companies. Therefore, decisions about what technology will be developed and which company will be responsible for the production are factors that influence the search, or not, of a new technological paradigm. Such decisions depend not only on the Armed Forces demand specificities, but also on the acceptance and budgetary authorization of the government, reinforcing the political influence in the innovative process. To Dombrowski and Gholz (2006, 2009), in some cases, possibly the choice of technologies to be acquired will be more influenced by political relations than by AF recommendations and financial calculations.

However, in spite of the acknowledged influence of the corporate lobby on the Ministry of Defense, especially in the United States, Ruttan (2006) argues that this kind of action has had fading influence on governments. These changes stem from the large and deep budget cuts in defense, which began in the 1990s and generated a restructuring of the defense industry, reducing the number of active companies and changing their position of dependence on military purchases. Against the budget cuts, companies began to focus mainly on the security civilian market and on the search for technologies that would attend this market.

During the 1970s, Melman (1974) had observed that compliance with specific demands, bureaucracy management, and military demands imposed high costs, in some cases up to three times higher than in other sectors of the economy. This aspect is also reinforced by Molas-Gallart (2008) when affirming that, until the end of the Cold War, the defense industry had been focusing on the increasingly demanding requests of the Armed Forces, which, in turn, always paid more for the improvements requested. The acquisitions were therefore determined by the product itself, without any concerns with the production costs. Innovations were becoming costly and inefficient, which the author called *gold platin* (gold-plated).

> Without the cost constraints of civil industry, and with the support and even encouragement of the customer, the military industry tended to generate systems of increasing complexity (and cost) by introducing new features and capabilities into each new generation of armaments. This practice has been described as "gold plating" to refer to the unnecessary of many of the capabilities and benefits that these products exhibited, and its result as "baroque technology": as the systems incorporate new functions. They were born more expensive to obtain, to maintain and difficult to operate (Molas-Gallart, 2008, p. 77).

As a result of the several factors mentioned, innovation in defense ends up differing from that observed in other sectors. For Sempere (2015), defense innovation depends on the acquisition dynamics that tends to take at least 10 years to require diversification (average equipment replacement times in developed countries and during peace times). According to the author, the innovation selection criteria to be implemented are less based on market efficiency. Thus, innovation in defense would have, over time, been conditioned by political and bureaucratic factors, while innovation in the civil area is market driven, which demands variety and also offers feedback in the short term, making the process much more dynamic.

Therefore, notwithstanding the significant technological advances arising from research for military purposes, it is observed that due to its intrinsic characteristics and management, the process has become expensive and inefficient, leading to a transformation of its role in the national innovation system. This transformation will be the focus of the next section.

FROM SPIN-OFF TO SPIN-IN: OVERFLOWS, ECONOMIC IMPACTS AND FLUX REVERSAL

While analyzing the leadership of the world system, military power allied with technological and economic potential are considered determining factors for achieving and maintaining hegemony, being also able to deepen differences in the patterns of economic development (Wallerstein, 1974, 1983; Fiori, 2004). This perception is particularly based on the American case, which would have promoted its "technological and military *catch-up* through an organized national system of innovation" (Moreira Jr., 2014, p. 32). In this sense, going beyond the debate on the hegemonic cycles in the field of political economy, as observed by Arrighi (1994, 2007), the relation between military power and technological development is extremely articulated to the economic development of the countries.

In the economic studies on innovation, which generally stem from Schumpeter's (1911) analysis of the relevance of innovation for economic development, the relationship between technological development and military purposes actions has also been emphasized. Nelson (1996) points out that the post-World War II American rise is due to its unique performance in the mass-production industry and high-tech industries, which reflected massive private and public investments in research and development. According to Dosi (2006, p. 48), "military programs in particular functioned as a powerful targeting mechanism for defined technological targets, while at the same time providing financial support for R&D and securing the market through Government purchases." In the same sense, Freeman and Soete (2008, p. 650) believe that

> [...] it seems difficult to deny that the industrial military complex has been a reality that greatly affects the behavior of companies, at least in some industrial branches. The scale and complexity of modern technol-

ogy has been taken to the extreme in research, design and development of military aircraft, missiles and nuclear weapons.

The scientific and technological performance reported by the above authors refers to the projects developed for military purposes in the period between the two great wars and more strongly from the Second World War, which ended up establishing new technological paradigms in the civil industry. Ruttan (2006) considers this process close to that of *Big Science*. For Malliki (2008), defense research was the engine of technological growth during the Cold War years, with a number of benefits addressed to the civil sector. The main impacts of this period were observed in the aeronautics and space industry, in the semiconductors industry, and through the development of the internet, computers and nuclear energy.

The impact on the aforementioned sectors generated a great deal of expectation around the defense innovation system, from which technological overflows were expected on an ongoing basis, the so-called *spin-off* effect. This effect became a constant ally in justification for greater investments in the defense area, including in the maintenance of the industry, particularly for Military Keynesianism. As a result, the industry began to look for ways to develop products with dual application – military and civil – that would guarantee greater return on investments made (Rutan, 2006; Dunne and Braddon, 2008; Sempere, 2015).

The effort towards technological improvement for military purposes continued to be intense during the Cold War, as well as the arguments for the *spin-off*, mainly in the United States and the Soviet Union, and in some European countries such as France and England. However, unlike the post-Second World War period, the 1980s were marked by low economic growth in the United States and the former Soviet Union, countries with the highest R&D spending at that time. On the other hand, Japan and Germany had barely invested in this heading and grew considerably at the same time, reinforcing questions about military Keynesianism as a driver of economic development. As for the limitation of overflows, Sempere (2015) summarizes the following points in his review:

- Defense innovation is more driven towards product development for military missions rather than basic or applied research. For this reason, technologies tend to be more specific and less dual, which reduces the chance of splitting;
- Defense technologies may be restricted, therefore delaying their diffusion into the civilian market;
- Technologies with civil application potential may still require considerable development to obtain a commercially successful product. Defense innovation can have an effect of *crowding out* on the civilian innovation market.

In their study of the economic impact of military R&D, Dunne and Braddon (2008) are even more pessimistic, and point out that military spending has had an insignificant or negative effect on economic growth in developing countries and an obvious negative effect on developed economies. Even during the Cold War, the impact of military technologies on the economy had become less noticeable (JAMES,

2009). This finding stems from structural changes in companies and political strategies, as the end of the Cold War significantly altered the *modus operandi* that was established in the immediate post-Second World War, profoundly affecting the innovative process and the direction of overflows.

According to Mowery (2010), in the 1980s, 1990s and 2000s there was a decrease in government investments in R&D. In the 1980s, R&D expenditures accounted for 38% of the total investments made jointly by the governments of Germany, Japan, France, Sweden and the United Kingdom. In the following decade, this percentage fell to 30% and during the years 2000, to 21%. In the U.S., R&D spending, that once accounted for 80% of federal investments, dropped to 40% in the early 1990s (Mowery, 2012).

According to Molas-Gallart (2008), if buyers had been finding a more favorable scenario during the Cold War, with the end of tensions, the cuts in defense budgets and the reduction of the government demand and the Armed Forces influence were inevitable, as well as the significant reduction of investments addressed to scientific and technological processes. This way, the acquisitions were affected and the government was not the main customer anymore. Military demand became less attractive, even financially, especially because all the requirements and regulations were maintained as before. Consequently, according to Bellais (2013) and Molas-Gallart (2008), military customers reduced the magnitude of the regulations, which made the process more costly, allowing for reductions in the production costs of the supplier companies and focusing on the commercial market. These authors also point to an intensification of the concerns related to internal security, which now add to the defense in some countries. Such reasoning requires new reflection on management of this system, which in turn demands training from the public institutions responsible for coordination, as well as policies that affect the defense.

Thus, the system has become progressively more open, with the participation of new actors; it is no longer restricted to military institutions and their rules, so that the paths of the innovative process are now driven by civilian technologies. These transformations give rise to a greater dependence on the civilian market rather than the defense market, as well as the adoption of management procedures inspired by the private civilian molds, and the intensification of the concerns related to internal security. On one hand, technological advances allowed companies to diversify their commercial production, previously restricted to military orders, so that they now have a larger consumer market. On the other hand, the government and the Armed Forces lost monopsony, thus reducing their influence on the technological trajectory (Molas-Gallart, 2008; Bellais, 2013).

Since the 1960[1]s the civil industry has been responsible for the improvement of technological innovation, especially about incremental innovation and the new paradigms diffusion in areas like semiconductors and information technologies. These incremental innovations would have ensured the vanguard of technology to the civil industry, which would take the lead in terms of radical innovations as well. As a result, several authors (Dosi, 1984; Ruttan, 2006; Gansler, 2011; Molas-Gallart,

2008) have argued that the overflowing effects of defense technology on the others would not be as significant.

Thus, while the argument of the *spin-off* has not been resistant to the impact of budget cuts for defense – and these overflowing effects no longer have the same relevance – the authors noted that the civil segment presented the technological dynamics in economy. In this regard, Mowery (2010) believes that investments in military R&D were a major impetus for technology in times of war, but the more concrete results came in times of peace, especially as civilian firms gained access to new technologies. Thus, it can be understood why civil-industry research has had greater commercial success after the Cold War. This fact changed the flow of the overflows and generated the so-called *spin-in*.

This perception is reinforced by Stowsky (2004), who adds that with the advent of communication technologies, technological diffusion has been increasingly rapid and intense. This, in turn, reduces protection over technologies used for military purposes, as a number of countries have access to information in a short period, reducing advantage over adversaries. Finally, the aforementioned author argues that the interactions among military institutions with national and foreign companies should be taken to benefit expanding of technological development and achieving greater productive efficiency, relegating the industrial secret to a secondary role. Lin et al. (2007) observed, for example, that many technologies have proved to be inefficient while facing terrorist attacks, even with the easier access to more modern technologies, which requires greater scientific and technological research to deal with the specificities of this kind of conflict. Therefore, the researchers also reinforce the assumption that conflicts and wars increase the demand for new technologies and, consequently, boost the investment in national defense.

For Ruttan (2006), the results obtained from technological overflows were only possible due to the period of strong military tension, in which the high and urgent investments enabled the success of these projects. However, the author does not believe it is possible to repeat this success after the reduction in military R&D budget in many countries since the 1990s, even if private investment reaches such levels of success and with the entire lobby made by companies connected to the area. While discussing whether war is necessary for economic growth, Ruttan (2006) recognizes that military innovations have had significant impacts on the economy, but suggests that one must consider changes in the world context, especially in terms of the relationship between civilian and military innovation, and how such changes can be transformative.

FINAL CONSIDERATIONS: SOME IMPLICATIONS TO BRAZIL

The bibliographic review here presented indicates that the defense innovation is afected by some specific factors, like the adherence to the doctrine, the military tension and conflicts, the public budget to the defense R&D, the role of the Armed Forces and the interactions of the national system of innovations relationed to the

area. It is observed that the technology should adequate to the doctrine in progress, and that transformations in the doctrines may demand new technologies. The existence of armaments races, politic tensions or conflicts enhance the military expenses, including those designated to the R&D. However, in the absence of these circumstances, cuts are often made. The participation of the Armed Forces and the State in the institutional scope of the innovation process of is differentiated, since it is stimulated in the initial moment, and may ensure a monopoly in the future. This factor admittedly reduces the productive efficiency of the companies.

The defense innovation system is modificated by the reduction of pressure deriving of the war occurrences. Particularly after the Cold War, the *spin-off* effect, for example, which was widely applicated to justify the huge investments in military R&D, has no longer been recognized in the same way. Along with the budget cuts, there is a reduction on the influence of the Armed Forces on the innovative process, with the concomitant leadership on the civil technologies. The defense products became just a fraction of the companies' productive plant, in such a way that the innovative process has had a stronger impulse in commercial or civil area. This area has been influencing the technological improvements in military area, inverting the order of the technological overflow.

It is important to point out that the bibliographic review in this work is mainly based on the examples of developed countries. However, in Brazil, these examples used to guide the debate about the industry and defense innovation, mostly the examples of success in the *spin-off,* with little or no attention to the context and to occurred changes. For this reason, it is relevant to highlight some points.

In Brazil, Fonseca (2000) tried to analyze the evidences of *spin-off* in the country by presenting many projects in which it the technological overflow isobserved. The author recognizes that a great part of the technologies that has enabled this *spin-offs* arose from the process based on the reverse engineering, way beyond the search for better productive qualification of industry, which defines the profile of the follower companies since the 1970s and the mid-1980. During this period, the proximate of the civil companies with those of higher military character, as well as those with dual production, would have enable significant benefits related to the overflows, as in the case of Avibrás and the others less known companies (Fonseca, 2000). Yet according to this author, companies origined in the civil market that started to produce defense products are more dynamic, satisfying both markets, civil and military. In addition to what Fonseca has pointed out, this characteristic shows that despite having a less specific production, civilian industries can be mobilized for defense purposes.

However, given the argument that the Brazilian defense industry is able to generate overflows of the innovations developed in the military area for the civil area, Dagnino (2007, 2010) affirms that national companies do not present indicators that point through this direction. According to the researcher, by observing data such as the number of patents registered by Brazilian companies and their innovative performance, the ability of the companies to absorb new technologies or even to commit themselves to a joint effort for their development and the ap-

plication of these technologies is suspicious. The indicators suggest that the percentage of patents registered in Brazil is very low when compared to other countries, and that the innovative effort of the companies is still internally concentrated and, in most cases, with greater emphasis on machinery and equipment purchase. Dagnino also considers that the level of investment in R&D by companies is still very low, as is the absorption of masters and doctors in areas such as engineering. These factors would limit the ability to grasp new knowledge, especially if these were related to new technological trajectories. Leske (2015) corroborates this perception by pointing out that defense-producing companies have an innovative profile when compared to the national manufacturing industry, but this feature is still based on reverse engineering (which reinforces the profile of follower companies rather than leaders, as proposed by Freeman and Soete [1982]), with fragile interaction with the Armed Forces, discrete export profile and low use of public policies.

The aspects related to the national industry must also be considered. According to Carvalho and Kupfer (2011), the specialization of the national productive structure was apparently precocious and directed to less competitive sectors. For Bresser-Pereira et al. (2016), Brazil has suffered from deindustrialization due to the stabilization policies introduced in the 1990s, among other things, which left the country susceptible to unfavorable exchange rate variation. What these and many other authors observe is that Brazilian industry has had difficulties in operating in more competitive sectors, specifically in those that are technology intensive and that this is not only a consequence of a lack of industrial policy, but also derives from harmful fiscal and monetary policies.

Thus, it must be noted that the productive structure as a whole should be included in the analysis of the Brazilian case, since it may limit the possibilities of technological overflows, the *spin-off*. On the other hand, would it be possible to plan defense innovation from the benefit of the *spin-in*? This and other issues related to the Brazilian case are beyond the scope of this study and should be developed in future endeavors.

Finally, it is believed that the understanding of the aspects related to defense innovation and how their behavior varies according to the environment contributes to the analysis of their profile in a general way. These elements can foster reflection on Brazil's possibilities in terms of defense innovation and industry. The country has very specific economic, social and political characteristics. Thus, any policy action or recommendation should consider the scarcity of existing resources, mostly in defense, the scientific and technological capabilities of the national industry, as well as the institutional routines that – deeply – affect the interactions within the innovation system, and specially the lack of involvement of the country in armed conflicts. Only with such reflections, it would be possible to think about an innovative and productive defense system that is adequate for Brazil.

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