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The Triple Helix and its Intervention in the Research and Development of Products for International Security and Defense*

Guillermo Alfonso Giraldo Martínez^a ■ Luis Rodrigo Valencia Pérez^b

Abstract: This article aims to analyze the concepts and relationships of the Triple Helix Model (THM) proposed by Etzkowitz & Leydesdorff as applied to international security and defense and the contribution of THM to the development of knowledge-based economies. The method used was a qualitative, descriptive analysis, reviewing reliable scientific sources and official web pages of countries and organizations such as the United Nations Educational, Scientific and Cultural Organization (UNESCO), the North Atlantic Treaty Organization (NATO) and the European Union (EU). The results showed that the generation of capacities in Science, Technology, and Innovation lead to assets in security and defense and the systemic development of products and innovative initiatives, creating a virtuous circle that allows universities, states and firms, to evolve basing their growth on the development of knowledge. Finally, as a conclusion it was found that investment in research and development in defense and security, articulated with the actors of the Triple Helix, is a driver of technological change that strengthen the concept of knowledge-based economies in the countries that achieve this articulation, as evidenced in the cases analyzed.

Keywords: Defense; economic and social development; innovation; security technology; triple helix

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La Triple Hélice y su intervención en la investigación y el desarrollo de productos para la seguridad y la defensa internacionales

Resumen: este artículo tiene como objetivo analizar tanto los conceptos y relaciones del Modelo de la Triple Hélice (MTH) que propone Etzkowitz y Leydesdorff aplicado a la seguridad y la defensa internacionales como la contribución del MTH al desarrollo de economías basadas en el conocimiento. El método utilizado fue un análisis cualitativo y descriptivo mediante la revisión de fuentes científicas confiables y páginas web oficiales de países y organizaciones como la Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura (UNESCO), la Organización del Tratado del Atlántico Norte (OTAN) y la Unión Europea (UE). Los resultados mostraron que la generación de capacidades en Ciencia, Tecnología e Innovación produce activos en seguridad y defensa y conduce al desarrollo sistémico de productos e iniciativas innovadoras. Este círculo virtuoso les permite a universidades, estados y empresas evolucionar fundamentando su crecimiento en el desarrollo del conocimiento. En conclusión, se encontró que la inversión en investigación y desarrollo para la defensa y la seguridad, en articulación con los actores de la Triple Hélice, es un motor de cambio tecnológico que fortalece el concepto de economías basadas en el conocimiento, como se evidencia en los casos analizados.

Palabras clave: defensa; desarrollo económico y social; innovación; tecnología en seguridad; triple hélice

A Tríplice Hélice e sua intervenção na pesquisa e desenvolvimento de produtos para segurança e defesa internacional

resumo: Este artigo tem como objetivo analisar os conceitos e relações do Modelo de Hélice Tríplice (THM) proposto por Etzkowitz & Leydesdorff aplicado à segurança e defesa internacional e a contribuição do THM para o desenvolvimento das economias baseadas no conhecimento. O método utilizado foi uma análise qualitativa, descritiva, revisando fontes científicas confiáveis e páginas da web oficiais de países e organizações como a Organização das Nações Unidas para a Educação, a Ciência e a Cultura (UNESCO), a Organização do Tratado do Atlântico Norte (OTAN) e a União Europeia (EU). Os resultados mostraram que a geração de capacidades em Ciência, Tecnologia e Inovação levam a ativos em segurança e defesa e ao desenvolvimento sistêmico de produtos e iniciativas inovadoras, criando um círculo virtuoso que permite que universidades, estados e empresas, evoluir baseando seu crescimento no desenvolvimento do conhecimento. Por fim, como conclusão constatou-se que o investimento em pesquisa e desenvolvimento em defesa e segurança, articulado com os atores da Tríplice Hélice, é um propulsor de mudanças tecnológicas que fortalecem o conceito de economias baseadas no conhecimento nos países que realizam essa articulação, conforme evidenciado nos casos analisados.

Palavras-chave: defesa; desenvolvimento econômico e social; inovação; tecnologia de segurança; hélice tripla

Introduction

Knowledge, productivity, education, and technology were not determining factors in economic growth at the beginning of the 20th century; however, with the democratization of information, capital and work became a factor of support for the development of economies and knowledge became the central axis for the generation of wealth. It is for this reason that the Organization for Economic Cooperation and Development (OECD) in 1996 coined the term knowledge economies as those that show dynamism and growth originated by the production and intensive use of information, technology, and knowledge, and, where knowledge is the greatest driver of growth, wealth and employment.

Under this concept, the knowledge generation capacity of a state will frame the well-being, social and economic development of its citizens, becoming an asset that requires the development of tools for the systemic growth of knowledge, resorting to the development of the science, technology and innovation as productive factors of society.

Models such as the Triple Helix proposed by Etzkowitz and Leydesdorff, designed to explain the development structure of knowledge-based economies, become important to guide the productive processes of a nation (Leydesdorff, 2012). For this reason, this article relates how the defense sector works in the dynamics of knowledge economies, how these are integrated into the three axes of the Triple Helix (Etzkowitz & Leydesdorff, 1995), where spaces of knowledge, innovation and consensus are generated, how the THM components are reflected in the sector (Ranga & Etzkowitz, 2013), and how investment in science, technology and innovation in the defense sector stimulates the economy and strengthens other economic sectors by analyzing the cases of successful projects in defense research and development in which actors of the Triple Helix take part.

This article aims to solve the following research question: how does R&D in security and defense at the international level drive science, technology, and innovation activities and the development of knowledge-based economies with the interaction

of the triple helix? The foregoing, supported by thematic axes based on industry, technology, politics, and strategy.

To do this, this research established the objective of analyzing the concepts and relationships of the actors in the Triple Helix Model (THM) proposed by Etzkowitz & Leydesdorff and their intervention in the research and development of products for international security and defense and the strengthening of knowledge-based economies. This was supported by studying the cases of reference countries for their scientific and industrial development in the security and defense sector of the continents of Africa, America, Asia, and Europe.

Methodology

The research under the qualitative approach takes as a sample related homogeneous cases to understand the phenomenon related to the concept of the Triple Helix, extracted from reliable scientific sources, official websites of countries and organizations such as the United Nations Organization Education, Science and Culture (UNESCO), the North Atlantic Treaty Organization (NATO) and the European Union (EU), and reviews reports and official reports to analyze the previously raised problem of understanding how the triple helix is involved in the research and development of products for international security and defense and allows the development of economies and societies of knowledge delimited in the study of cases presented in South Africa, Sweden, China, the United States, and the European Union.

In the investigation process, books, book chapters, and cases with validated information on the operation of national security and defense were reviewed, analyzed, and synthesized. The qualitative approach was used for the development of this article through the collection of consolidated information in documents, records and bibliography of the concepts generated in the triple helix by the representative exponents of this area of knowledge, taking as reference the number of citations in Microsoft Academic, filtering by the terms “triple helix” and taking the two authors who have

published the most publications in scientific journals on this topic “Henry Etzkowitz” and “Loet Leydesdorff”. Subsequently, a search was carried out on this same topic in the Redalyc database to consult Latin American publications, generating and taking a sample of twenty-four (24) documents for the development of the article.

Likewise, a search for cases was carried out in the Science Direct database and in different sources of information from defense entities and official documents in reference countries such as South Africa, Sweden, China, the United States, and the European Union on issues of R&D&I of Defense.

For the elaboration of the article, two thematic axes were used under which the documents that were taken for its construction were analyzed:

1. The thematic axis based on the THM: to determine the entire conceptual framework of the model, its dynamics, components, spaces for interaction and relationships.
2. The axis of analysis of official documents of the governments of South Africa, Sweden, China, the United States, the European Union, and case studies of the companies of the military industry, to reflect on the development of the THM scheme within the defense sector as it locks itself low.

The approach design used was phenomenological under the empirical approach, with a descriptive scope, seeking to analyze the common and different experiences related to THM presented in the countries and explore, describe, and understand the different perspectives and shared experiences related to this concept. (Hernández Sampieri *et al.*, 2014).

Theoretical framework

The Triple Helix Model (THM)

Multinational institutions, such as the European Union (EU), the World Bank (WB) and the United Nations (UN), are moving to adopt knowledge-based economic development concepts that lead the productive and regulatory spheres of society to new configurations (Etzkowitz & Leydesdorff, 1995). The transition from a political economy to a knowledge-based economy became an important engine of competition at the macro level after the fall of the Berlin Wall and the demise of the Soviet Union (Leydesdorff, 2012). Knowledge-based economies function under the dynamics of economic exchange in markets, geographic variations and the organization of knowledge (see Figure 1

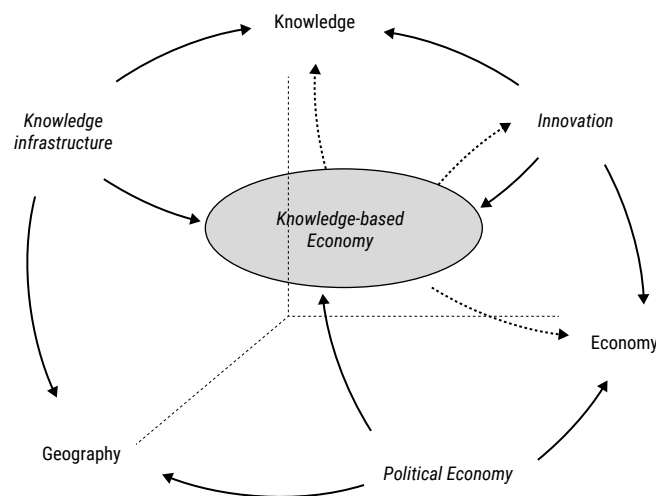


Figure 1. Economic relations based on knowledge

Source: Leydesdorff & Meyer, 2003

Knowledge-based economies relations). These three axes are integrated through the following factors (Leydesdorff & Meyer, 2003):

1. Knowledge - economy, integrated by innovation
2. Knowledge - geography, integrated by infrastructure
3. Economy - geography, made up of economic policies

The foregoing strengthens the concepts and novel work models that characterize this era: “the knowledge society” and “global economy” and, with them, special mention is made of knowledge in its various forms (creation, application or dissemination), as a resource and key product of socioeconomic management (Mora, 2014). It is here where the THM appears as a tool where the relationship between universities, companies and the state is considered in order to promote the development of the economy and society, and from which contributions are expected from three perspectives:

1. From the economic evolution, focus on the functions of the knowledge infrastructure in advanced systems (industrial) and consequently with the R&D policies.
2. Starting from the sociology of science, technology and higher education, reform the knowledge infrastructure such as technological sciences and the R&D systems of universities so that they lead to the intellectual reorganization of disciplines.
3. Starting from political analysis with an evaluative perspective, to make efforts to achieve changes in the relevant interfaces between science-technology-industry (Etzkowitz & Leydesdorff, 1995).

Although some authors speak of a tetra helix including actors such as society, in this article it is handled in an intrinsic way, because with the projects resulting from the interaction between the actors of the triple helix, we seek to obtain a benefit for society.

In the last two decades, THM has been viewed from two perspectives (Ranga & Etzkowitz, 2013) as related below:

1. Institutional perspective: where various aspects such as shareholders, socioeconomic development, vehicles, barriers, benefits and impact of technology transfer in university, entrepreneurship are studied; regional contribution for development, government policies, and aid for industry and university connections (Ranga & Etzkowitz, 2013). This perspective raises the following types of configurations of the triple helix
 - Static: the government plays a leading role, directing the academy, the industry and limits its capacities for initiative and development of the transformation of innovation.
 - Laissez-faire: limited intervention of the state in the economy; industry as a guiding force and the other two as support structures with limited roles in innovation: the university as a provider of qualified human capital and government as a regulator of social and economic issues.
 - Balanced: the three actors work in partnership. Each of the actors can take joint initiatives, this configuration offers greater insight into innovation because intersection spaces are generated where creativity emerges in synergy, where each of the actors can take the role of another in new organizational formats. This creates new technologies, new companies, and new types of relationships.
2. Evolutionary perspective: the three actors are subgroups that co-evolve and interact through networks and organizations that overlap, such as, for example, markets and technological innovation. This concept is inspired by the theory of social systems of communication and the mathematical theory of communications.

These interactions are part of two processes of communication and differentiation: one functional between science and the market and the other institutional between public and private control

at the level of universities, industries, and government. The interaction between the triple helix actors can be measured in terms of entropic probabilities (Ranga & Etzkowitz, 2013).

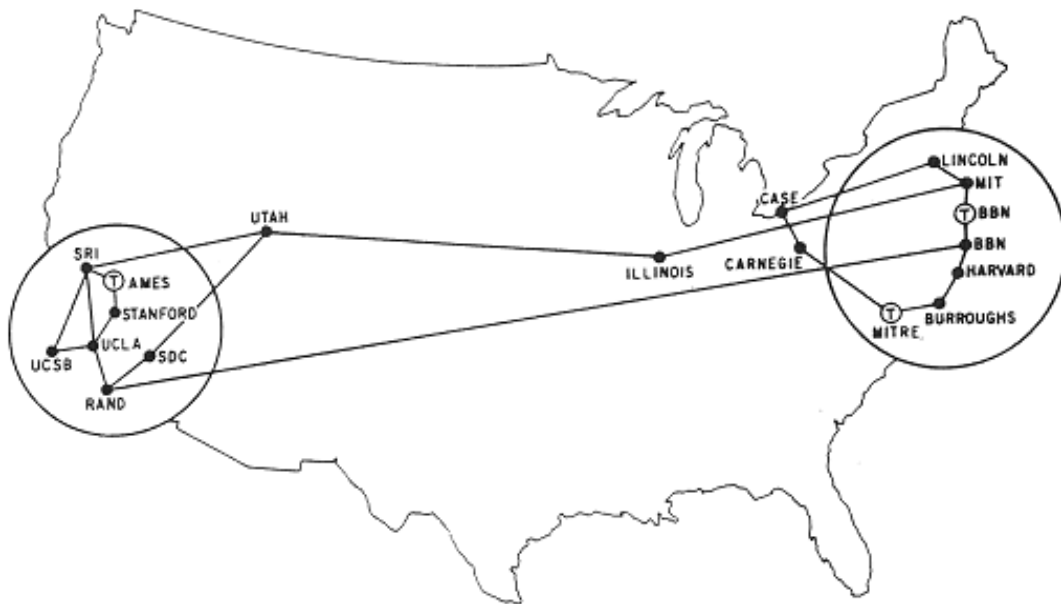
Results

The triple helix creates new social and institutional formats for the production, transfer and application of knowledge that contribute to economic development through knowledge societies. These new formats encompass creative destruction (which is natural) and the development of creativity, which arise within each of the three actors (Ranga & Etzkowitz, 2013). In this way, this virtuous circle allows humanity to access great technological changes, because institutions and their relationships provide a solid knowledge infrastructure that is strengthened to take on increasingly complex challenges (Leydesdorff & Meyer, 2003).

One of these great technological changes was produced by the Advanced Research Projects Agency (ARPA) through the United States

Department of Defense. The ARPA was made up of about 200 high-level scientists and had a large budget and was focused on creating direct communications between computers to connect the different research bases through the 'ARPANET' Network (see Figure 2. ARPANET Network 1971) connecting universities, private research centers and state entities.

Subsequently, due to the success of the network, computers began to be developed exponentially and this evolved into the World Wide Web (www) network today known worldwide as the Internet. While a political economy provides an institutional infrastructure, a knowledge-based economy develops in terms of communication flows through networks (Leydesdorff & Meyer, 2003) and it is here where the THM acts within the development dynamic of its actors in the improvement of national innovation systems (Leydesdorff, 2012), forming transcendental knowledge networks that facilitate the exchange, empowerment, generation, sharing and creation of new knowledge.



MAP 4 September 1971

Figure 2. ARPANET Network (1971)

Source: Universidad ICESI, 2019.

The knowledge base is fed back from the economic exchange and the organization of knowledge in innovation. Innovation arises from the interaction and relationship between the three helices: the potential for innovative knowledge, economic resources in conjunction with market possibilities and the norms and incentives of public innovation policies, which generates economic wealth, production based on new knowledge and the geographic variety to place contributions analytically without requiring the basic presumption of a priori integration (Leydesdorff & Meyer, 2003).

Understanding these relationships is important as it shows how the political economy gradually transformed to adopt knowledge as its main base as a consequence of the fact that the battle between different ways of configuring political economies had become obsolete (Leydesdorff, 2012). The most explicit reflection of this transition can be seen in the opening of China, where the change from a communist economy to a capitalist one based on knowledge, mainly committed to strengthening its industry, to positioning its universities among the best in the world (understanding that its growth was in the capacity to produce knowledge), the generation of state policies of opening to international trade and expansion of the Chinese economy. At the same time, terms such as the “new silk road” were grouped together, in which new approaches to development, cooperation and investments were proposed to geo-strategically position it as an important international actor, as well as an economic superpower of the 21st century (United States Department of Defense, 2020; Zheng-hong, 2007).

This change proposed by Deng Xiaoping, who considered that the only way for China to access the status of a great power was through a systematic policy of modernization with emphasis on economic development and maintenance, as has been indicated, the control structure. All this was encompassed under the motto of the four modernizations “agricultural, industrial, scientific and technological of national defense” (Cesarín *et al.*, 2005; Cheung, 2016)

This caused China to focus on carrying out structural reforms accompanied by an increase

in investment, to face environmental threats, improve business productivity and create a higher quality scientific workforce. Likewise, it took on the role of imitation through the transfer of foreign technology for dual use (civil and military) that would improve the capabilities of their defense industry in technological absorption, generating significant productive impact under an endogenous innovation strategy that consisted of three steps: introduction, assimilation, and re-innovation. This made it possible to generate a guided model of technological development based on advanced imitation, integrating innovations and generating original innovations from their country (Cheung, 2016).

China is the Asian leader in defense R & D, which is linked to its economic development of the last two decades, its geostrategic positioning in the region and the increase in its investment in defense spending in recent years above GDP, with an investment for the year 2019 of 177.418 billion dollars. Among its strategic objectives, China increasingly seeks to take advantage of its growing economic, diplomatic, and military influence to advance its national objectives and expand its international influence. Xi Jinping has predicted that China will become a world leader in science and technology (S&T) by 2050, projecting that by 2022 China’s budget in R & D will exceed that of the U.S. (Bitzinger, 2011; Budden & Murray, 2019).

This leads to the fact that functional and institutional roles can be exchanged on the basis of knowledge based expectations, as in the case of the “entrepreneurial university” (Leydesdorff & Meyer, 2003), with the transformation of the role of the state in academia, the role of corporations in innovation and of the university in economics (Etzkowitz, 1983 and 1995). The university and the company are taking on tasks that were once largely each other’s province. The boundaries between public and private, science and technology, university and industry are constantly changing. As the university crosses traditional boundaries in developing new links with industry, it develops formats to make research, teaching, and economic development compatible (Etzkowitz & Leydesdorff, 1998).

This forces the actors of the triple helix to modify their actions; entrepreneurs must regain confidence in academia, universities must train through their graduate programs managers in commercialization of technologies that can create the technology transfer offices within universities and companies. Understanding that the third mission of the university (apart from teaching and research) is to expand its role in the development of the economy, it must create bridges to reduce the technological gaps that are emerging. Although companies have increased their interest in collaboration with other universities, companies and government laboratories to develop technological knowledge in different areas of knowledge, a systematic flow of knowledge must be strengthened and guaranteed for the growth of the economy, in which the actors understand the role and perspective of each other, to improve the decision-making processes.

In Latin America, Brazil, due to its extensive territory, has been forced to use military innovation to contribute to local and regional development through technological innovations and the production of material, promoting the national defense industry. From the point of view of national defense, scientific and technological development is essential to achieve greater strategic autonomy and a better operational capacity of the Armed Forces, especially in the three strategic sectors of its national defense (cyber defense, nuclear and aerospace) (Rodríguez *et al.*, 2018).

The military has been in charge of developing the sectors of military influence with an economic vision at the country level with successful cases such as that of San Jose dos Campos (Rodríguez *et al.*, 2018). The industrialization of Brazilian defense is an interesting case study of the flow of technologies through the Brazilian defense sector, which has gone through three different stages. The first, from 1970 to the early 1990s, where the defense sector in aerospace terms was dominated by EMBRAER (aviation) and AVIBRAS (missiles) and showed solid development despite the economic and political instability of the country, responding to local needs; the second stage, one of lethargy between 1990 and 2009 where production was

seriously attenuated by the decrease in military spending; and the third stage beginning in 2009, with the National Defense Strategy, to generated new synergy in the sector where investments in defense came to be considered essential to promote industrial policy, generating much greater openness to international cooperation, renewing the fighter aircraft fleet and with an inclusive process with rotation of leadership between the Brazilian Air Force and the Brazilian industry (Amarante & Franko, 2017).

The state must assume the leadership of the organization of processes based on national and regional policies, lighten paperwork and bureaucracy to streamline project management; must support the business sector in the tax benefits that lead to increased competitiveness and productivity of the country under the scheme of patent results (Salazar & Valderrama, 2013). These changes that are being generated have led to conflicts of interest within the triad on issues such as intellectual property and confidentiality of information that sometimes hinder the fluidity of the system. When the triple helix system becomes complex, development occurs through networks, with actors of the social system playing specific roles in the established relationships and in which changes and incentives are caused, capable of varying the social system itself (Mora, 2014).

An important example of this activity is the case of Israel, in which the Infrastructure Units for research and technology of the Israeli Ministry of Defense are in charge of guaranteeing and maintaining collaboration between all DDR&D units (Directorate of Defense Research and Development) and stimulating their relationship with other Israeli research organizations to maintain contact with the highest levels of the international research and development community, under a long-term vision of obtaining operational capabilities (IMoD, 2021).

The Ministry of Defense of Israel influences the defense requirements advanced by the Department of Production and Acquisitions to stimulate the development of certain economic regions of the country; an example of this type of support is the acquisition of the F-35 aircraft from the

United States with offset credits involving market and technology transfer to Israeli companies and an order from Lockheed Martin of one billion dollars in components for the F-35 from Israeli companies (Donatas, 2019)

Another relevant aspect is that most of Israel's defense companies employ engineers and technicians who have served in the Israel Defense Forces and understand the characteristics of the systems and weapons they are developing. Likewise, the development of weapons is developed in cooperation with the Israel Defense Forces; this allows a significant improvement in the competitiveness of the industry. Israel understands that its success as a country lies in having a healthy defense industry, in technological superiority, under a strategy of interaction with other defense industries worldwide, with strong universities, with continuously growing technology-based entrepreneurship communities, with easy access to public and private risk capital, with developed and robust technology incubator programs, high-tech clusters, and laws that favor foreign investment with tax benefits (Broude *et al.*, 2013).

The THM can be generated more easily in those social systems whose actors have demonstrated local and international competitiveness thanks to local government policies, the local role of universities within the regional innovation system and the degree of intervention of the private actors (Mora, 2014). Likewise, the recognition of ideas by the triad as economic goods necessary to generate economic growth and development, generates a dynamic cycle: the more knowledge, the more capital and vice versa (Dzisah, 2010).

Therefore, the relationship between the university, company and state seek to create conditions for future innovations by taking advantage of existing resources to create niches for technological innovation and ensure a place within the division of labor in the global economy. (Etzkowitz & Leydesdorff, 1998). All this, through the generation of innovative technology management projects, which are closer to the reality of companies to develop joint 'win-win' benefits to the triple helix actors, which are maximized when driven from the highest levels of a government, company managers

and researchers (Aguilar *et al.*, 2013). The simplified triple helix model can be an effective framework for less advanced economies to promote innovation and counteract the effects of the economic crisis (Rodrigues & Melo, 2012), if the joint evolution of scientific research and product development research is properly stimulated by cross-fertilization of a variety of academic disciplines and industries and improved technology transfer practices supported by a public policy effort.

The triple helix regime emerges as well as "a recursive overlap of interactions and negotiations between the three institutional spheres" (Etzkowitz & Leydesdorff, 1999) which generate significant economic changes. This gives rise to the creation of new formats of organization or reinvention, such as incubators, science parks or venture capital companies, which support the translation of research into products, new companies, and the development of new productive capacities (Etzkowitz, 2008).

It is here where the defense sector plays a relevant role, such as the case of the United States, which in 2017 allocated around 116 billion USD in federal spending for research and development, with a little more than 40%, 51 billion USD, for defense purposes (Congressional Budget Office, 2018). This not only pays for research and development, but also plays a critical role in the growth of new industries, such as satellite communications, jet planes, computing, and the internet; in addition, it supports a large proportion of nations that manufacture equipment and have often led the way in developing advanced manufacturing technologies that have enabled these economies to emerge from technical technological obsolescence and bridge technology gaps (Gansler, 1988).

Thus, for the triple helix model to work, a change of mentality is required in the possible ways of working together, in the recognition of the potentials of the other parties (sectors, organizations, institutions), in the credibility to sustain programs and actions based on intervention, experience and the dynamics in which the triple helix is interconnected by the generation of economic wealth, production based on novel knowledge, and the geographic variety to place contributions

analytically, without demanding the basic presumption of a priori integration and with the understanding that economies are intertwined at the market level and in multinational terms, corporations and the sciences are organized internationally and governance is no longer limited by national borders (Leydesdorff & Meyer, 2003).

Relationship and interaction of the three helices

To better understand how the helices are related and interact, it is important to breakdown each of these components according to what is stipulated by the THM and identify how they are presented in the security and defense sector in different actors at a global level.

The relationships between the triple helix actors are given by the following mechanisms (Ranga & Etzkowitz, 2013):

1. Technology Transfer: This is the main activity of innovation systems, since it allows universities to provide graduates with entrepreneurial education and talent to contribute to economic growth through the creation of companies and jobs. The concept of university cities gains importance for the cities of the world because of the possibilities of accessing high-level employees, venture capital from investors and the participation of entrepreneurs. Likewise, universities are extending their capacities from individual education to organizational education.

The government is a driver of demand, which guide and motivate the execution of projects, such as the case of the United States and its 'OFFSET' strategies, which historically have supported the realization of technological-military quantum leaps that close gaps and accelerate the fulfillment of strategies for the growth of scientific and technological aspects that allow them to maintain a predominant position regarding their geopolitical interests and to modernize, update and potentiate their knowledge economy by strengthening companies and universities.

This boosts the technological infrastructure and it is for this reason that the United States

Department of Defense directly influences the economy through large investments in defense, which for 2016 amounted to 611 billion USD, with more than 40% allocated to R&D, which leads to almost a third of the scientists and engineers in the United States working in activities related to Defense (Ministerio de Defensa de Colombia, 2011). Not only does it pay for nearly a third of the nation's research, it plays an important role in the growth of new industries, with defense-led technology transfer plans to stimulate small business development. deployed through all its research units.

2. Collaboration and conflict moderation: This is the ability to transform tension and conflicts of interest into a convergence of interests, relating common objectives and win-win situations, which allow both conflict and tension to imprint knowledge on societies, aligned with the loads and workspaces and organizations.

Two dimensions of the conflict can be determined:

- Conflict tasks: understand the cognitive or constructive functions of the conflict and generate differences of opinions.
- Conflict relationships: these can be dysfunctional affective or destructive of the conflict, this generates frustration and tension, with negative repercussions.

To articulate the development of industry with the state, reduce conflicts and unite the Chinese productive defense apparatus, the Ministry of Industry and Information Technology of this country created the State Administration of Science, Technology, and Industry for National Defense (SASTIND), which works in coordination with the Chinese People's Army to guide state entities and defense industrial actors (Department of Defense, 2018).

Likewise, the actors rely on the National Science Foundation of China (NSFC) and the Chinese Academy of Science (CAS) for the development of high technology for defense and resolution of conflicts of interest that could arise between the triad, stimulating joint work

and eliminating tensions that may generate negative effects in the pursuit of industrial objectives and geopolitical interests.

3. **Collaborative leadership:** aims to generate the integration of different parties to create opportunities for knowledge exchange through the development of projects, carry out problem-solving tasks and guarantee a high level of satisfaction of the individual members of the association. An interesting example is how the university comes to play an important role by integrating with the government and the private sector through research centers such as the MIT Lincoln Laboratory, in charge of researching and developing a wide range of advanced technologies to satisfy critical security needs of the US. What sets it apart from many R&D laboratories is its focus on creating operational prototypes of the unique systems that they design seeking the development of disruptive technologies (MIT Lincoln Laboratory, 2019).

The internal organizational structure of the Lincoln Laboratory encourages the exchange of ideas among staff members and management. This structure includes only three levels of primary administration: the director's office, division heads, and group leaders. The director's office reports to the MIT leadership. A joint advisory committee comprised of representatives from all the military services and an advisory board comprised of leaders from government, industry, and academia provide guidance on the laboratory's R&D portfolio (MIT Lincoln Laboratory, 2019).

4. **Substitution:** This type of interaction arises when there are weak actors or spheres that do not fully fulfill their functions, so one of the remaining actors assumes the spaces of the weakness or when an actor, in addition to its control and regulation functions, begins to generate investment and provision of public capital, or when the industry takes university roles; for example, Pixar University, Intel Educator Academy, Cisco Networking Academy, Apple University.

Substitution between spheres is only seen in countries of the highest degree of scientific and industrial evolution where companies and the government can play interchangeable roles. An interesting case is the one presented by the investment programs of the Advanced Research Projects Agency (DARPA), which seeks to promote small businesses as investors by including them in innovation and technology transfer programs and supporting the transition and commercialization phases of products, assuming the role of angel investor to support the growth of the defense industry in the country (Department of Defense, 2019).

5. **Networking:** Formal and informal structures at the national, regional and international levels it is not unique to Triple Helix interactions; research networks have been compared to Joint Ventures. Networks reflect the increasing non-linearity and interactivity of innovation processes. The need for a broad and multifaceted relationship between organizations is needed to carry out innovation and bring new products to market in the strict competitive climate (Etzkowitz & Leydesdorff, 1995).

The network created from the negotiation of the JAS 39 Gripen aircraft of the Swedish company Svenska Aeroplan AB (SAAB) to South Africa led to, through the development of several offset agreements, the outsourcing of the manufacture of various components of this aircraft that modernized the South African defense industry and opened the door to the international network of distributors of aeronautical products. A large part of the transfer consisted of providing knowledge on the development of subsystems and components for the industry and passing on the commercial 'know-how' to enter international markets. This allowed South African companies to enter and sell to large companies such as AIRBUS™, ERICSSON™ and SAAB itself (Eliasson, 2010).

To seek faster organizational learning, an international global outsourcing agreement was made that led to an understanding of the dynamics of foreign markets and the

complications that arose, which forced the industry to carry out restructuring and major business changes to evolve and opened doors to enter other parallel markets (Eliasson, 2010).

Another important example is the European Defense System that concentrated European companies for the development of common projects with long-term state budgets with a complex strategy and network of civil and military suppliers to preserve innovation and competitiveness capabilities, improve exports and horizontal cooperation (domestic or regional or transatlantic), increase specialized skills in the production of a wide variety of diversified equipment that allow companies from European countries to seek constant cooperation opportunities to access complementary resources and shared technological spillovers (Matelly & Lima, 2016).

Within the triple helix model, it is interesting how the defense and security sector stimulates the creation of a high-tech economy in its earliest stages and the how concept of companies is addressed through spin offs, spin outs and start ups (Koster, 2004).

1. Start-ups are companies that are born with resources from entrepreneurs, but do not require specific experience. The United States Department of Defense has venture capital programs to invest in startups with programs such as 'AVCI' of the army that have been in operation for more than 12 years, investing in small companies for the development of advanced technologies, promoting the defense industry. For this, they use venture capital companies such as 'Arsenal', looking for entrepreneurs to scale new technologies (VP, 2019).
2. Spin outs are technology-based ventures that require specific knowledge that originates from work experience to transfer this 'know-how' to open new businesses. An example of the stimulus that governments must generate are the US innovation funding programs that support innovative small businesses with commercialization potential. The Bayh-Dole Act

of 1980 and the Federal Technology Transfer Act of 1986 help to facilitate the commercialization of technology in early stages and the undertakings related to these new technologies (Wonglimpiyarat & Khaemasunon, 2015). The main programs to support the company in the early stages are the Small Business Innovation Research and the Small Business Technology Transfer (SBIR/STTR), strengthened by the Department of Defense, which in 2019 was the state agency that contributed most to the development of the program, with an approximately 1.8 billion USD; this program's mission is to support for-profit companies. The focus is on carrying out R&D, but not on buying equipment, in order to market a technology that has already been developed or for which there is very low risk and only capital is needed (SBIR, 2020)

3. Spin offs are companies that are born from the actors of the triad with a group of experts supported by the actors of the triad, and this is where all their potential lies. Most of these types of ventures are successful due to the financial support they constantly receive. In South Africa, the company 'Denel', with public-private capital, made it possible to strengthen the aeronautical industry with the creation of several spin-offs such as Semprel™ that develops GPS tracking equipment and AEROSYSTEMS, which produces entertainment services for airplanes and interior design for commercial aircraft and manufactures sophisticated components for Airbus (Eliasson, 2010).

Etzkowitz and Leydesdorff emphasize that the triple helix relationship is not static or stable, since different strategies, intentions and projects are generated according to the structures of the organizations involved (Aguilar *et al.*, 2013; Etzkowitz & Leydesdorff, 2000). When the relationship is mainly between university and industry, it has been known as "academic capitalism", a term coined by S. Slaughter and L. Leslie in their eponymous book published in 1997 (Mora, 2014). However, when the relationship is generated between

more than two helices it can become chaotic due to the interests of each of the parties.

Likewise, it must be understood that if the investment in these relationships is made by the state, there will be a greater interest in solving problems of a social nature, and the funding calls will seek that the entities that want to access these resources be different in developed and developing countries. In developing countries, the entities must meet certain prerequisites of qualification and capacity under a social and idealistic and non-productive approach; In developed countries, this behavior is more pragmatic and seeks a direct impact on the economic system of the country under a more holistic vision that affects the improvement of the quality of life of its citizens and geostrategic interests. If the financing comes from the private initiative, the orientation will be primarily to competitiveness and productivity, while if they are carried out with university resources there will be greater autonomy and less capacity to generate interdependencies, since the orientation will be to scientific production within the academic sector.

Thus, the great challenge is to develop co-financed projects where a clear relationship with the triple helix is expressed, where there is a commitment from the government and the company to generate greater productive development in organizations as well as competitiveness (Aguilar *et al.*, 2013).

The general function of triple helix systems (the generation, dissemination, and use of knowledge) is carried out through a set of activities in knowledge, innovation and spaces for consensus. From the perspective of triple helix systems, the articulation and non-linear interactions between spaces can generate new combinations of knowledge and resources that contribute to the theory and practice of innovation, especially at the regional level (Ranga & Etzkowitz, 2013).

The spaces that have been considered suitable for the interaction of the triple helix are given by three types:

- Knowledge spaces: seek to build the transition towards knowledge societies, proposes to create or develop knowledge resources in accordance with local and regional knowledge bases.

(Ranga & Etzkowitz, 2013) For example, the case of the New England regional innovation system, named after a postwar route “Route 128” and originated in the mid-19th century with the founding of MIT, is a new type of technological university designed to infuse industry with the results of what is now known as “strategic research” (Etzkowitz, 1993).

- Innovation spaces: multi-sphere (hybrid) spaces that come together to develop an intellectual and entrepreneurial potential and a competitive advantage for the region or the country (Ranga & Etzkowitz, 2013).
- Consensus spaces: the set of competences between the triple helix systems that allow the discussion and evaluation of proposals towards knowledge based on a regime. Various mechanisms to create spaces for consensus are possible, from the creation or transformation of an organization to analyze problems and formulate solutions to the provision of access to the resources required to implement a project or provision of solutions to conflict or crisis situations. This is the key factor of interaction between the spaces of knowledge and innovation: (Ranga & Etzkowitz, 2013).

In these spaces of consensus, organizations such as the North Atlantic Treaty Organization (NATO) and the European Union (EU) have been established, where the interests of various nations converge and there are cooperation agreements on defense and research and development issues that in turn strengthen the advancement of the industries and academies of each country, allowing the transfer of technologies or knowledge and cooperation for technological co-developments that integrate multinational capacities that generate success, such as the alliances made for the development of the Tiphon combat fighter or the EuroFighter, which converge construction and development in four European countries: United Kingdom, France, Spain and Italy and its leading aerospace and defense companies, Bae Systems, Airbus Defense and Space and Leonardo (Eurofighter Typhoon, 2019).

Conclusion

In response to the research question posed, we can discern that the development of activities in research and development in security and defense is a transformative promoter of science, technology and innovation activities that generate a productive change in a nation, which through R & D & I projects and programs, with their high standards and requirements, find room in their dual application to meet needs in other types of markets, a fact that strengthens the relationship of the triple helix players, making them more competitive in knowledge-based economies.

The development of the triple helix in the defense sector supports the growth and creation of other economic sectors through relationships, in which the actors exchange roles and through activities such as networking, technology transfer and resolution conflict, articulate the productive actors, enhancing their capacities to simultaneously impact different industries and acquire capacities for the development of knowledge-based economies.

The cases presented from South Africa, China, the European Union and the United States show how the appropriate relationship of the Triple Helix actors generates products with high technological and economic impact that can be projected in the development and strengthening of knowledge-based economies and in turn, lead to the well-being and improvement of the quality of life of its population, as well as the generation of military advantages that efficiently guarantee security and defense of a nation, under concepts of technological independence.

For defense R&D to play an important role in economic development and ensure investment, it must ensure the development of second-order effects in innovation with an impact on economic growth and the national innovation system of a country through the generation of knowledge that can be directed to civilian use in the development of products, services and processes and the growth of the productivity of the research of the university system, as occurred after the cold war in the United States with the growth and strengthening of its

research infrastructure that has been an important source of civilian innovations, new firms, and trained scientists and engineers (Schmid, 2017).

The limitations of the research are in the collection of data and the analysis of successful cases of R&D&I projects in developing countries since it is difficult to identify cases of this type in high-impact defense security and safety projects involving the interaction of triple helix actors and the concepts that encompass it. This may be due to the low development of industries of this type and their high technological dependence on developed countries in sustaining their defense and security capabilities.

Future research is proposed to determine how the actors of the Triple Helix are articulated and what are the factors that allow a successful integration for the development of security and defense R&D&I projects, which strengthen the national industry and that allow developing countries to strengthen the generation of high-technology products with high added value and to integrate into the concepts of knowledge-based economies.

Investment in science, technology and innovation activities in the defense sector generates a virtuous circle, reducing technological dependence and closing gaps, a fact that generates a technological advantage that is expressed in the strengthening of the sustainable competitiveness of each of the actors in the Triple Helix, with continuous systematic improvement processes.

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