

THE ACADEMIC INDUSTRIAL DOCTORATE (DAI) AS A VECTOR OF THE TRIPLE HELIX: AN ANALYSIS OF THE BENEFITS FOR UNIVERSITY, INDUSTRY, AND GOVERNMENT

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ABSTRACT

This article analyzes the Academic Industrial Doctorate (DAI) as a vector for strengthening the Triple Helix model in Brazil. The objective is to identify the specific benefits that this collaboration, through the DAI, generates for each of the three actors: university, industry, and government. Based on qualitative research with stakeholders from the UFABC's program, the results indicate distinct advantages for each sphere. For the university, benefits include increased institutional visibility, the training of researchers in applied projects, and faculty development. For the industry, advantages consist of access to a highly qualified workforce to solve real-world problems, the ability to outsource research, access to university resources, and the absence of mandatory financial investment. Finally, the government benefits indirectly through the increase in the number of masters and PhDs in the country and the consequent rise in their employability in strategic sectors. The analysis concludes that the DAI serves as an effective mechanism that operationalizes the interaction among the Triple Helix actors, thereby driving innovation and sustainable development.

KEYWORDS: *Applied Research, Industrial Doctorate, Skill Development, Student Profile, University-Industry Collaboration*

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1. INTRODUCTION

Society constantly seeks, in various ways, to expand its economic resources while needing to preserve natural resources. This fact encourages countries to continuously invest in promoting technological innovation due to its contribution to the economy, society, and the environment (Zheng et al., 2020). Innovation can be compared to an engine that drives economies, where partnerships promoted by the Triple Helix model position themselves as drivers capable of making the sustainable innovation apparatus operate.

The Triple Helix model can be defined as "the articulation among three actors: industry, university, and government" (Audy & Piqué, 2016, p. 13), capable of promoting innovation within each actor internally and through their interrelations. This can lead to the creation of innovative environments such as technology parks and business incubators, which can boost economic development. Due to the knowledge-based economy, universities have played a relevant role in generating knowledge and skills in this process, as they have the potential to encourage entrepreneurship, innovation, and sustainability, in addition to training researchers capable of meeting the technological demand in

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highly competitive sectors. Berg and McKelvey (2020) emphasize that universities are required to collaborate with society and regional economic development, taking into account environmental aspects (Gustavsson et al., 2016).

The cooperation between government, university, and industry can bring benefits to all parties, especially through the development of research environments that combine practical experience with scientific aspects. This allows for work on real and relevant daily challenges to promote innovation (Lindén & Björkman, 2018), considering contemporary environmental needs. In this sense, the Industrial Doctorate was redefined in Brazil as the Academic Doctorate for Innovation (DAI) to incorporate the innovation variable into the association between universities and industries, through research aimed at solving real problems (Sin et al., 2020). This model is defined as a program to encourage university-company interaction, applied research, and technological innovation, which can be used to strengthen socio-environmental sustainability, an emerging demand of our time.

The DAI has the additional purpose of enabling doctoral students to conduct research aimed at solving real problems in collaboration with companies, thereby promoting innovative solutions (CNPq, 2024b). It should be noted that this type of doctorate began with the name DAI, a name maintained by the Federal University of ABC (UFABC), the locus of this research. In it, the doctoral student receives a scholarship (in cash) from the National Council for Scientific and Technological Development (CNPq, 2024a) through academic doctoral programs to develop innovative projects in partnership with a company/industry (CNPq, 2024b). Thus, the DAI is not an independent doctoral program, but rather an entry model into doctoral programs, with the obtainment of a CNPq scholarship.

This research aimed to identify the benefits obtained by the actors of the Triple Helix model, in interface with sustainability, involved in the DAI process promoted by the Brazilian UFABC. The investigation is justified by being a doctoral modality little explored in the literature. A search in the Scopus database in September 2024 found only 37 texts related to the industrial doctorate. In Brazil, a search in the Periódicos Capes database yielded only a single published article on the topic. According to the Analytical Report - DAI/2018 Program, no studies or research on the DAI were found (CNPq, 2024b). It is worth highlighting that the research is based on the perspective of analyzing the phenomenon as a process for promoting sustainability, as it incorporates social, economic, and environmental variables.

2. THEORETICAL FOUNDATION

According to Etzkowitz and Zhou (2017), the Triple Helix is "(...) an innovation model in which the university/academia, industry, and government, as primary institutional spheres, interact to promote development through innovation and entrepreneurship" (p. 24). In this perspective, Luengo-Valderrey et al. (2020) state that the Triple Helix has the capacity to promote innovation through the interaction between university, industry, and government.

The actors of the Triple Helix can enjoy their own advantages from the application of this model. Industries can expand their research, obtain agreements, licensing, subsidies for projects, and benefit from new collaborators from partner scientific research laboratories. Universities can provide consulting to industries through their expert faculty on specific topics, and the government assists with project financing. Thus, industries can learn from universities, and universities can enjoy the benefits of the Triple Helix model, such as obtaining additional funding from industry and government, enabling an improvement in research quality; better qualification of the academic community with the participation of industries; and the promotion of research projects aimed at long-term benefits for society and the environment.

The government, within the Triple Helix, has indirect functions as it does not act directly in the production of knowledge and ideas. It is the government's responsibility to correctly provide

resources to industries, seeking to encourage the socio-environmental and economic evolution of the country. It can benefit from economic growth and job creation, improved tax collection, and an enhanced quality of life for the population. The applicability of the Triple Helix is recognized by governments that have striven to create policies to improve their own innovation systems and provide resources for sustainable development (Cai & Etzkowitz, 2020).

Knowledge sharing improves the results of all involved organizations that have common goals and projects. Government subsidies can reinforce these associations and their outcomes. The interaction and synergy among the actors, whether through resources or influence, contribute to better results (Figueiredo et al., 2022). The literature presents a series of direct benefits from the application of the Triple Helix model, mainly for the university and industry, which can benefit from collaboration between the actors. This is not the case for the government, whose role as a public administrator is not to be a direct beneficiary, but to direct the benefits to society and the environment.

The implementation of an industrial doctorate involves the university and industry, positioning student researchers as a central and connecting element due to projects developed in universities but aimed at meeting the needs of industries. Thus, it is a doctoral model capable of meeting both economic and scientific knowledge demands (Yang & Jeffrey, 2021). The DAI is a category of postgraduate program that combines research components promoted by universities and the enhancement of industry-oriented skills. Industrial doctorates have a contemporary approach of uniting the university and industry to prepare a workforce from postgraduate studies. DAIs necessarily involve universities, industry, and funding agencies, including in the division of expenses, supervision, and execution of research (Tavares et al., 2019).

The actors of the Triple Helix can enjoy benefits obtained from the promotion of an industrial doctorate. Among the benefits for universities are obtaining research grants, the possibility of using more modern facilities and research-related information, the application of research in practical situations, access to various disciplinary areas, and the incorporation of skills geared towards the job market (Gustavsson et al., 2016). Other expected benefits are the promotion of socio-environmental responsibility, entrepreneurship, innovation, and sustainability; the enhancement of academic research with contributions from industry, improving the university's role in innovation; understanding the technical difficulties of the industry; supplying a specialized workforce to the job market; and collaboration in research. The university can attract investments, create networks with industries, and grow in quantity and quality, with a focus on innovation and sustainability.

Industries can benefit from the DAI, as the research developed has the potential to be directly relevant to the involved industries. Industries can also benefit from advanced equipment made available by universities, which makes it possible to assess the impact of technology use and the level of knowledge required for its operation. This contributes to the use of new techniques and processes, resulting in evolved technological performance. The long-term training of qualified leaders who contribute to economic success is pointed out as a benefit to industries. The DAI can also act as an effective recruitment program, as graduates can be subsequently hired by the companies where they developed their projects. Industries find in the DAI a possibility to enhance the skills of their professionals, as well as an opportunity to develop innovation processes (Tiraboschi, 2019). With this type of doctorate, industries get an opportunity to correct shortcomings related to the lack of certain skills and knowledge not present in their staff (Cardoso et al., 2019).

For Lindén and Björkman (2018), the main intention of a DAI is for an industry employee to enroll in a university's doctoral program, so that the collaboration between the two institutions can enhance the solution of problems of mutual relevance. This program proves capable of improving the workforce and contributing to the training of leaders within industries, in addition to investing in relevant research and, consequently, developing innovative and sustainable projects. In turn, governments do not enjoy direct benefits from this process, but economic and social development and the encouragement of entrepreneurship can be considered contributions to the government and

society in general. The DAI seeks to encourage innovation in industrial processes. The research of Lima et al. (2020), Machado Jr. et al. (2020), Leal et al. (2022), and Brando et al. (2023) express the potential benefit of innovations in the industrial sector for sustainability, whether through processes that mitigate the impact of industrial operations on nature, the proposal of products with better environmental performance, social benefits, or even better cost performance—variables related to sustainability.

3. METHODOLOGICAL PROCEDURES

For this descriptive and exploratory research, a qualitative approach was used (Creswell & Creswell, 2021). The research participants were the actors involved in the projects developed within the scope of the DAI promoted by UFABC and actors involved at the institutional level: a) six alumni; b) six supervising professors; c) seven representatives of the companies involved in the projects; d) the DAI Coordinator at UFABC; and e) a CNPq official involved with the DAI. For the identification of the actors, the UFABC's Pro-Rector of Graduate Studies provided information about the students and supervisors; however, it was not possible to obtain data on the company representatives, as the university was not authorized to release such information.

According to the Pro-Rector of Graduate Studies at UFABC, the population to be researched would total approximately 86 actors, but due to the difficulty in accessing all those involved, it was decided to use a sample of this population. The type of sample used was non-probabilistic, stipulated by the researcher's criteria. The sample was defined by accessibility, which does not require statistical rigor. Three delimitations were defined for the choice of actors to be researched: i) DAI alumni, as they have experienced all phases of the DAI, thus having a greater possibility of contributing to the research; ii) students' theses available to the public, as they contribute documentarily and theoretically, through access to the theses developed by the students and to mitigate possible problems with project confidentiality; and iii) projects related to processes, observing that the profile of most of the developed projects was aimed at solving problems related to processes in the involved companies.

With the use of these inclusion and exclusion criteria, the total population was reduced from 86 to 27 actors. Adding the CNPq official, the total reached 28 actors to be interviewed. It is noted that the DAI Coordinator also serves as a supervising professor, so he was not added to the count. An effort was made to interview the students, supervisors, and company representatives involved in the same project. All 28 actors were invited to participate in the interviews. Information about the company representatives was obtained through the Snowball technique, in which students or supervising professors indicated the most suitable representative to provide information about the development in the DAI in their respective companies.

The data collection technique employed was the semi-structured interview, conducted with the actors involved in the process. All 20 interviews were conducted from April 12, 2024, to July 4, 2024. The duration of the interviews ranged from 23 to 88 minutes. Participants were invited via email, WhatsApp, or the LinkedIn social media platform. Eight invited individuals did not respond to contact attempts. The interviews were conducted via videoconference using Google Meet, and the transcription was performed simultaneously using the Google Scribbl extension. There was access to documents, especially the project of the DAI course under analysis. The analysis of the data obtained through documents and interviews was carried out according to Bardin's (2016) content analysis, with the categories being defined beforehand. The data analysis was supported by the Atlas.ti software, where the interview transcripts were inserted for analysis. In this software, codes were defined and subsequently inserted into their respective categories. After the analysis was completed, the text was written.

4. RESULTS

Benefits for the University

Through the participants' testimonies, it was possible to identify four benefits that the university enjoys through the DAI. The most cited benefit by the interviewees was 'visibility'. Because UFABC was the pioneering university in implementing the DAI, the interviewees believe that the university has become a showcase and a protagonist in terms of relations with companies and interaction with the CNPq. Students also contribute to the university's visibility by achieving success in the development of their projects with companies.

The next benefit highlighted is the 'training of a qualified workforce'. In the view of the faculty, the training of good professionals in applied research is capable of benefiting the university. In turn, the benefit related to the 'creation of applied knowledge' refers to the fact that the applied research developed through the DAI can be understood as something positive not only for the university but also for the industry and society. The 'training of faculty' to act in traditional and applied research, interacting with industry, for the benefit of sustainable development and innovation. Obtaining visibility, for a university, is a considerable gain, as is the promotion of applied research, the generation of knowledge, and the training of faculty in non-traditional research.

Benefits for the Company

Through the participants' testimonies, it was possible to identify five benefits that organizations enjoy through the DAI. The most cited was the 'obtainment of a qualified workforce'. The appeal of being able to use a highly qualified workforce arouses the interest of companies in participating in the DAI, including for possible future hiring. The second most cited benefit was the 'outsourcing of research', which refers to the fact that companies can save time and human resources, not needing to displace employees or interrupt other processes to develop the proposed research.

Next, the 'knowledge from the university' shows one of the main attractions that companies see in partnering with universities, which is the opportunity to obtain theoretical knowledge in the area of the developed project. The benefit of 'access to university resources' shows that even large companies often cannot afford some resources such as machinery, laboratories, specialists, among others. Therefore, the partnership with the university can be beneficial for the company, as it would not need to bear the financial burden to obtain them. The benefit of 'non-mandatory financial investment' was also mentioned. The Internal Rules of the DAI at UFABC state that the company may pay the student doctoral scholarships, not exceeding the amount paid by the CNPq (PROPG, 2019). Therefore, companies are not obliged to fund scholarships for the student during the project's development. The almost free participation of the company in the DAI was also pointed out as a benefit. It can be said that the benefits obtained by companies with the DAI are more explicit compared to the benefits for the university. Companies have the possibility of using a doctoral-level workforce to develop research without having to displace employees from their staff, being able to obtain knowledge and resources from the university.

Benefits for the Government

Through the testimony of the CNPq representative, it was possible to identify two benefits that the government enjoys through the DAI: the 'increase in the number of masters and doctors' and the 'increase in the employability of doctors'. At the beginning of his response, the CNPq official stated that the benefits from the DAI are not directly for the government, but for society as a whole, as well as for the environment, when considering aspects of sustainability.

5. DISCUSSION

Four benefits to the university from the DAI were mentioned; however, the benefits reported by the participants were more restrictive and lacked a broader view of the program. The most cited benefit was the visibility that UFABC gained for being a pioneer in the implementation of the DAI, for the relationship established with the CNPq, and for the relationship with companies that the program provides. The training of a qualified workforce is a benefit acquired due to the fact that DAI projects are developed in partnership with companies. Some participants mentioned that academia is not able to absorb all the doctors trained annually, corroborating Gustavsson et al. (2016). The creation of applied knowledge is referenced in the literature as a benefit of using research in practical situations. Another related benefit is adding contributions from industry to academic research (Gustavsson et al., 2016). The least cited benefit was the training of faculty in applied research, which aligns with the statements of Gustavsson et al. (2016).

Regarding the benefits for the company, five were identified from the participants' testimonies, and it can be observed that they are interconnected. The most cited was the obtainment of a qualified workforce for the development of the research project—which is usually based on a technological difficulty that the company is facing. In addition, there is the possibility of a subsequent hiring by the company of a professional at the doctoral level. It is not mandatory, but the doctoral student can be hired by the company. The outsourcing of research was one of the most cited benefits by the interviewees, as the company does not need to displace employees who would be involved in other functions and who would not be able to dedicate themselves to the problem from which the research originates.

The knowledge from the university comes from both the student conducting the project in the company and the university itself, to which the company or the student can turn. Access to university resources is also linked to the partnership resulting from the DAI between the university and the company. This benefit proves more advantageous for small companies, but medium and large companies can also benefit from available resources without having to disburse financial resources. The company benefits from the mentioned advantages without the need for a mandatory financial investment. The company basically allows the student access to the facilities, equipment, and materials needed for the development of the project for the company itself. The company is not obliged to supplement the scholarship received by the student.

Companies participating in a DAI can benefit from the research developed due to its direct relevance. Depending on their size, they can benefit from equipment available at the university, contributing to the use of new techniques and processes, resulting in the evolution of technological performance. The collaboration between the two institutions can contribute to the resolution of problems of mutual relevance (Lindén & Björkman, 2018). The DAI can be an important recruitment tool due to the possibility of hiring alumni doctoral students. In addition to recruitment, some authors mention that the DAI is also capable of enhancing the skills of the existing workforce in the company, as well as contributing to the training of qualified leaders (Cardoso et al., 2019; Tiraboschi, 2019).

Only two benefits for the government were mentioned: one referring to the increase in the number of masters and doctors due to the number of scholarships provided, which act as facilitators, making doctoral courses more accessible; and another related to the increase in the employability of doctors, due to the possibility of being hired by partner companies in the development of projects, or by other companies with which the student may come into contact through the network established by the student during the project. The government has indirect functions regarding industrial doctorates and does not enjoy direct benefits from the collaboration between university and industry in doctoral courses. However, there are benefits for society in general, such as the promotion of innovation, sustainable economic and social development, the reduction of environmental impacts, and the encouragement of entrepreneurship.

The benefits observed from the implementation of the DAI model align with the potential for developing innovations that impact sustainability as pointed out in the studies of Lima et al. (2020), Machado Jr. et al. (2020), Leal et al. (2022), and Brando et al. (2023). This study contributes theoretically by strengthening the articulation between the Triple Helix theory and the promotion of sustainability, showing how the DAI acts as an integrating instrument between university, industry, and government for sustainable development. The research expands the understanding in the literature by demonstrating that this interaction not only fosters innovation but also incorporates economic, social, and environmental dimensions in a systemic and structured way.

The work advances conceptually by repositioning the Triple Helix model beyond the promotion of technological innovation, introducing the concept of sustainable innovation, which emerges from the convergence of academic, industrial, and public agendas. By analyzing the DAI as a strategic vector, it is evident that it operationalizes sustainability through the training of a qualified workforce and the generation of applied knowledge, promoting positive impacts for both the productive sector and society. Furthermore, the article contributes by empirically demonstrating that the Triple Helix model can be successfully applied in emerging countries like Brazil, even with limited resources, when there are public policies that encourage inter-institutional collaboration. This perspective broadens the scope of the theory, offering a view more adapted to the realities of developing countries, and supports the idea that the university-industry-government tripod can be a powerful lever for the transition to a more sustainable and inclusive economy.

6. FINAL CONSIDERATIONS

It is understood that the objective of identifying the benefits obtained by the actors of the Triple Helix model involved in the process of the Academic Industrial Doctorate (DAI) promoted by the Federal University of ABC was fully met. Through the analyzed documents and interviews, the following benefits for the university through the DAI were identified: visibility due to UFABC being a pioneer in the implementation of the DAI in Brazil; the training of a qualified workforce, generating positive publicity for the university; the creation of applied knowledge that is transmitted to both industry and society; and greater training of university faculty in applied research.

The following benefits for companies through the DAI stand out: obtaining a qualified workforce by virtue of the doctorates who develop projects in partnership with companies; the outsourcing of research, which allows companies not to need to direct their own workforce for the development of research and innovation; the knowledge from the university shared with companies through the partnership with the university; access to university resources from the said partnership; and the fact that the company does not need to invest financially to obtain a partnership with the university through the DAI.

From the government's perspective, the benefits identified from the DAI were: the increase in the number of masters and doctors in Brazil and the increase in the employability of doctors. It is concluded that the DAI has the potential to obtain satisfactory results in the collaboration between university and company, in the development of applied research, and in the promotion of technological innovation. From this study emerges, as a theoretical contribution, the understanding that innovation actions developed through the Triple Helix model should incorporate among their objectives the vector of sustainability, which reconciles the social approach through the development of researchers, the economic one due to improvements for the participating companies, and the environmental one as its projects have this premise.

The research had as limitations the fact that it was carried out in only one locus, although it is the one that hosts the oldest DAI program in Brazil. UFABC promotes the DAI, noting that it has some differences not specifically addressed in this work, as they are not directly related to this research, but which constitute a differential. For future research, an amplification of the research locus is suggested so that the experience of other ICTs participating in the Academic Doctorate for

Innovation can be studied. It is also suggested to conduct research regarding the advantages obtained by students in pursuing a doctorate through the DAI.

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