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JOÃO CARDIM FERREIRA LIMA

SOCIOECONOMIC IMPACTS OF UNIVERSITY-INDUSTRY COLLABORATIONS

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Tese apresentada ao Programa de Pós-Graduação em Engenharia de Produção da Universidade Federal de São Carlos (UFSCar), para a obtenção do título de Doutor em Engenharia de Produção.

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O conhecimento não conhece limites

(Antigo Provérbio)

RESUMO

As colaborações universidade-empresa criam impactos socioeconômicos nas áreas em que são realizadas. Embora estas colaborações sejam reconhecidamente potenciais geradoras de benefícios econômicos e sociais, não há um consenso na literatura acerca de um modelo conceitual consolidado para avaliação de seus impactos socioeconômicos. Diante deste contexto, esta tese tem como objetivo construir um modelo para avaliar os impactos socioeconômicos diretos das colaborações universidade-empresa e avaliar as grandes empresas brasileiras. O método de pesquisa foi: revisão sistemática da literatura a partir de 94 estudos sobre os impactos socioeconômicos a partir da configuração contexto-intervenção-mecanismo-resultados, foi desenvolvida uma escala (questionário) para mensurar os impactos enviado para as empresas do “Ranking – 1500 Empresas + Estadão” das 1.500 maiores empresas do Brasil organizadas pela Fundação Instituto de Administração (FIA) e Austin Consulting. Foram coletadas 210 respostas completas e válidas de gestores de inovação de empresas que realizam colaborações formalizadas com universidades. Realizou-se análise multivariada de dados para simplificação do modelo (análise fatorial) e identificação da estrutura relacional das variáveis (correlação canônica). Foi construído um modelo de impacto socioeconômico para as grandes empresas brasileiras, com impactos categorizados em: Benefícios Financeiros, Inovação Tecnológica, Social e Comunitário, e Gerenciamento de Recursos Externos com 21 variáveis. Existe correlação positiva entre Inovação Tecnológica e Benefícios Financeiros: o “lançamento de novos produtos” correlaciona-se com: “aumento das vendas” (aprox. 0,659), “aumento das exportações” (aprox. 0,549), aumento de “valor comercial e corporativo/ acionista” (aprox. 0,550), “aumento da receita” (aprox. 0,563) e “aumento de lucro” (aprox. 0,536). O “aumento de vendas” também está correlacionado positivamente com a “comercialização de novas tecnologias” (aprox. 0,617) e com o “desenvolvimento de novos produtos, processos e serviços” (aprox. 0,534). Existe também uma correlação positiva entre Social e Comunitário, e Gestão de Recursos Externo: a “qualificação da força de trabalho profissional” está correlacionada com a “criação de novos postos de trabalho de alta tecnologia”, e entre Social e Comunitário, e Benefícios Financeiros, a “geração de empregos” está correlacionada positivamente com o “valor comercial e corporativo para o acionista” (aprox. 0,556). Do ponto de vista teórico, este trabalho contribui para a estruturação de um modelo conceitual de avaliação dos impactos socioeconômicos das colaborações universidade-empresa. Além disso, os resultados trazem contribuições para a gestão em cada ator da tripla hélice. Esta tese poderá ser utilizada para orientar universidades e empresas sobre como mensurar os benefícios socioeconômicos de cada parceria estabelecida, instruindo agentes públicos na avaliação dos resultados dos investimentos realizados, e contribuindo para a formulação de políticas de inovação e gestão de tecnologia.

ABSTRACT

University-industry collaborations create socioeconomic impacts for the areas where they are undertaken. Although these collaborations have recognized the importance and a high potential to generate economic and social benefits, there is no consensus in the literature on a consolidated conceptual model for assessing their socioeconomic impacts. Given this context, this thesis aims to build a model to assess the direct socioeconomic impacts of university-industry collaborations and evaluate the Brazilian large firms. The research method was: a systematic literature review of 94 studies on the socioeconomic impacts realized using a Context-Intervention-Mechanism-Outputs (CIMO) configuration, a scale (questionnaire) was developed to measure the impacts sent to the companies in the "Ranking - 1500 Empresas + Estadão" of the 1,500 largest companies in Brazil organized by Fundação Instituto de Administração (FIA) and Austin Consulting. 210 complete and valid responses by innovation managers from companies that carry out formal collaborations with universities were collected. Multivariate data analysis was performed to simplify the model (factorial analysis) and identify the relational structure of the variables (canonical correlation). A socioeconomic impact model was built for large Brazilian companies, with impacts categorized as: Financial Benefits, Technological Innovation, Social and Community, and External Resource Management with 21 variables. There is a positive correlation between Technological Innovation and Financial Benefits: the "launch of new products" correlates with: "increase in sales" (approx. 0.659), "increase in exportations" (approx. 0.549), increase in "commercial value and corporate/ shareholder" (approx. 0.550), "revenue increase" (approx. 0.563) and "profit increase" (approx. 0.536). The "increase in sales" is also positively correlated with the "commercialization of new technologies" (approx. 0.617) and with the "development of new products, processes and services" (approx. 0.534). There is also a positive correlation between Social and Community, and External Resource Management: the "qualification of the professional workforce" is correlated with "the creation of new high-tech jobs", and between Social and Community, and Financial Benefits, "job creation" is positively correlated with "commercial and corporate shareholder value" (approx. 0.556). From a theoretical point of view, this work contributes to the structuring of a conceptual model for evaluating the socioeconomic impacts of university-industry collaborations. In addition, the results bring contributions to the management of each actor in the triple helix. These can be used to guide companies on how to measure the socioeconomic benefits of each partnership, instructing public agents in evaluating the results of investments made, and contributing to information on innovation policies and technology management.

Keywords: University-Industry, Socioeconomic Impacts, Innovation**.**

TABLES

CHARTS

FIGURES

SUMÁRIO

1. INTRODUCTION

The globalization of the economy demands that businesses to be able to adapt and evolve to thrive. Companies take the lead in their market by leveraging strategic knowledge management. Knowledge is progressively considered as a source of competitive advantage. This demonstrates the importance of universities in research and technology, serving as an unending source of information and technological resources (Berbegal-Mirabent *et al*., 2015).

The traditional function of the university is teaching. The “first academic revolution” occurred when universities included research as an academic function, in addition to the traditional teaching activity (Jencks and Riesman, 1968). The “second academic revolution” was characterized by the inclusion of economic development as an academic function together with research and teaching. This “capitalization of knowledge” is at the heart of a new mission established for the university and which established it as an economic agent (Etzkowitz, 1998).

Interactions between universities and businesses, as well as technology transfer, have several potential benefits, including contributing to economic growth (Huggins and Prokop, 2016). Academics and policymakers see universities as potential engines of regional economic development (Fisher *et al*., 2018). The commercialization of academic research has social and economic benefits (Alessandrini *et al.*, 2013).

Academic research is critical to innovation and economic progress. Effective technology transfer methods are required for the successful use of new information. Knowledge development is a collaborative and progressive process. Knowledge transfer necessitates the active participation of its participants, who must all learn together (Berbegal-Mirabent *et al*., 2015).

The entrepreneurial university seeks to enhance the transfer of academic knowledge to businesses while also promoting socioeconomic development. The first "wave" happened at pioneering universities in the United States, such as MIT and Stanford, which defined a patent policy for the entire university, established a technology transfer policy, formed university-industry relationships, and founded firms. The second "wave" happened in Western Europe, including the United Kingdom, France, Belgium, the Netherlands, and other countries where the university has evolved into an entrepreneurial institution capable of commercially responding to social and economic stakeholders (Etzkowitz, 2008).

A third "wave" of academic knowledge transfer has recently emerged in rising economies in Eastern Europe, Asia, and South America, where academic entrepreneurship and the establishment of entrepreneurial universities are high on the political agenda. Pioneering initiatives were launched to promote socioeconomic development (Dalmarco *et al.*, 2018).

The growth of entrepreneurial activity in universities is generally driven by an implicit need for economic development and a greater emphasis on social responsibility. Universities have a critical role in enhancing human resource capacity and efficiency, which benefits global competitiveness (Alessandrini *et al.*, 2013). The entrepreneurial university is seen as a key accelerator for regional economic and social growth, owing to its ability to generate and capitalize on knowledge as a source of business opportunity (Urbano and Guerrero, 2013).

The triple helix approach established universities as proactive entrepreneurial enterprises (Budyldina, 2018). The triple helix shows a new design of structural factors emerging in innovation systems, presents an interactive model of innovation (non-linear), and trilateral adjustment of collaboration between academia, government, and industry that contradicts the traditional view that only businesses are responsible for economic production. The triple helix model acknowledged that the division of labor between the three institutions had become more unclear (Etzkowitz, 2008).

The firms can be highly benefited from collaborations with universities, utilizing their resources and the intellectual capital to develop and improve their businesses. Furthermore, the government should use university resources to improve public administration and modernize the cities with social and environmental responsibility.

1.1 Research Problem

Although the university and its collaborations with the industry are recognized for promoting socioeconomic development, several authors point out the need to create metrics to assess the socioeconomic impact of these collaborations.

A university that develops and transforms knowledge into social and economic growth is becoming an increasingly essential global goal. The most frequently used metrics to analyze the universities' impacts, on the other hand, were developed when research and teaching were the main academic goals (Etzkowitz *et al.*, 2017).

Universities lack clear data and methods for tracking and evaluating overall entrepreneurial success (Etzkowitz *et al.*, 2017). Existing technology transfer output metrics are widely considered to be not only insufficiently defined but also inaccurate. The national impact of technology transfer personnel's efforts is not taken into consideration. Rather than relying simply on indicators like the number of patents filed and revenue from licensing agreements, the efficacy of the technology transfer role may be assessed in terms of social community impact, job generation, and poverty reduction (Alessandrini *et al.*, 2013).

Academic entrepreneurship demands a thorough evaluation that goes beyond specific metrics such as financial returns on an intellectual property portfolio or individual performance. It is important to consider the wider social and economic benefits such as knowledge dissemination, the building of intangible assets in the context of new venture development, and the contribution of employment for social, cultural, and economic reasons (Etzkowitz *et al.,* 2017).

Given the context presented regarding the problematization of research, the question arises: **What are the direct socioeconomic impacts of university-industry collaborations, on the perspective of Brazilian large firms?**

1.2 Objectives

In line with the research problem presented, the general objective of the work is to identify and analyze the direct socioeconomic impacts of university-industry collaborations of Brazilian large firms.

The specific objectives are the construction of the conceptual model of socioeconomic impacts of the university-industry collaborations, develop a scale (questionnaire) to measure the socioeconomic impacts of university-company collaborations, according to the companies' perspective, and analyze the Brazilian's large firms.

1.3 Method

It's important to highlight that the thesis was elaborated based on 3 articles. To achieve the objectives of this thesis was used the systematic literature review (Article 1 – Chapter 3), the scale (questionnaire) development and pretest (Article 2 – Chapter 4), and the Brazilians large firms analysis (Article 3 – Chapter 5) using the statistical multivariate techniques, factorial analysis, and canonical correlation. The method is detailed in each Article (present in this thesis).

1.4 Thesis structure

As mentioned in the previous topic This thesis was structured from 3 scientific articles elaborated during the doctoral research and organized into 6 chapters.

Chapter 1 – Introduction – In which the themes addressed are contextualized and the concepts related to university-industry collaborations, triple helix, and entrepreneurial university are presented. It presents the problematization of the work, highlighting the origin of the research problem, exposes the research objectives, method, and the structure of the thesis.

Chapter 2 – Brief review – which provides a brief presentation of the literature that introduces the concepts and theories used in this thesis.

Chapter 3 – Socioeconomic impacts of university–industry collaborations– a systematic review and conceptual model – Article 1 of a literature review published in the Journal of Open Innovation: Technology, Market, and Complexity, 2021, 7(2), 137.

Chapter 4 – Socioeconomic impacts of university-industry collaborations: scale development and pretest – Article 2 of the questionnaire elaboration accepted in the CLADEA – the Latin American Council of Schools of Administration – 2021.

Chapter 5 – Socioeconomic impacts of university-industry collaborations: Brazilian large firms' perspective – Article 3 of the Brazilian large firms' socioeconomic impacts submitted in the SEMEAD – Administration Seminars (FEA-USP) – 2021.

Chapter 6 – Conclusions – presents the conclusions obtained in the performed research, presenting the theoretical and managerial contributions, besides the research limitations and suggestions for future studies.

2. BRIEF REVIEW

2.1 University-industry collaborations

According to Etzkowitz (1983), firms and universities recognized the value of academic research for business development and modernization. Universities began to examine new sources of financial resources, such as patenting academic scientists' discoveries and selling knowledge gained via research conducted under contracts with companies.

The university, which was previously thought of as a source of only people training and specialized consulting services for businesspeople, has evolved into a factor of production, progressing from an institution dependent on donations and fees paid by students to an enterprise capable of earning income from their research activities (Etzkowitz, 1983).

The capitalization of knowledge and its transformation into equity capital by academics engaging university sectors (which had previously not related to businesses) such as basic science departments, and the university's growth as a leading participant in the economic development of its region have shifted the direction of engagement in connections between the corporate world and the university, as well as the university and the world of business (Etzkowitz, 1998).

Universities generate basic knowledge at the barrier of technological possibilities. Although this knowledge is far from the market, it is required for the development of products and services that can have a high market value and provide businesses with a competitive advantage (Piva and Rossi-Lamastra, 2013).

Piva and Rossi-Lamastra (2013) identified in the literature the goals that companies generally seek to achieve when establishing alliances with universities:

(a) access to basic knowledge;
(b) Improve your ability to solve problems: universities are providers of solutions to technological problems that companies face in their daily work;
(c) access to new tools and techniques for the development of new technologies;
(d) improve the company's reputation among potential partners;

(e) access to academic network;

(f) explore public funding opportunities.

Dutrénit and Arza (2010) classify the corporate benefits of university-industry collaborations into short- and long-term benefits:

(a) short term: the resolution of production problems, testing, and help with quality control;

(b) long-term: growth in the capacity of corporations to absorb knowledge and easier recruiting crucial research partners to supplement or replace the company's internal research and development (R&D) sector.

The motivation of firms and financial partners to collaborate in a research study validates a concept's economic potential. Furthermore, the price paid by investors for equity stakes in the company is a measure of the economic value of intangible assets (Hearn *et al*., 2004).

Collaborative research between universities and businesses should focus on areas of mutual interest: scientific and corporate. It is critical for the long-term viability of collaboration that research outcomes contribute long-term value from both the institution and the firm's perspectives. This value perception will be determined by the impact of research on improving the performance of businesses and universities (Philbin, 2008).

2.2 Entrepreneurial university

According to Etzkowitz *et al.* (2000), an entrepreneurial university is any university that engages in entrepreneurial activities with the goal of enhancing regional or national economic performance as well as the university's and its faculty's financial benefit.

The entrepreneurial university incorporates and expands the research university, upgrading it and applying a linear reverse dynamic to the traditional linear model. The entrepreneurial university takes a proactive approach to put knowledge into reality and growing its contribution to academic knowledge generation. As a result, it functions on an interactive model of innovation rather than a linear one, seeking scientific solutions to business problems (Etzkowitz, 2003).

In various academic systems, there are numerous routes to the entrepreneurial university. To be entrepreneurial, a university must have a high level of autonomy from the state and businesses, as well as a high level of contact with these institutional realms (Etzkowitz, 2013).

Academic entrepreneurship can have a double benefit when working with non-academic's problems (basic practical challenges). On the one hand, this effort serves the demands of academic enterprise supporters and sustains that enterprise. These research activities, on the other hand, have the potential to generate new research topics with theoretical implications (Etzkowitz, 2013).

In response to rising international competitiveness, university-business connections grew dramatically in the United States during the 1970s and 1980s. Because the progressive evolution of products within corporations was insufficient to guarantee economic growth, academia introduced a new alignment to corporate interests. There was a need to integrate new technology into current businesses and to establish new firms based on new technologies. The integration of research and application has established the base of a civil technology development policy, a paradigm previously restricted to the military sector (Etzkowitz *et al.,* 2003).

Simply conducting the scholarly study in basic disciplines did not generate enough information to contribute to economic growth and performance. The demand, to develop new multidisciplinary subjects and research areas devoted to offering solutions to specific societal problems and difficulties, encouraged the establishment of the entrepreneurial university (Audretsch, 2014).

Etzkowitz (2013) points out the existence of three stages for the development of the entrepreneurial university: (Stage 1) the academic institution develops a strategic vision for its future orientation and gains some power to evaluate its objectives, generating funds through contributions and grants or negotiating with resource providers; (Stage 2) the academic institution takes active participation in the commercialization of intellectual property generated by its academics, professionals, and students; (Stage 3) The academic institution takes the efforts to improve the efficacy of its regional innovation ecosystem, frequently in conjunction with business and government actors.

The entrepreneurial university should focus its studies on improving the firms from their cities, states, and countries. The universities have many resources capable of bringing development to the countries. In developed countries, this phenomenon already shows good and significant results, the entrepreneurial universities can boost the developing countries making possible the creation of a development model that fits the developing countries' needs. These countries should not simply copy the developed countries' model, they should construct their model by considering their specificities, peculiarities, potentialities, strengths, and weaknesses.

Brito Cruz (2018) analyzed the proportion of the financial resources by the companies in comparison with the total of the university research contracts in the 2000-2016 period on the universities MIT, UC Davis, UC Berkeley, USP, and Unicamp, and found that in any case, the proportion does not exceed 25%; The MIT differs from the others in that it has seen a surge in the use of business resources in recent years, reaching 21% of the total in 2016; Unicamp had a larger rate than MIT between 2006 and 2012, reaching 23% in 2007; The percentage for USP and Unicamp are nearly the same value as the University of California, Berkeley.

2.3 Triple helix

According to the Triple Helix concept, the interaction between universities, businesses, and governments are essential to supporting the conditions for innovation in a knowledge-based society. In addition to the development of new products in businesses, new institutional arrangements that support the conditions for innovation must be built (Etzkowitz, 2003).

The Triple Helix model of Etzkowitz and Leydesdorff (2000) is shown in Figure 1.

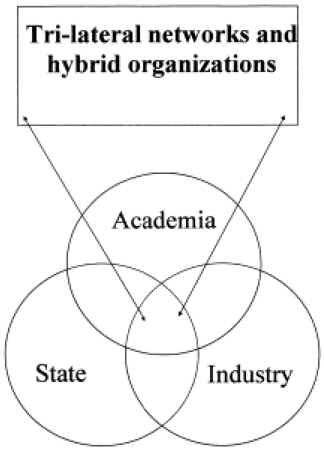

Figure 1 - Triple Helix

Source: Etzkowitz e Leydesdorff (2000)

The analytical model developed in Triple Helix contributes to the description and analysis of a wide range of institutional configurations and policy frameworks. As one institution becomes more connected to the other two, there is an expanding intersection of communication, relationships, and organization between the helices (Etzkowitz and Leydesdorff, 2000).

The triple helix emanates in the interaction between universities, businesses, and governments, as well as an internal development in each of these institutional domains. The overlap of the spheres gives a social structure model for explaining the interaction between scientific knowledge production and business agreements. Partnerships do not have to be formed exclusively with national governments or specific industrial sectors. Businesses take global positions. Blocks such as the European Union and Mercosul provide opportunities for breaking down internationalization obstacles (Etzkowitz and Leydesdorff, 2000).

The collaboration of universities, businesses, and governments, or the triple helix, that results in the efficient generation of innovation has received a lot of scientific attention recently. This institutional connection produces win-win outcomes, such as greater company competitiveness, human capital development, and overall economic development. The fast application of information and results of scientific research conducted in universities and other public research organizations is critical to a company's competitiveness (Prokop *et al*., 2018).

2.4 Socioeconomic impacts of university-industry collaborations

The Pasteur's quadrant, according to Stokes (1997), contains basic research aimed at pushing the boundaries of understanding while simultaneously being motivated by considerations of use. Given how well Pasteur's quest for knowledge and application exhibits the combination of targets.

The recognition that university-industry links can play an important role in promoting the capacity for innovation and competitiveness of the economic systems increased the interest given to the subject by the researchers who work on socioeconomic development issues that will be the focus of their future research (Rosa-Pires *et al*., 2002).

The university's position as one of the primary drivers of a knowledge-based society is related to its novelty-producing capacity. Part of this discovery has practical consequences for institutional and personal advantages, as well as increased regional and national competitiveness. Despite differences in national contexts, there are elements common to the university's role in economic and social development that is built on innovation (Etzkowitz, 2013).

The perception of the university as a motor of regional growth has long stimulated the interest of academics and policymakers. Universities participate in knowledge transfer, build relationships with enterprises, and assist in the development of innovation infrastructure, including research laboratories, scientific parks, and industrial clusters. As a result, in recent decades, universities have evolved into managerial organizations interested in producing profits and making a local, regional, and national economic effect (Budyldina, 2018).

In the face of the old triumvirate of land, labor, and capital, science appeared as an alternative engine of economic growth (traditional sources of wealth). Scientists and engineers became entrepreneurs by creating new enterprises, and science and technology became a more crucial factor of capital (Etzkowitz, 2013).

The university is a key resource in the dynamics of innovation, as well as a fantastic source of ideas for firms. Furthermore, academic specialists are qualified and have the necessary resources for assessing the technical feasibility of new technology application. Thus, the analysis and comprehension of the socioeconomic implications of university–industry relationships are extremely critical.

3. SOCIOECONOMIC IMPACTS OF UNIVERSITY–INDUSTRY COLLABORATIONS–A SYSTEMATIC REVIEW AND CONCEPTUAL MODEL[1]

This chapter refers to Article 1, according the previously presented in item 1.3 – Thesis structure from the Introduction chapter.

ABSTRACT

University–industry collaborations create socioeconomic impacts for the areas where they are undertaken. Although these collaborations have recognized importance and a high potential to generate economic and social benefits, there is no consensus in the literature on a consolidated conceptual model for assessing their socioeconomic impacts. Given this scenario, this study reviews 94 studies on the socioeconomic impact of university–industry collaborations using a context–intervention–mechanism–outcomes configuration. The impacts identified in the systematic literature review are classified into: (1) economic, (2) social, and (3) financial. The systematic literature review also indicates that the impact of collaborations can change the context and enhance the mechanisms of technology transfer. From a theoretical viewpoint, this work contributes to the structuring of a conceptual model for assessing the socioeconomic impacts of university–industry collaborations. In addition, the results have contributions for management in each strand of the triple helix: they may be useful to guide universities and companies on how to assess the socioeconomic impacts of each collaboration, direct public agents in the evaluation of results of investments, and support the development of policies for innovation and technology management.

Keywords: University–Industry; Economic Development; Innovation; Socioeconomic Development.

3.1 Introduction

Firms must continually adjust and change to thrive in a competitive, globalized economy. Despite the constant shift, firms drive markets by exploiting and strategically managing knowledge. Markets are driven by creative, efficient, and strategic knowledge management. Universities

[1] Lima, J.C.F.; Torkomian, A.L.V.; Pereira, S.C.F.; Oprime, P.C.; Hashiba, L.H. (2021) Socioeconomic Impacts of University–Industry Collaborations–A Systematic Review and Conceptual Model. *Journal of Open Innovation: Technology, Market, and Complexity.* 7(2), 137-159. https://doi.org/10.3390/joitmc7020137.

using knowledge to generate competitive advantage makes them fundamental elements in the science, technology, and innovation ecosystems [1].

The open innovation paradigm points out that firms must carry internal and external knowledge management in order to enhance the internal innovation process of companies, making it faster through the application of both internal and external ideas, with the improvement of its technology [2].

The university is a valuable resource in the open innovation dynamics, as well as a great source of ideas for companies. In addition, academic specialists are trained and have the required resources for technical feasibility evaluation of new technologies implementation. Thus, for the open innovation study area, it is extremely strategic, the analysis and understanding of the socioeconomic impacts of university–industry collaborations.

The triple helix thesis proposes that universities are increasingly vital to discontinuous innovation in knowledge-based societies, superseding companies as the primary source of future economic and social development. The three members of the triple helix are these: industry (as the locus of production); government (as the source of contractual ties that ensure secure interactions and exchange); and universities (as the source of new information and technology, the generative concept of knowledge-based economies) [3].

In the innovative university–industry–government triple helix, three institutional spheres interact to achieve innovation. Any one of them can take the lead as the organizer of innovation. The broad goals of the three actors are uniform: they all strive for innovation, even they follow different strategies to achieve that goal. Thus, the university–industry– government triple helix is in alignment [4]. There has been a growing recognition of the triple helix's potential contribution to economic development, especially in the relationship between universities and companies [5].

Entrepreneurial ecosystems, organized environments that promote the success of new ventures, come in many forms, including academia [6]. Entrepreneurial universities play critical roles in various triple helix configurations, jump-starting regional innovation by creating a new academic function, economic development [5,7].

The general theory of the economics of entrepreneurial ecosystems differs from the traditional neoclassical theory of economics. Entrepreneurial ecosystems are multifirm and multiproduct markets that might exist in the future; the traditional neoclassical theory of economics cannot capture the combinations of multifirm and multiproduct markets [6].

The metrics to measure the successes and impacts of technology transfer outputs have not yet been well defined [8]. There are several ways universities can positively impact local economies' development beyond technology transfer. However, university-led knowledge- based economic development needs time and patience, which are not always in sync with political schedules [9].

Despite the incentives and an increasing commitment to developing entrepreneurship practices at universities, better information management is still needed, including tools to analyze the entrepreneurial activities' performance. We need broader analysis methods for university entrepreneurship that go beyond specific indicators (e.g., financial returns on intellectual property) and consider the broader social and economic benefits (e.g., knowledge dissemination, creation of intangible assets, employment, socioeconomic and cultural development) [10]. We must develop better metrics to measure the impact and performance of technology transfer [8]. The effectiveness of technology transfer activities can be expressed through such parameters as the social impact on the community, job creation, and poverty reduction, which are all associated with long-term financial benefits [8]. Most university–company collaborative research focuses on specific elements, resulting in fragmented and inadequate research [5].

Consequently, this study sought to provide an embracing understanding of the socioeconomic impact of university–industry collaborations through a systematic literature review; the review addresses the context in which these interactions occur, the mechanisms or channels for technology transfer, and the resulting socioeconomic impacts. The systematic literature review reveals several lines of thought. This article is structured as follows. Section 3.2 describes the research method, followed by a presentation of the results in Section 3.3. Section 3.4 refers to a discussion on the socioeconomic impacts found in literature, the developed conceptual model, and future research directions. Section 3.5 concludes the article.

3.2 Materials and Methods

The systematic literature review has been widely used in management research as a research strategy aimed at situating the literature on a given topic in a systematic, transparent, and replicable manner [11,12]. A rigorous literature review should follow a well-defined method that provides detailed explanations of how it was conducted, and the relevant works selected so others could reproduce the review following the same steps. Systematic literature reviews analyze and synthesize the works published by researchers and academics [13]. Tranfield *et al.* [12] propose a systematic literature review framework based on a three-step approach to provide evidence-informed management knowledge: (1) review planning, (2) review conducting, and (3) results reporting [13]. Figure 2 summarizes these stages.

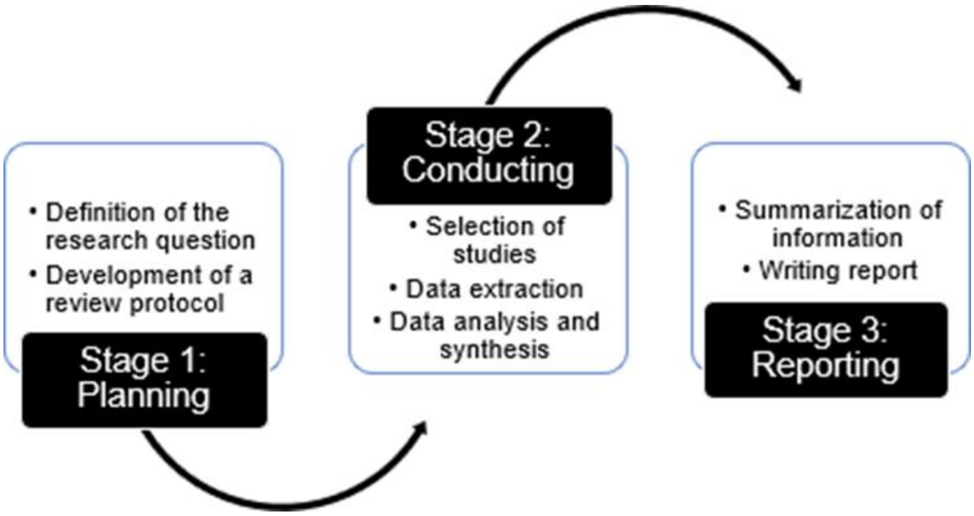

Figure 2 - Systematic literature review stages

3.2.1 CIMO Analysis

CIMO analysis is suitable for research that seeks to generate prescriptive knowledge. The CIMO-logic incorporates certain types of interventions to generate mechanisms that achieve the intended results [14]. CIMO helps explain the socioeconomic impacts of university–industry collaborations because it contextualizes the collaborations and inter-actions (i.e., interventions) between universities and businesses that affect both parties' activities and the mechanisms that generate the socioeconomic impacts.

Design proposals in traditional management literature often adopt simplistic Input- Outcome-logic [14], ignoring the outcomes' context-dependence or the mechanisms that produce the outcomes. In practice, concept proposals based on CIMO logic and derived from academic research often include an extensive learning process rather than the direct application of basic rules [14].

- Planning (Stage 1)

In the planning of the systematic literature review, the research question and the keywords used were defined and a review protocol elaborated, which is described in Table 1.

First, we defined the research question and chose the keywords. We searched two databases, Scopus and Web of Science, considered the most relevant databases with the largest number of studies on the topic of interest. We then defined the inclusion and exclusion criteria according to studies on systematic literature reviews and research objectives. The search is described in Section 2.2. The topics evaluated in the data extraction are presented in Table 2. For our analysis and synthesis, we used two computer programs: (1) we used the StArt1 software to select articles by evaluating the titles, abstracts, and keywords based on the inclusion and exclusion criteria (we conducted a peer review of the selected studies to remove inappropriate documents); and (2) we used the NVivo®2 software for data extraction, data management, and content analysis of the studied theme.

Table 1 - Review protocol

Steps	Description
Research question definition	What are the direct socioeconomic impacts of university–industry collaborations?
Keyword's definition	("knowledge transfer" or "technology transfer" or "collaboration" or "contract" or "interaction") and ("university" or "academic" or "faculty") and ("social" or "economic" or "socioeconomic") and ("growth" or "impact" or "effect" or "development" or "spillover" or "progress" or "sustainability") and ("firm" or "business" or "company" or "industry" or "corporation" or "establishment" or "organization" or "enterprise")
Definition of databases	Web of Science and Scopus
Articles' inclusion/exclusion criteria	Main selection criterion: adherence of the article to the topic "University–industry collaboration" - Checking the title, abstract, and keywords, and if necessary, a more in-depth reading of the text - Inclusion criteria: only articles mentioning the socioeconomic impacts of theuniversity–industry collaboration and that present resulting impacts - Articles in English - Articles published in peer-reviewed journals - Main exclusion criterion: Articles published in congress proceedings, book chapters, theses or dissertations, newspaper reports, opinion pieces, and other similar papers - Exclusion of duplicated articles - Exclusion of articles that are studies in progress/unfinished - Exclusion of articles that do not meet the other inclusion criteria
Data extraction	- Authors - Journal - Country - Year - Nature of the study (if conceptual or empirical research, if it follows a qualitative or quantitative method or analysis) - Socioeconomic impact
Analysis and synthesis	- Use of StArt® for the selection of articles in the systematic review - Use of NVivo® for data management and content analysis - Data summary: Descriptive statistics and content analysis - CIMO analysis

Notes: CIMO = context–intervention–mechanisms–outcome [14].

Table 2 - Number and percentage of articles per journal

Journal	Number	Percentage (%)
Journal of Technology Transfer	18	19.15
Research Policy	9	9.57
Technological Forecasting & Social Change	8	8.51
Science and Public Policy	5	5.32
Economic Development Quartely	5	5.32
R&D Management	3	3.19
Entrepreneurship & Regional Development: An International Journal	2	2.13
Growth and Change	2	2.13
Higher Education	2	2.13
Industry & Higher Education	2	2.13
Journal of the Knowledge Economy	2	2.13
Management Decision	2	2.13
Science, Technology & Society	2	2.13
Technovation	2	2.13
Economy of Region	1	1.06

Table 2. Cont.

Journal	Number	Percentage (%)
Economic Research	1	1.06
Engineering Economics	1	1.06
Evaluation and Program Planning	1	1.06
Foresight	1	1.06
Futures	1	1.06
Industrial and Corporate Change	1	1.06
Innovation	1	1.06
Innovative Higher Education	1	1.06
International Entrepreneurship and Management Journal	1	1.06
International Journal of Entrepreneurial Behavior & Research	1	1.06
International Journal of Global Environmental Issues	1	1.06
International Journal of Sustainability in Higher Education	1	1.06
International Journal of Technology Management	1	1.06
Journal of Business Research	1	1.06
Journal of Business Venturing	1	1.06
Journal of Chinese Economic and Business Studies	1	1.06
Journal of Intellectual Capital	1	1.06
Journal of Product Innovation Management	1	1.06
Journal of Regional Science	1	1.06
Knowledge Management Research and Practice	1	1.06
Measuring Business Excellence	1	1.06
Prometheus: Critical Studies in Innovation	1	1.06
Regional Studies	1	1.06
Research Evaluation	1	1.06
Social Science	1	1.06
Social Science Information	1	1.06
Studies in Regional Science	1	1.06
Tertiary Education and Management	1	1.06
The Annals of Regional Science	1	1.06
Total	94	100

- Conducting (Stage 2)

We conducted our keyword search in June 2020. Our search for relevant articles published between 1945 and 2019 turned up 2516 articles: 1488 (59%) listed by Web of Science and 1028 (41%) listed by Scopus. We imported the research data from the databases into the StArt software in BibTeX format. Duplicate articles (393) were removed, leaving a total of 2123 articles. We read the titles, abstracts, and keywords and applied the inclusion and exclusion criteria identified in Table 1, which left us with 180 articles. After evaluating the full texts based on the above-mentioned criteria, we retained 94 articles for the study (86 did not qualify for inclusion). Figure 3 shows the literature filtration process.

We extracted the following information: authors, year of publication, title, journal, nature of the study (conceptual or empirical), methodology [15–17], and the country of origin of the author's institution [16,17]. We used the context–intervention–mechanisms– outcome (CIMO) methodology to conduct our analysis [14]. The CIMO analysis considers a context in which an intervention is suggested, creating mechanisms that, in a certain context, are triggered by the intervention to achieve the intended outcome(s) [14]. In the context of this study, CIMO refers to how university–industry collaborations are carried out, considering the context in which they occur, as well as interventions, mechanisms, and results in terms of socioeconomic impacts.

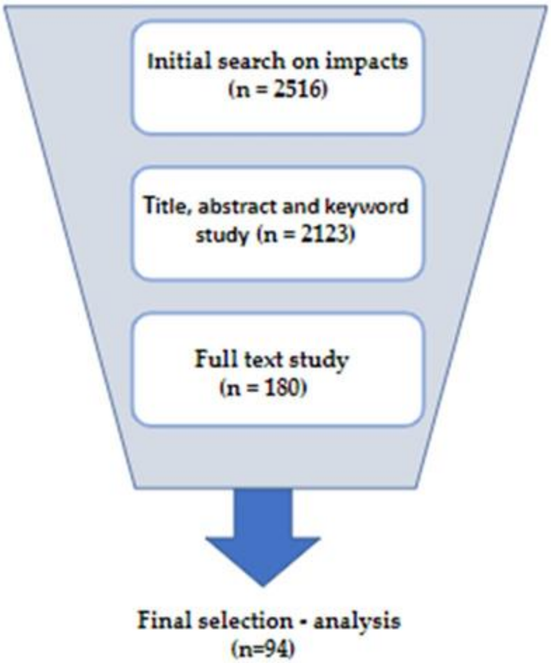

Figure 3 - Selection of studies

3.3 Results

This section shows the results (Stage 3) with the descriptive analysis.

- Descriptive Analysis

Table 2 illustrates the production of scientific articles and classifies them based on the journals with the highest publication volume. The selected papers have been published in a variety of academic journals. The articles, numbers, and percentages of publication in each journal are shown.

The authors who participated in more than one article were David Urbano (4), Albert Link, Christopher Hayter, David Audretsch, Erik Lehmann, Matthias Menter, Maribel Guerrero (3), and Andrés Barge-Gil, Aurelia Mondrego, Helen Lawton Smith, Peter Nijkamp, Joaquín Azagra-Caro, Elena Tur, Magnus Klofsten, Alain Fayolle (2) (Appendix A). The remaining authors contributed to only one article each.

Figure 4 illustrates the overall increase in the number of articles published on the subject during the selected period. Figure 4 shows a trend of significant growth in publications since 2010, with the highest number of published articles in 2019, with 17. In 2019, the *Journal of Technology Transfer* published the special issue “Economic, Technological and Societal Impacts of Entrepreneurial Ecosystems” and the journal *Technological Forecasting & Social Change* published the special issue “Understanding Smart Cities: Innovation Ecosystems, Technological Advancements, and Societal Challenges.”

Our analysis of the countries that produced scientific articles considered the countries of the institutions to which the authors and co-authors were linked. If an author was linked to more than one institution in different countries, we considered all the institutions. The greatest percentage of researchers were linked to institutions in the United States (25 articles; 27%), the United Kingdom (15 articles; 16%), and Spain (12 articles; 13%) (Appendix A). All 94 articles addressed socioeconomic impacts of university–industry collaborations and presented relevant information for the construction of the conceptual-theoretical framework of this research. Each article analyzed university–industry collaborations under a specific perspective on a main theme that was identified in the theoretical construction of each study.

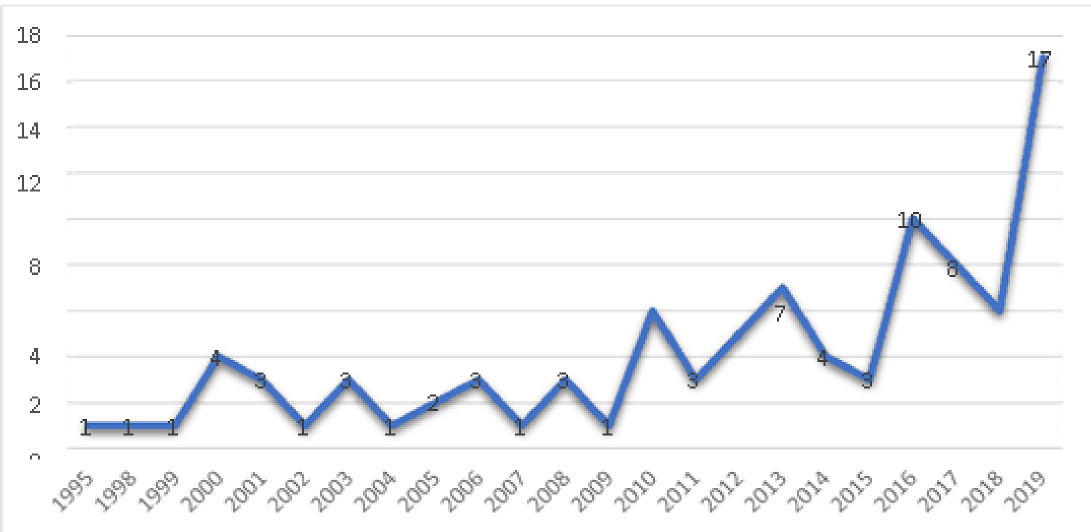

Figure 4 - Frequency of publications (1995–2019)

This literature review divided the 94 articles into two methodological categories: conceptual and empirical. Conceptual studies are those that formulate emerging concepts, frameworks, and models. Empirical studies are those that use surveys, case studies, interviews, and experiments [17,18]. Our evaluation found more empirical studies (85) than conceptual studies (9). In the empirical research, the predominant methods were surveys (57), case studies (21), interviews (6), and experiments (1), as shown in Table 3.

Table 3 - Research methods

Research Method	Quantity	Percentage (%)
Conceptual	9	9.57
Empirical	85	90.43
Survey	57	60.64
Case Study	21	22.34
Interview	6	6.38
Experiment	1	1.06

3.4 Discussion

This section presents the discussion based on the CIMO structure. Section 3.4 presents the CIMO analysis and discusses the context of university–industry collaborations, the intervention, the results, and the mechanisms that lead to the results.

- Context

In the CIMO perspective, the contexts analyzed are the internal and external environments that influence behavioral change [14,16]. This systematic literature review identified both external and internal contexts: (1) the external contexts were the socioeconomic conditions and the national and regional laws and policies; (2) the internal contexts were the universities' characteristics, the firms' characteristics, and the researchers' characteristics. A region's capacity to absorb knowledge is most often associated with its socioeconomic conditions [19]. The ability of universities to invest in research and development (R&D to generate knowledge and apply it in industries generating innovations depends on political, economic, and social conditions [9].

Technology transfer policies support a commitment that considers knowledge spillovers to be public and offers property rights to guarantee the commercialization of developed technologies and a return on additional private investments. In the innovation system, the political and legal environment influences the type of knowledge generated, prioritizing the areas of greatest interest, and directing investments, affecting the rate of technological transformation [9]. Therefore, consolidating entrepreneurial universities created national and regional programs and public policies to encourage university–industry collaborations; this benefited local companies and opened a new market for academic innovation R&D [20].

Universities and companies follow distinct paradigms and have different interests and objectives, the latter totally focused on profits and financial returns, and the former with their own interests. However, universities are under increasing pressure to generate economic benefits for society [19]. Universities invest financial and intellectual capital in startups in exchange for part of the businesses created from scientific research. They also establish collaborations with technology companies, based on R&D in exchange for participation in the generated intellectual property and benefits to the status of their faculty [21].

Commercial companies have the same relatively simple goal: earning profits. In contrast, universities have multiple objectives beyond the obvious ones of educating students; they also serve the greater society by developing and sharing knowledge and nurturing their faculty, scientists, and researchers to support the scientific community in general [9]. Research in collaborations between universities and industries should focus on areas of mutual interest, both academic and business. For a collaboration to be sustainable, the research results must add long-term value for the university and the industry or company. The value will depend on the perceptions of the research's impact on enhancing companies' and universities' strengths [22].

Several authors have reported on how various firm characteristics influence the establishment of university collaborations: size [22,23]; time of existence [24]; geographic location [21,25,26]; operating sector [19]; and specialization in the operating sector [27]. Ahrweiler et al. [28] investigated the role of university–industry links for innovation generation and diffusion in networks in two contexts: large, diversified companies and small technology companies. The latter context has been studied by several authors, such as Audretsch et al. [29] and Doh and Kim [24].

Although favorable external contexts (socioeconomic conditions, national and regional laws and policies) and favorable internal contexts (companies' and universities' characteristics) are necessary, they are not sufficient to ensure technology transfer. Further- more, although cutting-edge research universities are critical assets for urban and regional economies, their presence does not guarantee regional economic development [25].

Ahrweiler et al. [28] found no direct and instant link between increasing knowledge inputs and financial returns with increasing profitability; nor did they find that companies with collaborative projects with universities were any better at adapting to changes in environmental conditions than their nonaffiliated counterparts. The average life of companies that interacted with universities was no longer than that of those that did not; additionally, increasing the knowledge quantity input automatically did not elevate the innovation generated or economic benefits.

The context presented by Bramwell and Wolfe [25], Bercovitz and Feldman [9], and Ahrweiler et al. [28] showed that despite the existence of robust structures with favorable conditions for the transfer of technology and the establishment of university–industry collaborations, the objectives of the collaborations were not always realized. This evidences the need for and importance of another factor in collaborations: the people and personal characteristics critical for technology transfer. The participants must connect academic research and its industrial and marketing applications, transforming scientific knowledge into financial profit. Effectively managing the available resources is essential for competitive advantage. Researchers and those involved in collaborations with access to cutting-edge technological research must identify the opportunities for pioneering innovations in the market efficiently and competitively.

Bradley et al. [30] outlined the various challenges for technology transfer: (1) university entrepreneurs are often older and generally lack many relevant business skills; (2) product research faculties are not always willing to adapt or align their research to technologies that can be transferred; (3) universities often lack the strong and consolidated social network necessary for successful technology transfer; and (4) university policies (e.g., promotion and tenure, financial and intellectual property) often do not offer the necessary subsidies and motivations for faculties to participate in technology transfer activities.

Figure 5 shows the context of university–industry collaborations.

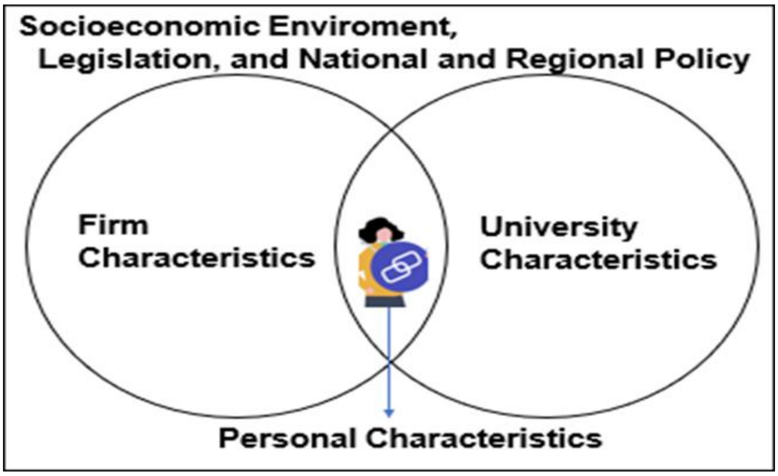

Figure 5 - Context of university–industry collaborations

- Interventions

Interventions are inserted in a broader system, the social system [18]. They are influenced by interpersonal links, the institutional configuration, and the broadest infrastructural system [14,31]. Managers have interventions at their disposal to influence behavior [18].

University–industry interactions are multifaceted, complex, and diverse. Commercialization can include a wide variety of transactions between universities and industries [9]. Although the flow of knowledge drives innovation, knowledge transfer from university to company is fluid, complex, and iterative [25]. Many authors have found formal and informal links in university–industry interactions: Budyldina [20], Bercovitz and Feldman [9], Bramwell and Wolfe [25], Ahrweiler et al. [28], Dutrénit and Arza [32], Perkmann et al. [33], Hope [34], Lendel and Qian [35], Azagra-Caro et al. [36], Kochetkov et al. [37], and Owusu-

Agyeman and Fourie-Malherbe [38].

Numerous formal and informal empirical works have investigated the possible ties between universities and firms. Universities are expected to provide the permanent growth, development, and diversification of knowledge for potential transfer to the industry that drives innovation. Furthermore, universities are strong network partners that are considered highly reliable because they are tied to public investments that largely isolate them from market fluctuations [28].

University–industry collaborations associate formal and informal interactions and are affected by industries' characteristics and business strategies, universities' rules, and the operational mode of the technology transfer activities and government policy interests [9]. The interactions between universities and industries frequently start as informal relation- ships that develop into more formal relationships with detailed descriptions of planning, roles, and expectations [38]. Formal channels involve the contractually supervised use of universities and firms' skills, resources, and facilities. In the absence of a formal contract, informal channels provide access to a pool of knowledge reflected in skills, resources technological and scientific capacities and requirements, and the preparation, procurement, and distribution of skilled personnel [36].

Commercialization generally occurs outside of formal academic channels, and universities seldom keep track of it [33]. Local economic effects are generally the result of a complex, dynamic, temporally unfolding series of interactions between formal and infor- mal channels of knowledge transfer [36]. Knowledge created during formal interactions can be transferred through informal networks [36].

- Mechanisms

Mechanisms produce outcomes [14]. In the context of university–industry collabo- rations, the mechanisms are the channels for technology transfer. We analyzed the links between contexts, interventions, and outcomes to establish the mechanisms. Table 4 shows the results by computing the percentage of each dominant mechanism. Appendix B shows the citations for each article used in the CIMO analysis, obtained from Google Scholar (5 April 2021), including the authors, year of publication, and the dominant mechanism.

Table 4 - Dominant mechanisms

Dominant Mechanism	Presences	Percentage %
Intellectual property	18	19.15
Spin-offs	15	15.96
Spin-offs and intellectual property	15	15.96
Hybrid organizations	13	13.83
Sponsored research	11	11.70
All mechanisms	10	10.64
Consulting and hiring professionals with academic knowledge	7	7.47
Spin-offs and hybrid organizations	2	2.13
Spin-offs and sponsored research	1	1.06
Intellectual property and hybrid organizations	1	1.06
Intellectual property and publications	1	1.06
Total	94	100%

The mechanisms identified were intellectual property, spin-offs, hybrid organizations, sponsored research, consulting and hiring professionals with academic knowledge, and publications and conferences. Table 4 shows the dominant mechanisms. Intellectual property (47.87%) and spin-offs (45.75%) stood out from the rest of the dominant mechanisms. The relevance of intellectual property has been noted by Perkmann et al. [33], Mets et al. [39], Jones and De Zubielqui [40], and Secundo et al. [41]. Licensing intellectual property provides legal rights that give companies access to technological solutions in the universities' intellectual property [9]. Spinning off companies and hiring professionals with academic knowledge enables more straightforward technology transfers through human resources movement [9]. Chiesa and Piccaluga [42] called academic spin-off enterprises one of the most promising ways to get scientific findings to the market.

The triple helix concerns the relationships among universities, industries, and governments and the creation of such hybrid organizations as incubators, science parks, and technology transfer offices [3]. The original business support structure of incubation has been reconsidered to emphasize its focus on the educational mission in training organizations [3]. According to Guadix et al. [43], considering the regional economic, business, and industrial context, science and technology parks have a high strategic value for the regions where they are located and carry out operations that promote research, development, innovation, and technology transfer. Universities transfer internally developed technologies to the public domain via technology transfer offices [19]. Audretsch et al. [29] emphasized the importance of technology transfer offices in universities' technology licensing. Bercovitz and Feldman [9] maintained that the setting of technology transfer offices represents an independent variable that partially accounts for the evaluated differences in patenting, licensing, and sponsored research between institutions.

Technology transfer offices differ considerably in their commercialization capacity. The license income distribution is highly localized, with a few big commercial hits yielding strong profits for a few universities [9]. Many high-impact start-up projects have emerged from academic studies in many developed countries, with the majority of these firms originating with a limited group of strongly entrepreneurial universities [44].

Sponsored research is a contract between a university and an industry. A sponsored research project supports university-commissioned studies and offers funding for facilities, graduate students, course launches, and faculty summer care [9]. Examples include collaborative research [45,46], contract research [22,35,47–50], and the establishment of R&D organizations [22,51–53].

Several authors considered consulting and hiring professionals with academic knowledge an important mechanism, such as Bramwell and Wolfe [25], Breznitz and Feldman [19], Chen et al. [51], and Hope [34]. Universities do not usually have individual consultancy agreements with the faculty member(s), as companies nearly always own all the created intellectual property and directly remunerate the faculty member; in these cases, the university does not have access to new investments and potential generation of intellectual property [9].

Dutrénit and Arza [32] argued that publications and conferences are traditional technology transfer mechanisms. They classified mechanisms into four types: (1) traditional (hiring professionals with academic knowledge and publication and conferences); (2) ser- vices (providing science and technical resources in exchange for funds, such as consulting, use of quality management facilities, tests, instruction, and so on); (3) commercialization of scientific results already obtained (academic spin-offs, licensing, patents, and incubators); and (4) bidirectional mechanisms motivated by long-term aims of knowledge (contract research, joint R&D projects, and scientific–technological parks). Their model was also used by Orozco and Ruiz [54] and Fernandes et al. [55]. Serendipity is considered an unconventional mechanism that could possibly start relationships that later unfold through different mechanisms [9].

University offices are often regarded as displays for companies and treated as cooper- ation platforms for marketing their R&D results. The mechanisms vary depending on the context in which a university and a company are engaged (e.g., the country, region, and prevailing incentive policies). Hayter and Link [56] listed numerous university-affiliated proof-of-concept centers (PoCCs) in the United States that contributed to a rise in that country's academic spin-offs. Chang et al. [57] presented a model created in China of a university–industry cooperation platform in which companies could seek partnerships with any higher education university in the country or vice versa. The China cooperation platform has improved the economic performance of that country's high-tech companies; this suggests a positive connection between economic performance and the number of cooperating parties. Different cooperation mechanisms impact the economic performance of high-tech companies at different levels [32,57].

- Outcomes

In this systematic literature review, the outcomes are the socioeconomic impacts of the university–industry collaborations. We classified the outcomes into three dimensions: (1) economic, (2) social, and (3) financial. We further subdivided each dimension as follows: (1) economic: infrastructure, production and processes, and scientific development; (2) social: jobs, skills, and qualification; and (3) financial: purchases, taxes, investments, and income generation. Figure 6 shows the proposed model for measuring the economic impact of university–industry collaborations.

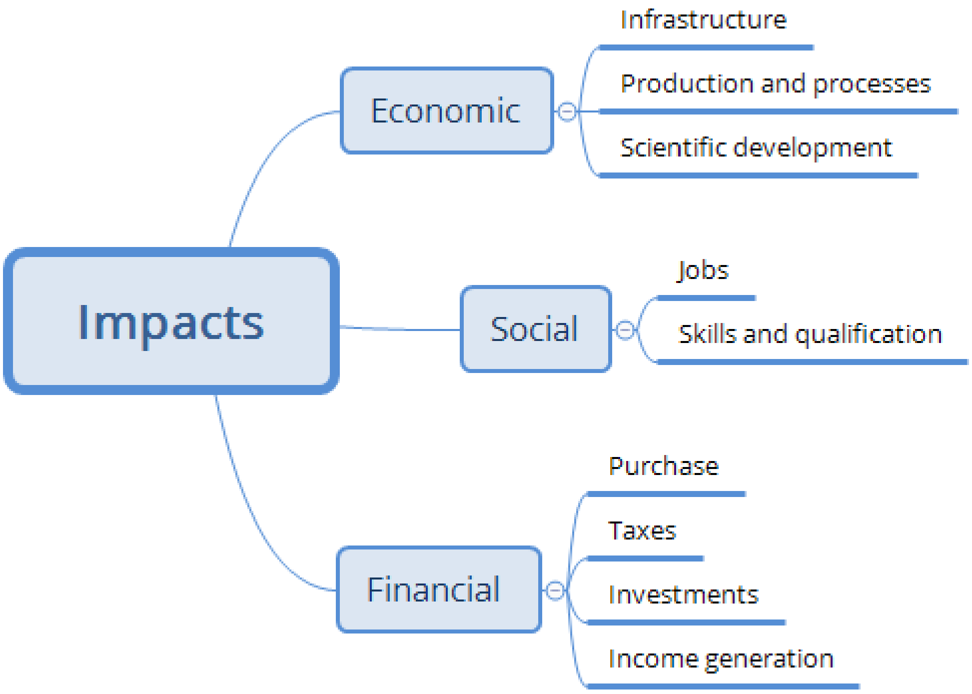

Figure 6 - Evaluation model

Several authors have addressed some of the socioeconomic impacts of university– industry collaborations on the technology transfer mechanism, such as the emerging of companies (startups and spin-offs), patents and licensing, and relevant scientific publications. Ahrweiler et al. [28] and Urbano and Guerrero [50] claimed that these collaborations could lead to new business opportunities. Etzkowitz [21] contended that universities have emerged as leading actors in a society predicated on knowledge owing to their nature as creators of original ideas. University–industry collaborations often result in new scientific and technological development partnerships that generate intellectual properties and market opportunities, such as industrial applications and new enterprises. Scientific novelty is of interest to academics, too, because it can generate new avenues for research. An enhanced mechanism from a university–industry collaboration can directly lead to such positive results as higher productivity, new products, increased sales, and commercial and societal value creation. Most of the authors in the systematic literature review regarded job creation as a socioeconomic impact of university–industry collaborations that could be quantified and influences people's quality of life.

Entrepreneurial universities can contribute through an advisory role in public policy formulation [19,46,58]. In this role, universities engage with local communities on a variety of themes. Nevertheless, most of the services and activities supplied by institutions cannot be easily quantified [19]. A university–industry collaboration can have several socioeconomic impacts on the actors in [59] triple helix; therefore, we propose a conceptual model of socioeconomic impact based on the main benefits from the actors in the triple helix. Figure 7 illustrates our Socioeconomic Triple Helix Conceptual Model.

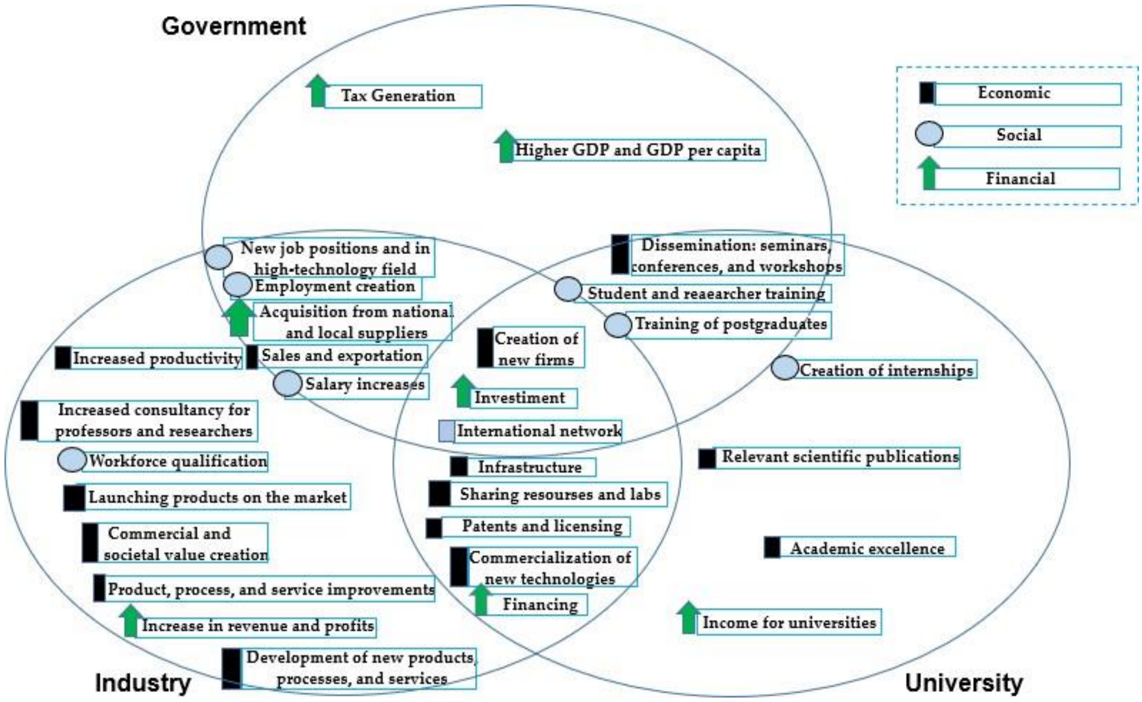

Figure 7 - Socioeconomic triple helix

The triple helix model puts the institutional spheres into perspective. An understanding of the most significant impacts and the stakeholders who benefit from such impacts facilitates negotiation between the constituents and enables strategies to be defined with the objective of enhancing the socioeconomic impacts based on interests and priorities.

The advantage of organizing the model according to the triple helix thesis is that the model has a visual and didactic advantage that makes it possible to quickly map the impacts and the main stakeholders, allow cuts or partial indicator applications for more specificity, and evaluate the impact of particular actions or public policies.

3.5 Conclusions

University–industry collaborations can have appropriate economic and social advantages. We developed the socioeconomic triple helix, a conceptual model of socioeconomic impacts identified in the systematic literature review based on Etzkowitz and Leydesdorff's [59] triple helix model. Our model has significant academic and managerial contributions.

- Theoretical Contributions

Many authors, including Galan-Muros and Davey [5], Audretsch et al. [6], Alessandrini et al. [8], Bercovitz and Feldman [9], and Etzkowitz et al. [10], have claimed that traditional metrics and indicators cannot capture the socioeconomic benefits of university– industry collaborations. Our work enables a deeper analysis of the socioeconomic impacts of university–industry collaborations, highlighting the existing effects in the literature through synthesizing high-value insights into the theory of socioeconomic development based on strategic knowledge management, R&D, and technological innovation. Our model complements the triple helix model with a socioeconomic perspective of the interactions among government, universities, and industries, thus adding knowledge and elaborating on the theory. This work provides a guide for researchers and scholars who are interested in university–industry collaborations.

- Managerial Contributions

In addition to its academic contributions, this research and our new conceptual model benefit all the actors in the triple helix: (1) universities and companies can use the model to assess the socioeconomic impacts of individual collaborations; (2) public agents can use it to evaluate the impacts of their investments; and (3) government agencies can use it to inform their development of public policies for innovation and technology management. The CIMO analysis enabled us to arrive at a deeper understanding of the peculiarities of university–industry collaborations and the generated socioeconomic results. CIMO made it possible to modify the contexts in which collaborations were undertaken to create a more conducive environment for the knowledge-based socioeconomic development that enables new public policies and mechanisms to enhance technology transfer.

- Research Limitations

The limitation of the research is that the model is generic, the types and areas of university–industry collaboration and their specific characteristics for each one must be taken into account in order to understand which indicators have the greatest strategic value in your institution’s position. Another important aspect to observe is the phase of university–industry collaboration, applying the most significant, important indicators and with the greatest variations in impact on that phase.

- Future Research Directions

Based on the results and the discussion on the socioeconomic impact of university– industry collaborations, we offer a few suggestions for future research: (1) an application of an evaluation model to university and companies and (2) a development of methods for the indirect impact assessment in local communities.

Future research should pursue applications of the proposed model, which will require developing metrics for each indicated variable. These additional metrics will enable the assessment of the socioeconomic impact of collaborative activities of university–industry partnerships by creating indicators that can be controlled and enhanced based on actions focused on the technology transfer mechanisms. Research has shown that conventional and quantitative metrics are not sufficient to measure the socioeconomic impact of university– industry collaborations fully [9,20]. In addition, a more qualitative assessment is suggested that addresses the indirect impact of university–industry collaborations—for instance, the creation of public policies [19,46], regional human capital attraction [5], and community and city development [19].

Author Contributions: Abstract and Introduction, J.C.F.L. and A.L.V.T.; Materials and Methods, J.C.F.L., A.L.V.T., S.C.F.P. and L.H.H.; Results J.C.F.L., A.L.V.T. and P.C.O.; Discussion, J.C.F.L., A.L.V.T.and S.C.F.P.; Conclusions, J.C.F.L. and A.L.V.T. All authors have read and agreed to the published version of the manuscript.

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Appendix A

Table A1. Authors who participated in more than one article.

Author	Articles	Year
David Urbano	4	2013, 2016 (2) and 2019
Albert Link	3	2013 (2) and 2015
Christopher Hayter	3	2013 (2) and 2015
David Audretsch	3	2009, 2013, and 2019
Erik Lehmann	3	2015, 2018, and 2019
Matthias Menter	3	2015, 2018, and 2019
Maribel Guerrero	3	2013, 2016, and 2019
Henry Etzkowitz	2	2005 and 2013
Maryann Feldman	2	2006 and 2012
Iryna Lendel	2	2010 and 2016
Andrés Barge-Gil	2	2010 and 2011
Aurelia Mondrego	2	2010 and 2011
Helen Lawton Smith	2	2003 and 2012
Peter Nijkamp	2	2007 and 2014
Joaquín Azagra-Caro	2	2017 and 2019
Elena Tur	2	2017 and 2019
Magnus Klofsten	2	1999 and 2019
Alain Fayolle	2	2016 and 2019

Table A2. Participation of analyzed countries in the number of publications.

Country	Participation (Number of Publications)	Percentage (%)
United States	25	26.60
United Kingdom	15	15.96
Spain	12	12.77
Germany	8	8.51
Italy	8	8.51
The Netherlands	8	8.51
Sweden	5	5.32
Norway	4	4.26
Australia	3	3.19
Canada	3	3.19
Portugal	3	3.19
South Korea	3	3.19
Austria	2	2.13
Belgium	2	2.13
Brazil	2	2.13
Denmark	2	2.13
Mexico	2	2.13
Russia	2	2.13
South Africa	2	2.13
Spain	2	2.13
Taiwan	2	2.13
Argentina	1	1.06
China	1	1.06
Colombia	1	1.06
Costa Rica	1	1.06
Croatia	1	1.06
Czech Republic	1	1.06
Estonia	1	1.06
France	1	1.06
India	1	1.06

Table A2. *Cont.*

Country	Participation (Number of Publications)	Percentage (%)
Indonesia	1	1.06
Ireland	1	1.06
Japan	1	1.06
Lithuania	1	1.06
Malaysia	1	1.06
Nigeria	1	1.06
Singapore	1	1.06
South Africa	1	1.06

Appendix B

Table A3. Number of citations and dominating mechanisms.

Authors and Year	Citations	Dominating Mechanisms
Ahrweiler et al. (2011) [28]	189	Spin-offs
Alessandrini et al. (2013) [8]	27	Intellectual property
Aparicio et al. (2016) [60]	40	Consulting and hiring professionals with academic knowledge
Audretsch et al. (2013) [29]	37	Intellectual property
Audretsch et al. (2019) [6]	131	Spin-offs and intellectual property
Azagra-Caro et al. (2017) [36]	81	Intellectual property
Azagra-Caro et al. (2019) [61]	9	Sponsored research
Barge-gil and Modrego (2011) [23]	107	Hybrid organizations
Baskaran et al. (2019) [62]	4	Hybrid organizations
Bercovitz and Feldman (2006) [9]	1070	All mechanisms
Bradley et al. (2013) [30]	72	Hybrid organizations
Bramwell and Wolfe (2008) [25]	771	Intellectual property
Breznitz and Feldman (2012) [19]	267	Intellectual property
Budyldina (2018) [20]	54	Spin-offs and intellectual property
Carayannis et al. (2017) [63]	54	Consulting and hiring professionals with academic knowledge
Carlsson et al. (2009) [64]	276	Spin-offs and intellectual property
Chang et al. (2006) [57]	62	Spin-offs and intellectual property
Chen et al. (2016) [51]	13	Sponsored research
Cheshire and Magrini (2000) [65]	233	Consulting and hiring professionals with academic knowledge
Chiesa and Piccaluga (2000) [42]	546	Spin-offs
Civera et al. (2019) [66]	18	Spin-offs
Coronado et al. (2017) [27]	4	Intellectual property
Dalmarco et al. (2018) [67]	65	Spin-offs and intellectual property
Dill (1995) [68]	202	All mechanisms
Doh and Kim (2014) [24]	285	Intellectual property
Dutrénit and Arza (2010) [32]	121	All mechanisms
Etzkowitz (2013) [21]	278	All mechanisms
Etzkowitz et al. (2005) [3]	490	Hybrid organizations
Fadeyi et al. (2019) [69]	4	Spin-offs and intellectual property
Farinha et al. (2016) [70]	92	Sponsored research
Fernandes et al. (2010) [55]	143	All mechanisms
Fischer et al. (2018) [71]	10	Hybrid organizations and intellectual property
Galan-Muros and Davey (2019) [5]	66	Sponsored research
Gjelsvik (2018) [72]	10	Spin-offs and intellectual property
Guadix et al. (2016) [43]	63	Hybrid organizations
Guerrero et al. (2016) [73]	174	Spin-offs and intellectual property
Handoko et al. (2014) [74]	46	Consulting and hiring professionals with academic knowledge
Hayter (2013) [75]	112	Spin-offs
Hayter and Link (2015) [56]	48	Hybrid organizations
Hearn et al. (2004) [76]	54	Spin-offs and intellectual property

Table A3. Cont.

Authors and Year	Citations	Dominating Mechanisms
Holley and Harris (2018) [52]	15	Spin-off and sponsored research
Hou and Wang (2019) [77]	2	Spin-offs and intellectual property
Hope (2016) [34]	16	Intellectual property and publications
Iacobucci and Micozzi (2015) [78]	90	Spin-offs
Jones and De Zubielqui (2017) [40]	61	Consulting and hiring professionals with academic knowledge
Jones-Evans et al. (1999) [79]	257	Hybrid organizations
Kalantaridis (2019) [80]	3	Intellectual property
Kim et al. (2012) [81]	151	Spin-offs
Klofsten et al. (2019) [82]	101	Hybrid organizations
Kochetkov et al. (2017) [37]	15	Spin-offs
Kourtit et al. (2014) [53]	2	Spin-offs and hybrid organizations
Langford et al. (2006) [83]	173	Sponsored research
Lee (2019) [84]	7	Intellectual property
Lehmann and Menter (2016) [85]	60	All mechanisms
Lehmann and Menter (2017) [86]	40	Intellectual property
Lendel (2010) [26]	104	Spin-offs
Lendel and Qian (2017) [35]	8	Consulting and hiring professionals with academic knowledge
Liu (2019) [87]	2	Intellectual property
Looy et al. (2003) [88]	203	Spin-offs
Macpherson and Ziolkowski (2005) [48]	37	Hybrid organizations
Mariani, Carlesi and Scarfò (2018) [89]	21	Spin-offs
Mascarenhas et al. (2019) [90]	7	Intellectual property
Mccullough (2003) [91]	7	All mechanisms
Metz et al. (2016) [39]	9	Intellectual property
Nicolaou et al. (2002) [92]	665	Spin-offs
Núñez-sánchez et al. (2012) [93]	25	Sponsored research
O'shea et al. (2008) [44]	574	Spin-offs
Olmos-peñuela et al. (2014) [47]	142	Consulting and hiring professionals with academic knowledge
Onken et al. (2019) [94]	1	Intellectual property
Orozco and Ruiz (2010) [54]	35	All mechanisms
Owusu-Agyeman and Fourie-Malherbe (2019) [38]	2	Sponsored research
Perkmann et al. (2015) [33]	62	Intellectual property
Philbin (2008) [22]	52	All mechanisms
Piirainen et al. (2016) [45]	39	All mechanisms
Raguž and Mehičić (2017) [95]	3	Intellectual property
Ramos-Vielba and Fernández-Esquinas (2012) [46]	93	Spin-offs and intellectual property
Ratinho and Henriques (2010) [96]	413	Hybrid organizations
Roessner et al. (2013) [97]	96	Intellectual property
Sá et al. (2019) [98]	27	Sponsored research
Sánchez-Barrioluengo and Benneworth (2019) [99]	61	Sponsored research
Secundo et al. (2017) [41]	115	Spin-offs and intellectual property
Sherman and Chappell (1998) [100]	267	Hybrid organizations
Shane (2001) [101]	58	Spin-offs and intellectual property
Smith (2003) [102]	145	Hybrid organizations
Smith and Bagchi-Sen (2012) [58]	157	Spin-offs and intellectual property
Steffensen et al. (2000) [49]	700	Spin-offs
Urbano and Guerrero (2013) [50]	297	Spin-offs
Van Geenhuizen et al. (2007) [103]	4	Hybrid organizations and spin-offs
Varga (2000) [104]	662	Spin-offs and intellectual property
Villasana (2011) [105]	27	Hybrid organizations
Vincett (2010) [106]	139	Spin-offs
Wakkee et al. (2019) [107]	31	Sponsored research
Wen and Kobayashi (2001) [108]	91	Sponsored research
Zucker and Darby (2001) [109]	443	Intellectual property

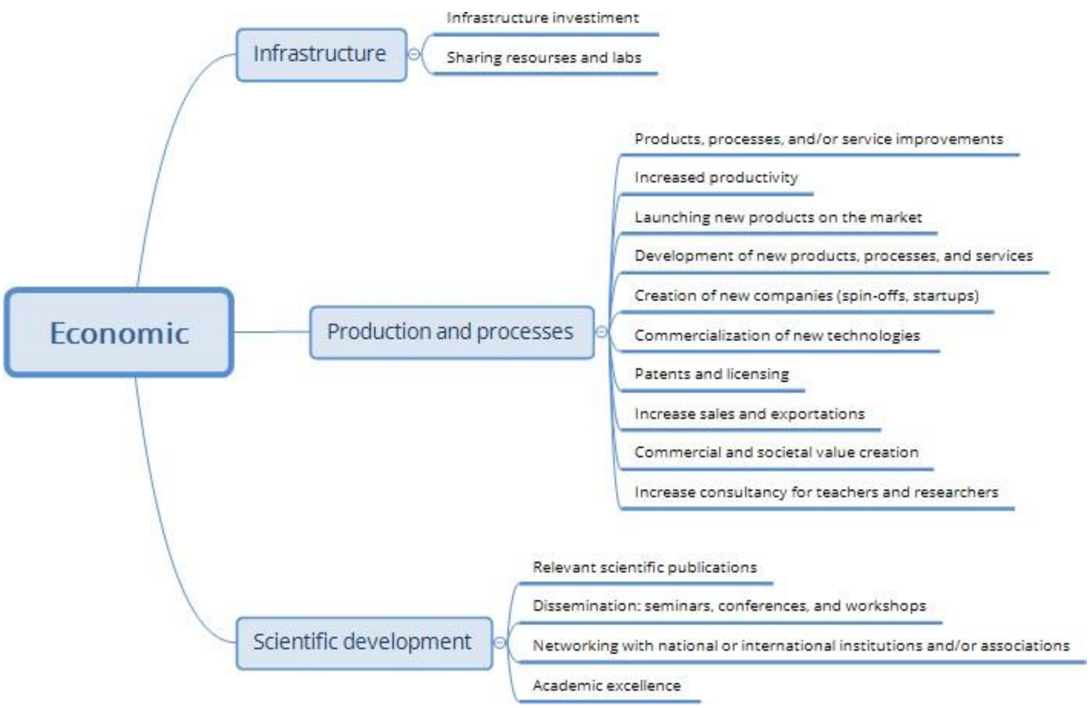

Figure 8 - Economic impacts of university–industry collaborations

Table A4. Economic impacts of university–industry collaborations.

Economic Impact	Presences	Percentage (%)
Infrastructure investment	2	2.13%
Sharing resources and labs	9	9.57%
Product, process, and/or service improvements	4	4.26%
Increased productivity	8	8.51%
Launching new products on the market	1	1.06%
Development of new products, processes, and services	4	4.26%
Creation of new companies	10	10.64%
Creation of spin-offs	27	28.72%
Creation of startups	13	13.83%
Commercialization of new technologies	8	8.51%
Patents and licensing	54	57.45%
Increased sales	10	10.64%
Increased exportations	2	2.13%
Commercial and societal value creation	2	2.13%
Increased consultancy for professors and researchers	17	18.09%
Relevant scientific publications	23	24.47%
Dissemination: seminars, conferences, and workshops	10	10.64%
Networking with national or international institutions and/or associations	5	5.32%
Academic excellence	2	2.13%

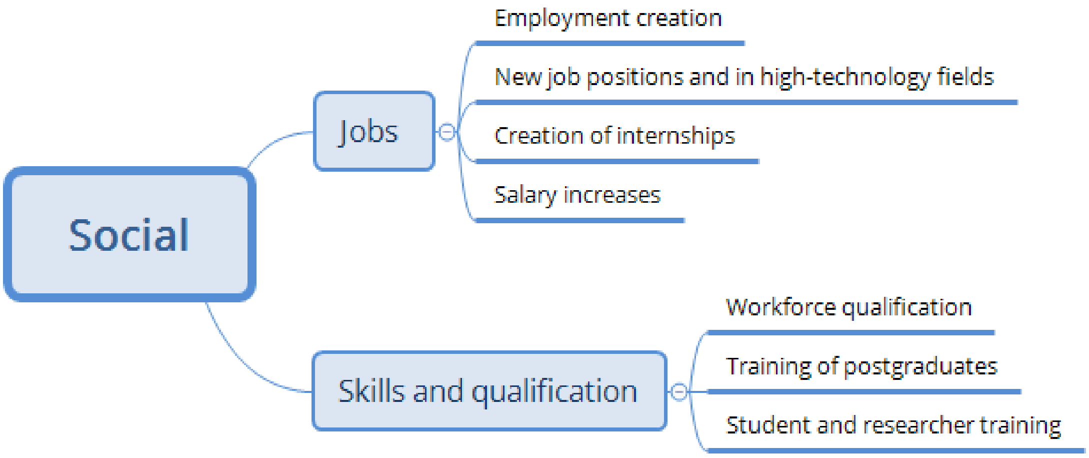

Figure 9 - Social impacts of university–industry collaborations

Table A5. Social impacts of university–industry collaborations.

Social Impact	Presences	Percentage
Employment creation	40	42.55%
New job positions and in high-technology fields	7	7.45%
Creation of internships	3	3.19%
Salary increases	1	1.06%
Workforce qualification	7	7.45%
Training of postgraduates	1	1.06%
Student and researcher training	4	4.26%

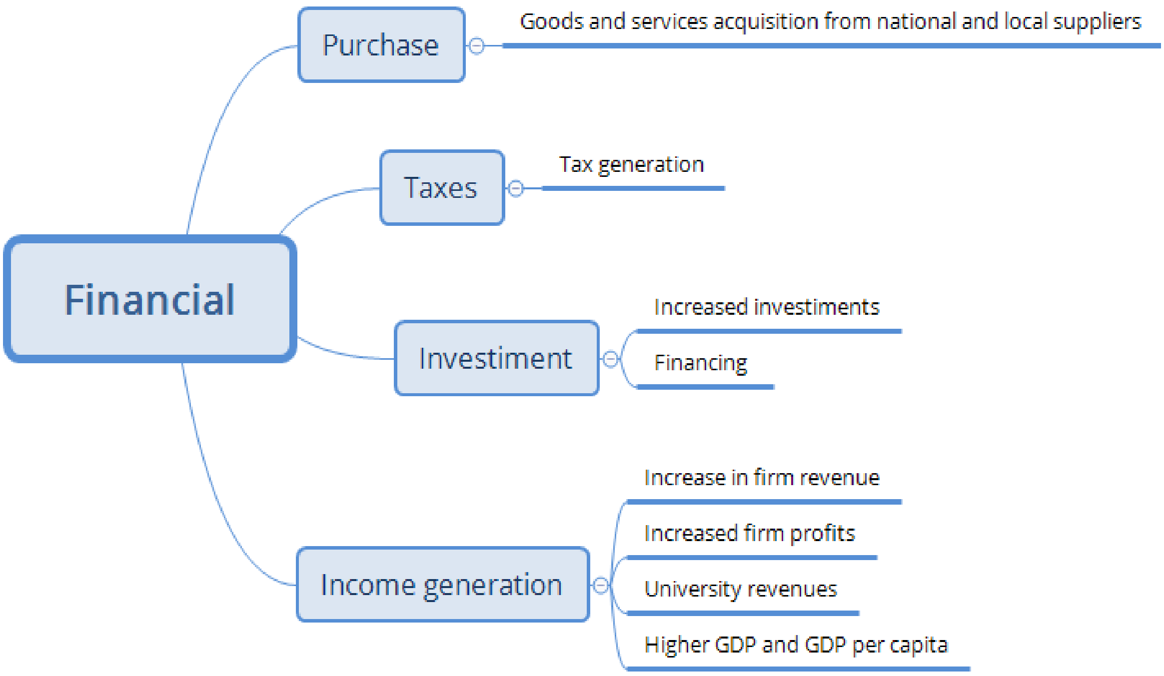

Figure 10 - Financial impacts of university–industry collaborations

Table A6. Financial impacts of university–industry collaborations.

Financial Impact	Presences	Percentage
Good and services acquisition from national and local suppliers	1	1.06%
Tax generation	4	4.26%
Investments	11	11.70%
Financing	9	9.57%
Firm revenue	1	1.06%
Firm profits	7	7.45%
University revenues	3	3.19%
Higher GDP and GDP per capita	13	13.83%

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4. SOCIOECONOMIC IMPACTS OF UNIVERSITY-INDUSTRY COLLABORATIONS: SCALE DEVELOPMENT AND PRETEST[2]

This chapter refers to Article 2, according the previously presented in item 1.3 - Thesis structure from the Introduction chapter.

ABSTRACT

University-industry collaborations result in generation of significant socioeconomic impact. Although these collaborations are recognized as drivers of socioeconomic development, there is a lack of metrics for assessing these impacts. Considering this gap, this study developed a scale to measure the socioeconomic impacts of university-company collaborations according to the companies' perspective. From a theoretical standpoint, this work contributes to the structuring of a measure model to evaluate the socioeconomic impacts of university-industry collaborations. The findings also have managerial implications enabling improvement, planning and performing of necessary actions to generate greater socioeconomic impacts from university-industry collaborations.

Keywords: University-industry. Socioeconomic development. Socioeconomic impacts.

4.1 Introduction

To survive in a dynamic global context, firms must constantly adapt and evolve. Firms drive markets by exploiting and strategically managing knowledge, despite the constant change. Universities are critical within the science and technology ecosystem as an inexhaustible source of information and technological capabilities, given the growing awareness of knowledge as a possible source of competitive advantage (Berbegal-Mirabent *et al.*, 2015).

Sabato's triangle has come up in debates on the link between three vertex, government, the productive sector, and scientific-technological infrastructure, as a foundation for growth via innovation. The triangle considers intra-relations within each vertex, inter-relations among the three vertexes, and extra-relations with exterior borders (Hatakeyama and Ruppel, 2004).

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[2] Lima, J.C.F.; Torkomian, A.L.V.; Oprime, P.C.; Borges, T.M.D. (2021) Socioeconomic Impacts of University-Industry Collaborations: Scale Development and Pretest. *LVI Asamblea Anual Cladea-Consejo LatinoAmericano de Escuelas de Administracion*. In press.

Academics and policymakers have recognized universities as potential drivers of regional economic growth (Fischer *et al*., 2018). The acknowledgement of universities as proactive entrepreneurial institutions was marked by the triple helix model (Budyldina, 2018).

The triple helix depicts a new configuration of institutional forces in innovation systems, as well as an interactive (non-linear) model of innovation and a trilateral adjustment of collaboration between academics, government, and business that contrasts to the traditional concept in which firms alone are responsible for economic production, universities are solely responsible for knowledge generation and transmission, and the government serves as a facilitator, regulator, and co-investor. The triple helix model acknowledged that the demarcation lines between the three institutions became less clear (Etzkowitz, 2008).

The entrepreneurial university attempts to stimulate socioeconomic development by promoting the transfer of academic knowledge to firms (Etzkowitz, 2008). The university has gained reputation as a potential resource for enhancing innovation and establishing a science-based economic development environment. Entrepreneurial activities are conducted with the goal of enhancing regional or national economic performance and producing revenue for the university and its faculty (Etzkowitz *et al*., 2000).

The growth of entrepreneurial activity at higher education institutions is largely due to an underlying need for economic development as well as a greater focus on social responsibility. Higher education institutions have a critical role in developing human resource capacity and efficiency (Alessandrini *et al.*, 2013).

Academic entrepreneurship operates within the limitations of various scientific and professional contexts in the economy knowledge, requiring the need for supportive help to overcome these limitations. The entrepreneurial university is deemed as a key accelerator for regional economic and social growth, because it develops and investigates knowledge as entrepreneurial potential (Urbano and Guerrero, 2013). In the face of the old trinity of land, labor, and capital (traditional sources of richness), science has arisen as an alternative engine of economic expansion. Scientists and engineers have been establishing new enterprises, and science and technology became a most important element of capital (Etzkowitz, 2013).

Although the university and its collaborations with the industry are recognized for promoting socioeconomic development, several authors point out the need to create metrics to assess the socioeconomic impact of these collaborations.

An increasingly important global goal from university is to develop and transmute knowledge and research into social and economical progress. However, the most widely used measures were created when research and teaching were the main academic goals (Etzkowitz *et al*., 2018).

According to Etzkowitz *et al*. (2018) despite the growing interest in finding solutions to help academics promote entrepreneurial behavior and practices, universities lack precise information and tools to track and evaluate overall entrepreneurial performance and processes.

It is commonly acknowledged that existing output metrics from the technology transfer are not only inadequately defined, but also fail to account for the national impact of technology transfer personnel's efforts. Instead of focusing solely on metrics such as the number of registered patents and revenue from license agreements, the efficacy of the technology transfer function could be measured in terms of social impact on communities, job creation and poverty reduction, all of which can be translated into long-term financial benefits for the country (Alessandrini *et al.*, 2013).

Academic entrepreneurship requires a comprehensive assessment that goes beyond specific criteria like financial returns on an intellectual property portfolio or individual performance, it must be considered broader social and economic benefits such as knowledge dissemination, production of intangible assets behind new venture process, and the contribution to employment for social, cultural, and economic reasons (Etzkowitz *et al*., 2018).

Consequently, in this work, a scale was developed to measure the socioeconomic impact of university-industry collaborations on the business perspective. The article is structured as it follows: the second section presents the literature review, the third section describes the research method and the fourth section refers to results, with the research development followed by conclusions, recommendations and future research possibilities in last section.

4.2 Literature review

The theoretical model used to develop the scale is a result of a systematic review of the literature carried out with 94 scientific articles (Lima *et al*., 2021). In this topic the results of the literature review and the model will be presented.

The socioeconomic impacts of university-industry collaborations found in the literature were categorized into (1) economic, (2) social and (3) financial. The dimensions were divided into (1) economic: infrastructure, production and processes, and scientific development; (2) social: jobs, skills, and qualification; and (3) financial: purchases, taxes, investments, and income generation (Lima *et al*., 2021).

Figure 11 presents the Lima et al. (2021) model for evaluating the economic impact of university-industry collaborations.

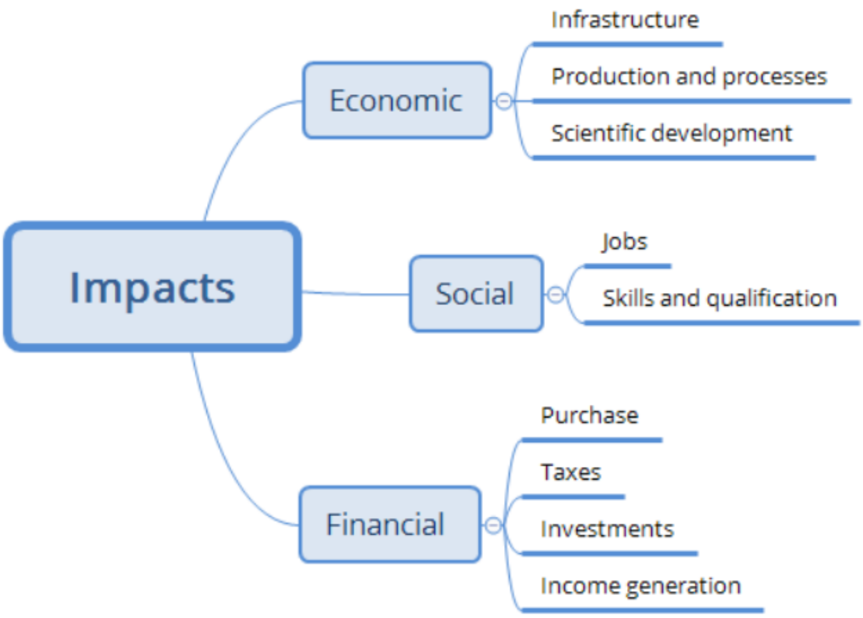

Figura 11 - Evaluation model

Source: Lima *et al.* (2021)

Based on the key benefits from the actors in the triple helix, Lima *et al.* (2021) developed a conceptual model of socioeconomic impact of the university-industry collaborations. The institutional realms are put into perspective using the triple helix paradigm. Understanding the most significant consequences and the stakeholders who benefit from them, contributes to the discussion between constituents and allows the development of policies aimed at improving socioeconomic impacts based on interests and objectives (Lima *et al.*, 2021).

Figure 12 illustrates the Socioeconomic Triple Helix Conceptual Model.

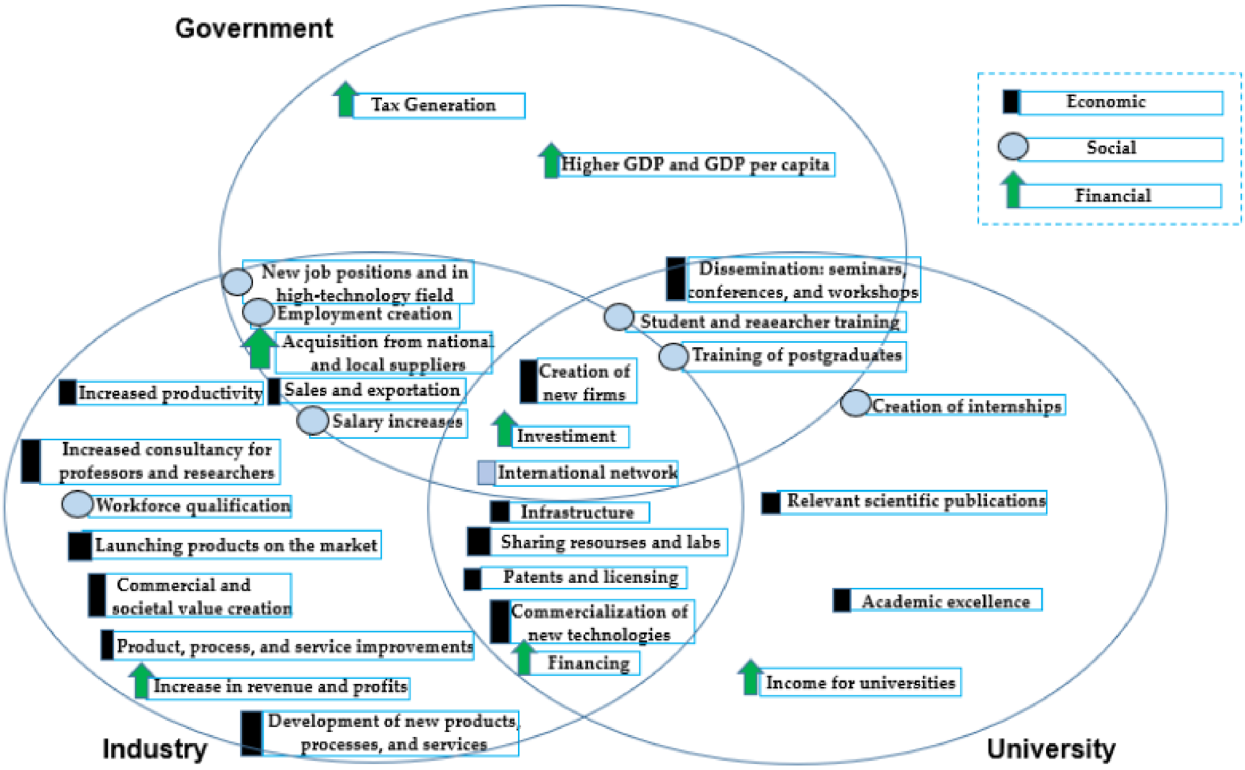

Figure 12 - Socioeconomic Triple Helix

Source: Lima *et al.* (2021)

We decided to analyze the perspective from the companies to verify what the impacts of collaborations are for this actor, considering that they represent more directly the socioeconomic development, for example, the income generation, jobs, and the development of new products and processes, inserting new products into the market derived from the university collaborations. On the other hand, understanding the impacts will enable actors to draw action plans to achieve the desired goals with each collaboration, being a highly strategical tool. As the objective of this study is to develop a scale to assess the socioeconomic impacts of university-industry collaborations on the perspective of companies, a model was cut accordingly to the research's area of interest.

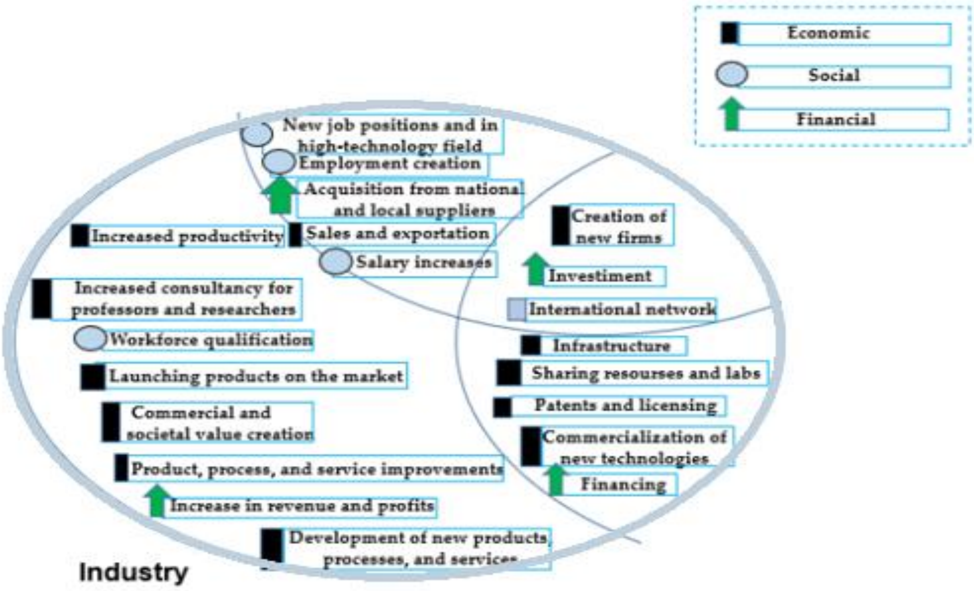

Figure 13 - Socioeconomic Impacts to Industry

Source: Based in Lima *et al.* (2021)

For the scale development, the guidelines of DeVellis (2017) were followed.

4.3 Research method

In a wide variety of social science contexts, measurement is very important (DeVellis, 2017).

To quantify processes that are thought to exist based on our scientific view of the universe but that can't be determined directly, we develop scales. Scales are measurement instruments that consist of a series of items combined into a composite score, they are used to reveal levels of theoretical variables that are not easily measurable by direct means (DeVellis, 2017).

The scale has been developed according to the recommended procedures and steps by DeVellis (2017): (1) determine clearly what is it that you want to measure and generate an item pool; (2) determine the format for measurement and have the initial item pool reviewed by experts; (3) consider the inclusion of validation items and administer items to a development sample; and (4) evaluate the items and optimize scale length.

- Determine clearly what it is you want to measure and generate an item pool

Authors like DeVellis (2017) claim that the initial poll must be greater than the final scale.

The items must be written according to the research objective, several items must be used but avoiding repetition, the items must be concrete, precise, and objective (Jonhson and Morgan, 2016).

- Determine the format for measurement and have (the) initial item pool reviewed by experts

There are several different types of question formats. Early on in the study process, the researcher should understand the format. This move should take place at the same time as item creation to ensure that the two are compatible (DeVellis, 2017).

According to DeVellis (2017), the identification of the target stimulus is followed by a list of adjective pairs. Each pair represents opposite ends of a continuum, defined by adjectives (e.g., disagree and totally agree). In essence, the individual lines represent points along the continuum defined by the adjectives. The respondent places a mark on one of the lines to indicate the point along the continuum that characterizes his or her evaluation of the stimulus.

Additionally, experts can be invited to comment on individual items. This makes the job a little more difficult, but it can yield excellent information. Some comments based on experts' experience about why certain items are ambiguous, for example, can make the items much easier to understand (DeVellis, 2017).

- Consider inclusion of validation items and administer items to a development sample

Many of the issues associated with shift score unreliability are avoided by using the initial state as a control variable (DeVellis, 2017).

It may be feasible and practical to include some additional items in the same questionnaire that will aid in assessing the final scale's validity (DeVellis, 2017).

- Evaluate the items and optimize scale length

According to DeVellis (2017) the ultimate quality we look for in a product is a high correlation with the latent variable's true score. The higher the correlations between items, the higher the reliabilities of individual items (i.e., the more intimately they are related to the true score).

The more reliable the items are, the more reliable the scale they form would be (assuming that they share a common latent variable). As a result, the first characteristic we look for in a group of scale objects is that they are highly intercorrelated (DeVellis, 2017).

The investigator has a pool of products that show acceptable reliability at this point in the scale creation stage. A scale’s alpha is influenced by two characteristics: the extent of covariation among the items and the number of items in the scale. For items that have item-scale correlations about equal to the average inter-item correlation (i.e., items that are fairly typical), adding more items will increase alpha and removing more will lower it. Generally, the shorter the scales, the better for respondents, who can respond more easily. Longer scales, on the other hand, tend to be more reliable (DeVellis, 2017).

Alpha coefficient is useful for estimating reliability in a particular case: when item-specific variance in a unidimensional test is of interest. If a test has a large alpha, then it can be concluded that a large portion of the variance in the test is attributable to general and group factors. This is an important information because it implies that there is very little item-specific variance (Cortina, 1993). This coefficient is best detailed in the next item (4.4 Results).

4.4. Results

The results are presented according to the guidelines of DeVellis (2017).

- Determine clearly what it is you want to measure and generate an item pool

The first step was to understand the concepts related to the socioeconomic impacts of university-business collaborations with an exploratory analysis of the literature. Thus, it was found that the main socioeconomic impacts of these collaborations comprise three fundamental groups: (1) economic, (2) social, and (3) financial.

The systematic bibliographic review (Lima *et al.*, 2021) was used to map the state of the art of the socioeconomic impacts of university-industry collaborations in the dimensions identified, which also made possible the establishment of subdimensions of each construct. Figure 14 shows the conceptual model used for the development of the scale.

Lima *et al.* (2021) identified 33 socioeconomic impacts from the systematic bibliographic review to be measured on the scale.

The 33 socioeconomic impacts identified were rewritten in the format of statements in order to provide a clear language for respondents according to guidance of Jonhson and Morgan (2016) presented in section 3 of the research method.

- Determine the format for measurement and have initial item pool reviewed by experts

The format for measurement used is the semantic differential scale.

Obtaining item significance assessments normally entails presenting the expert panel with the understanding work of the construct. They are then asked to rate each object in terms of its importance to the construct as described by the researcher.

The content validation of each practice was carried out by three groups of experts. The first group consists of internal academic research specialists: members of the research group in technology and innovation management (Department of Production Engineering – UFSCar), the second group of external academic research specialists: members of the doctoral qualification committee (from UFSCar and FGV), professor with factorial analysis and correlation experience (from UFSM), and the third group of management specialists: professors with experience in Incubators and Science Parks (from UFRN) and companies from Innovation Agency – UFSCar.

The review by internal specialists indicated the separation of impacts according to stakeholders, selecting only the direct impacts on companies for the scale, which resulted in 23 items.

The external experts suggested the inclusion of more items for the assessment of the social construct which resulted in a total of 24 items. The review by management specialists was used to assess the clarity of the questionnaire and the understanding of all items by the respondents.

Chart 1 presents the questionnaire in the third version.

Chart 1 - Questionnaire (third version of the scale)

Dimension	Subdimension	Socioeconomic impacts of university–industry collaborations	Code
Economic	Infrastructure	The partnership of our company with university(ies) results in greater amounts of investments in the company infrastructure	A1
		The partnership of our company with university(ies) results in resources sharing and/or universities laboratories.	A2
	Production and Processes	The partnership of our company with university(ies) results in products, processes and/or services improvement.	A3
		The partnership of our company with university(ies) results in the development of new technologies	A4
		The partnership of our company with university(ies) results in new technologies commercialization.	A5
		The partnership of our company with university(ies) results in the development of new products, processes and services.	A6
		The partnership of our company with university(ies) results in the release of new products	A7
		The partnership of our company with university(ies) results in the creation of new companies	A8
		The partnership of our company with university(ies) results in the generation of intellectual property (deposit of patent application, trademark registration, software registration or any other kind of intellectual property protection)	A9
		The partnership of our company with university(ies) results in patent licensing	A10
		The partnership of our company with university(ies) results in the increasing of our sales	A11
		The partnership of our company with university(ies) results in the increasing of our exportations	A12

		The partnership of our company with university(ies) results in the creation of commercial and corporate/shareholder value of our company.	A13
	Scientific Development	The partnership of our company with university(ies) results in the creation of network with other institutions and/or international associations	A14
Social	Employment	The partnership of our company with university(ies) results in employment generation	A15
		The partnership of our company with university(ies) results in the creation of new high technology workstations	A16
		The partnership of our company with university(ies) results in salary increase of employees who participated in the university-company collaboration	A17
	Skills and Training	The partnership of our company with university(ies) results in the professional qualification of our workforce	A18
Financial	Purchases	The partnership of our company with university(ies) results in the purchase of goods and services of local suppliers.	A19
		The partnership of our company with university(ies) results in the purchase of goods and services of national suppliers.	A20
	Investment	The partnership of our company with university(ies) results in the increasing of external investment on the company.	A21
		The partnership of our company with university(ies) results in the increasing of public or private financing of our company.	A22
	Revenue Generation	The partnership of our company with university(ies) results in the increase of company's revenue	A23
		The partnership of our company with university(ies) results in the increase of company's profit.	A24

- Consider inclusion of validation items and administer items to a development sample

In our study, we include a verification question initially to verify if the firm realizes formal collaborations with universities. In case of a positive answer, the respondent is sent to a questionnaire, if there is a negative response, then the respondent is sent to a different screen thanking and isn't included in the research.

- Evaluate the items and optimize scale length

The created questionnaire was sent to companies that collaborate with universities (with the University of Campinas – UNICAMP and the University of São Paulo – USP), and the companies from ANPEI – National Association for Research and Development of Innovative Companies, via e-mail and LinkedIn® to the scale pretest, in which 10 Brazilian firms, that have formalized collaboration projects answered the questionnaires. We analyzed the Cronbach Alpha with the SPSS® software. The data obtained are shown in Table 5.

Table 5 - Cronbach alpha

Cronbach's Alpha	Cronbach's Alpha based in standardized items	N of items
,931	,932	24

According to Almeida *et al.* (2010) Cronbach's Alpha is a statistical tool that measures the reliability of a questionnaire on a scale of 0 to 1. For a reliable questionnaire, 0.7 is the minimum appropriate value. As the value obtained in Cronbach's Alpha (0.931) was much higher than the minimum value (0.7) described by Almeida *et al*. (2010) the Cronbach's Alpha value (0.931) was accepted.

Another important issue is that checking the improvement of Cronbach's Alpha when it comes to removing the variables, there is minimal variation (almost null), considering that the only possibility of obtaining a greater Cronbach's Alpha would be with the removal of variable 15 and the Alpha obtained would be 0.932 (a practically insignificant difference from 0.931).

Therefore, all variables were included because the value of Cronbach's Alpha was well above the minimum accepted value (0,7) proposed by Almeida et al. (2010).

4.5 Conclusions

Although university-industry collaborations are recognized as capable of generating socioeconomic development, a literature gap is perceived in the area of comprehensive metrics to measure the socioeconomic impacts of these collaborations. This work achieved its objective of developing a scale to assess the socioeconomic impacts on the perspective of the firms and the scale pretest. This article of methodological applications includes both theory and practice aspects.

- Theoretical, Knowledge and Teaching Contributions

Several authors like Alessandrini *et al*. (2013), Etzkowitz *et al.* (2018) and Audretsch *et al*. (2019) agree that traditional measurements and indicators are incapable of capturing the socioeconomic benefits of university–industry relationships. Our work created a powerful tool for deeper analyzing the socioeconomic impacts of university-industry collaborations. The scale developed will contribute to the creation of new knowledge of great value and interest for academics, firms and the government. This study contributes to professional education and teaching with a new tool for analyzing important impacts of university-company collaborations.

This work provides scientific contributions of high knowledge value because it fills a gap present in the literature and noted by several authors, hence the lack of comprehensive metrics to measure the socioeconomic impact of university-company collaborations. In this way, it provides a powerful tool capable of analyzing the socioeconomic impacts on the companies' perspective. The described method can be replicated for the construction of scales to evaluate the socioeconomic impact from the perspective of both government and universities.

Regarding the contributions to education, it can be highlighted that the tool developed can be applied by students to assess the socioeconomic impact of their universities' collaborations with companies, the strategic information obtained can be used to strengthen collaborations and focus on the areas of greatest importance and interest of the stakeholders present. Additionally, the inclusion of practical activities in the teaching and education processes is widely recognized to be beneficial, contributive and capable to the formation of better qualified professionals, with practical experience of strategic analysis in the area of innovation and technology management.

- Managerial Contributions

The developed scale is a tool of fundamental importance for firms that carry collaborations with universities, which measures the socioeconomic impacts of their collaboration projects and guide their entire innovation strategy towards the main aspects of interest, in this way, a tool enables a thorough analysis of the socioeconomic impacts aspects of these collaborations, enabling companies to implement improvements and actions necessary to achieve better results in collaborative projects of research and development (R&D), and technological innovation.

Scales can also be constructed according to the perspective of universities and the government to assess the socioeconomic impacts of university-company collaborations, with greater strategic information according to the aspects of interest of these other actors.

- Research Limitations

The research limitation is that the scale is generic. It is necessary to comprehend the reality of the firms analyzed to identify what are the most important variables to the study proposed. Additionally, can be included other variables according to the specificities of the evaluated context.

- Recommendations and Future Research

According to the results obtained in the research, it is recommended to apply the tool to assess the socioeconomic impact on the perspective of companies serving as a support for strategic decision making, to improve the results in innovation and research.

As future research, it is suggested the creation of scales to assess socioeconomic impacts from the perspective of universities and the government. The data and information generated from the analyzes can be compared and the collaborations with better performance can serve as an example, allowing other collaborations to learn from and be inspired by, so they can generate significant socioeconomic impacts as well.

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5. SOCIOECONOMIC IMPACTS OF UNIVERSITY-INDUSTRY COLLABORATIONS: BRAZILIAN LARGE FIRMS PERSPECTIVE[3]

This chapter refers to Article 3, according the previously presented in item 1.3 - Thesis structure from the Introduction chapter.

ABSTRACT

Covid-19 has put public health services to the test. Economic systems will soon be put to the test by Covid-19. In order to recover from the effects of the coronavirus, innovation will be essential (Chesbrough, 2020). Firms must continuously adapt and evolve to thrive in a dynamic, global environment. Despite the continuous change, firms drive markets by utilizing and strategically managing knowledge. Universities are crucial parts of the scientific and technological ecosystem because they provide an endless supply of data and technical capabilities (Berbegal-Mirabent *et al.*, 2015). Universities lack clear data and methods for tracking and evaluating overall entrepreneurial success (Etzkowitz et al., 2018). Existing technology transfer output metrics are widely considered to be not only insufficiently defined, but also inaccurate (Alessandrini *et al*., 2013). This article is part of a doctoral research in the area of innovation and technology management on the socioeconomic impacts of university-industry collaborations. This work presents a multivariate statistical analysis of the socioeconomic impacts of university-industry collaborations from the firm's perspective. We used the Lima *et al.* (2021) model based in a systematic literature review of the socioeconomic impacts of university-industry collaborations, the impacts were categorized into (1) economic, (2) social and (3) financial. The dimensions were divided into (1) economic: infrastructure, production and processes, and scientific development; (2) social: jobs, skills, and qualification; and (3) financial: purchases, taxes, investments, and income generation. According to the research's focus, a model was cut to evaluate the firm perspective. Multivariate analysis refers to all statistical techniques that analyzes multiple measurements at the same time. Some multivariate techniques are designed specifically to address multivariate aspects such as factor analysis. Canonical analysis aims to correlate simultaneously numerous metric dependent variables and several metric independent variables (Hair *et al.*, 2009). The survey was sent to the "*Ranking 1500 – Empresas + Estadão*" of the 1,500 largest companies in Brazil. We collected 210 complete and valid responses from companies that have formalized collaborations with universities. Factor analysis identified the sets of data into 4 factors instead of the initial 3 factors. The 4 factors were categorized into financial benefits; social and community; technological innovation and management of external resources. We found a positive correlation of various items. The professional workforce qualification is correlated with the creation of new high-tech workstations. New technologies commercialization and development of new products

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are correlated with increased sales. Release of new products is correlated with increased: sales, exports, revenue, profit, commercial and shareholder value. Although university-industry collaborations are considered as providing the ability to increase socioeconomic growth, there is a literature gap in the field of comprehensive metrics to measure these collaborations' socioeconomic impacts. This work achieved evaluate the socioeconomic impacts of large Brazilian firms that carry out formal collaborations with universities. The analyzes allowed the construction of a model of socioeconomic impacts from the perspective of large Brazilian companies. This article performed a comprehensive analysis of the socioeconomic impacts of large Brazilian firms using multivariate statistical techniques to analyze the collected data. The analysis allowed the construction of a model of socioeconomic impacts from the perspective of large Brazilian companies.

Keywords: University-Industry. Socioeconomic Development. Innovation.

5.1. Introduction

The Covid-19 pandemic completely transformed work activities, relationships, and interpersonal communication (inside and outside companies). The social distance imposed by the propagation characteristics of Covid-19 accelerated the digital transformation, in which companies began to relate increasingly with their customers and society by the internet and digital media, using for their communication: electronic address (website, URL – Uniform Resource Locator), E-mail Marketing, Google Ads, Facebook, Instagram, Youtube, Tiktok, Podcasts, and others. For internal communication between corporate employees, remote video calls and information sharing became common, with the high popularization of applications such as Google Meet, Zoom, Dropbox, and Google Drive.

The internet allows real-time trading between people and companies located in any region of the planet (with internet access), making it possible to make a purchase order and financial transactions between very distant locations (requiring only a few clicks on the web and very little time). The ease of purchasing imported products from other countries in the Business-to-Consumer (B2C) model from sites such as Amazon, eBay, Wish, and others, contributes to the acceleration of globalization and points to the growing need for industrial development and modernization in emerging countries so that products manufactured in these countries (especially those from some segments such as clothing and electronics) remain competitive with quality and attractive prices.

Covid-19 has put public health services to the test. Economic systems will soon be put to the test by Covid-19. In order to recover from the effects of the coronavirus, innovation will be an essential way (Chesbrough, 2020).

The health, economic and financial crisis caused by the Covid-19 pandemic has significative harmed emerging countries. In Brazil, for example, the economy was severely affected with many companies closing (some of them with many years of existence in the market), accompanied by unemployment and increasing poverty. The new reality imposed by the pandemic showed the importance of flexibility for companies needed to adapt quickly to meet new demands arising from an atypical scenario.

Firms must continuously adapt and evolve to thrive in a dynamic, global environment. Despite the continuous change, firms drive markets by utilizing and strategically managing knowledge. Universities are crucial parts of the scientific and technological ecosystem because they provide an endless supply of data and technical capabilities (Berbegal-Mirabent *et al.*, 2015).

The open innovation paradigm emphasizes the need of an internal and external knowledge management in order to improve a company's internal innovation process, making it significantly faster through the implementation of both internal and external ideas, as well as creating technological advancements (Chesbrough *et al.*, 2006).

In the open innovation dynamics, the university is a significant resource as well as a wonderful supplier of ideas for firms. Furthermore, academic professionals are taught and equipped to assess the technical feasibility of new technology deployment. As a result, the investigation and understanding of the university-industry socioeconomic collaboration consequences is highly important in the open innovation study field (Lima *et al.*, 2021).

Collaboration with universities and external partners is the only way for managers to obtain the internal technical expertise they need (Najafi-Tavani *et al*., 2018). The collaborative innovation allows the firms a special chance to conduct externally focused exploration (Heil and Bornemann, 2017). Managers should expand business partnership with universities because these research organizations have the potential to significantly improve both product and process innovation skills (Najafi-Tavani *et al*., 2018).

The entrepreneurial university promotes the transfer of academic knowledge to companies in an effort to enhance socioeconomic growth (Etzkowitz, 2008). The expansion of entrepreneurial activity in higher education is substantially due to an underlying need for economic development as well as a greater emphasis on social responsibility. Higher education institutions play an important role in the development of human resource capability and efficiency (Alessandrini *et al.*, 2013).

These universities that execute the entrepreneurial activities are a significant driver of economic and social regional development because it produces and explores knowledge as a source of entrepreneurship (Urbano and Guerrero, 2013). Faced with the conventional triumvirate of land, labor, and money (traditional sources of richness), scientists and engineers started new businesses, and science and technology became a more vital source of capital (Etzkowitz, 2013).

In the Covid-19 pandemic, the world “stops”, and global efforts focused on vaccines development, safe and effective treatments for the Covid-19, and related technologies and equipment. The science, research, and development (R&D) results in innovations to solve global problems (as in the case of the pandemic) became evident, with the participation of universities in the creation of vaccines, as was the case of the University of Oxford in partnership with the AstraZeneca company. Additionally, various scientific studies on Covid-19 have been widely disseminated (both on the internet and the main television channels, radio, and newspapers). A large part of the population began to periodically follow the scientists’ opinion, medical, and reports on issues related to the pandemic, public health, and its consequences and impacts, which increased recognition from the society of the value and importance of technoscientific development to solve the biggest problems of the planet.

Although the university and its collaborations with the industry are recognized for promoting socioeconomic development, several authors point out the need to create metrics to assess the socioeconomic impact of these collaborations.

A university that develops and transforms knowledge and discovery into social and economic growth is becoming an increasingly essential global goal. The most frequently used metrics, on the other hand, were developed when research and teaching were the main academic goals (Etzkowitz *et al*., 2018).

Universities lack clear data and methods for tracking and evaluating overall entrepreneurial success (Etzkowitz *et al*., 2018). Existing technology transfer output metrics are widely considered to be not only insufficiently defined, but also inaccurate. The national impact of technology transfer personnel's efforts is not taken into consideration. Rather than relying simply on indicators like the number of patents filed and revenue from licensing agreements, the efficacy of the technology transfer role may be assessed in terms of social community impact, job generation and poverty reduction (Alessandrini *et al.*, 2013).

Academic entrepreneurship demands a thorough evaluation that goes beyond specific metrics such as financial returns on an intellectual property portfolio or individual performance. It is important to consider the wider social and economic benefits such as knowledge dissemination, building of intangible assets in the context of new venture development, and the contribution of employment for social, cultural, and economic reasons (Etzkowitz *et al*., 2018).

Zhou and Etzkowitz (2021) highlight that developing countries often followed an economically unsustainable path, importing highly polluting equipment discarded by developed countries. On the other hand, sustainable development, considering the different environmental-socioeconomic aspects, is safe, with potential benefits for human beings, the environment, and the economy.

If emerging countries can develop their technologies, their level of dependence on developed countries will be reduced, on the other hand, emerging countries will also become more attractive for participation in international research networks and the establishment of partnerships with international institutions. The creation of a model for the socioeconomic development of emerging countries makes it possible to take advantage of their potential to create unique competitive differentials. The entrepreneurial university plays a central role in the development of R&D and Innovation with companies that result in socioeconomic impacts.

Consequently, in this research, we investigate the socioeconomic impact of university-industry collaborations on the firm’s perspective presenting a multivariate statistical analysis of Brazilian large firms. The article is structured as follows: the second section presents the literature review, the third section describes the research method, and the fourth section refers to the results, followed by conclusions, recommendations, and future research possibilities in the last section.

5.2 Theoretical background

According to Lima *et al.* (2021), the socioeconomic impacts of university-industry collaborations can be categorized into (1) economic: infrastructure, production and processes, and scientific development; (2) social: jobs, skills, and qualification; and (3) financial: purchases, taxes, investments, and income generation, as shown in Figure 14.

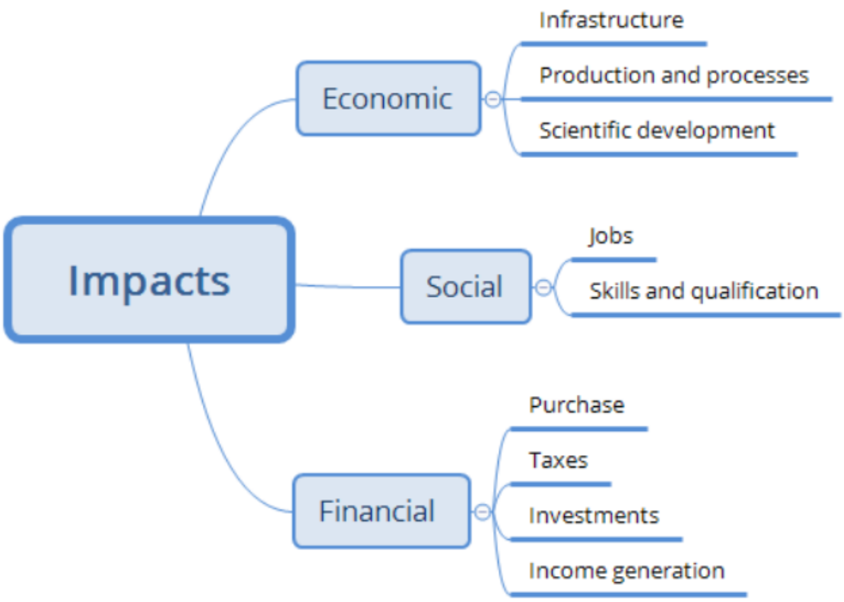

Figure 14 - Evaluation model

Source: Lima *et al.* (2021).

A dynamic arrangement of institutional forces in innovation systems, as well as an interactive (non-linear) model of innovation and a trilateral adjustment of collaboration, are shown by the triple helix. The triple helix model acknowledged that the demarcation lines between university-industry-government became less clear in contrast to the traditional model, in which firms are solely responsible for economic production, universities are solely responsible for knowledge generation and transmission (Etzkowitz, 2008).

According to Zhou and Etzkowitz (2021) create more helices does not help the comprehend the phenomenon. Many studies add more helices to make it more complex, but that is an ineffective method. It may be more efficient to analyze the triple helix upon different perspectives to raise the research level and understanding of global sub-regions reality with build coalitions and resources aggregation. Developing countries have a role to play in constructing relevant knowledge spaces.

We used Lima *et al.* (2021) because the model systematically organizes several high-value socioeconomic impacts for technology management, categorized according to the interest of each actor in the Triple Helix (Government-University-Industry). We analyze large Brazilian firms, for such, we use only the part of the model that refers to the object of study (firms).

Figure 15 illustrates the Socioeconomic Triple Helix Conceptual Model.

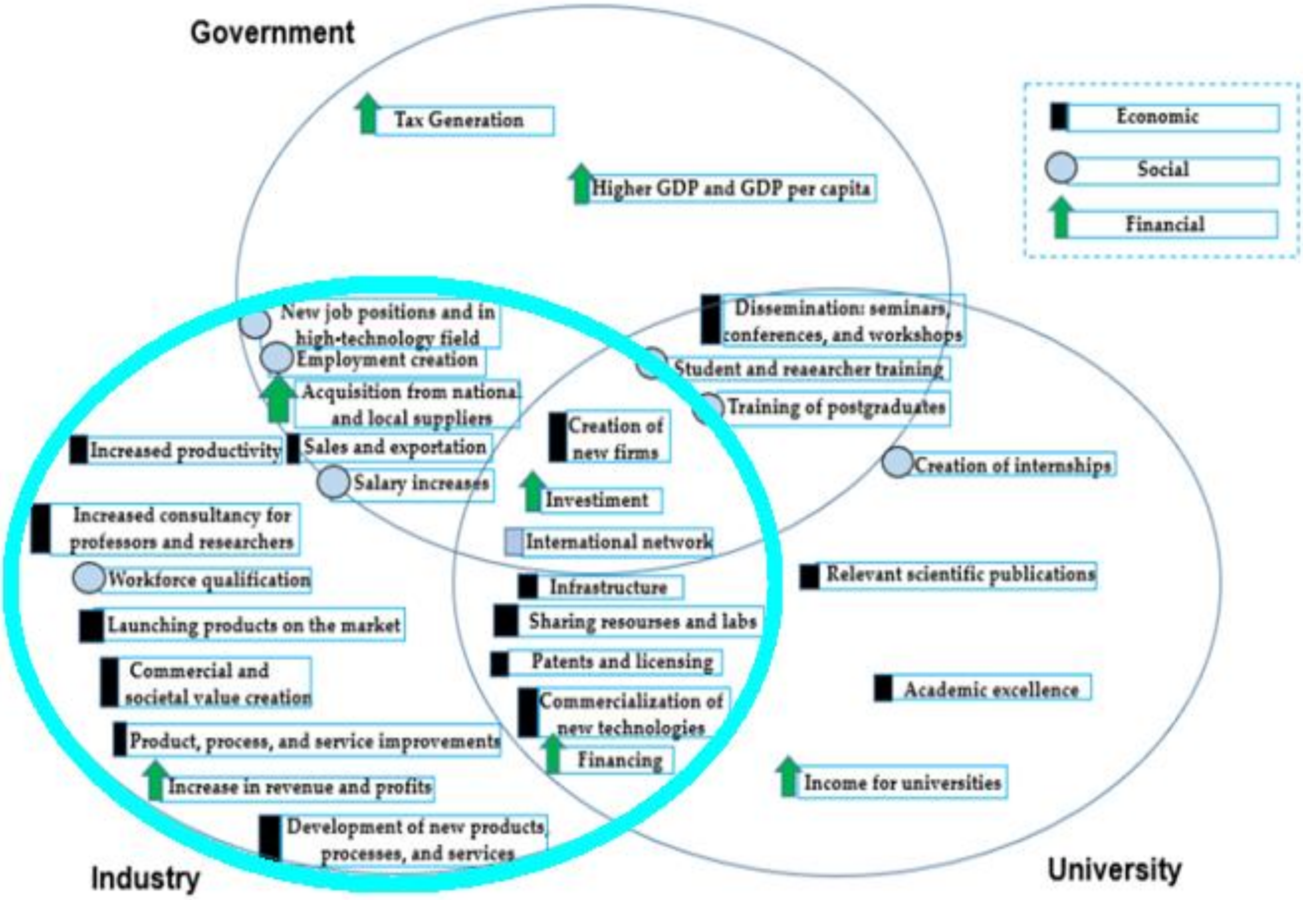

Figure 15 - Socioeconomic triple helix

Source: Lima *et al.* (2021).

5.3 Method

Multivariate analysis approaches are popular because they enable organizations to create information, which helps them make better decisions. Multivariate analysis refers to all statistical techniques that analyze multiple measurements on individuals or objects under evaluation at the same time (Hair *et al.*, 2009).

Some multivariate techniques are designed specifically to address multivariate aspects such as factor analysis, which identifies the inherent structure within a set of variables (Hair *et al*., 2009). The multivariate statistical techniques used were factor analysis and canonical correlation.

The factor analysis is a statistical method that represent the structure or patterns of the variables and their intercorrelations (Hair *et al.*, 2009). This analysis is used to organize the model's variables (according to their intercorrelations), it also simplifies the model obtained by reducing the number of variables, enabling a more simplified, didactic, and easier to apply model, capable of explaining the phenomenon. The factors resulting from the analysis and the final arrangement of the variables provide a detailed understanding of the relationships inserted in the analyzed phenomenon.

Canonical correlation analysis can be seen as a logical extension of multiple regression analysis. Canonical analysis aims to correlate simultaneously numerous metric dependent variables and several metric independent variables. Multiple regression has a single dependent variable, whereas canonical correlation has multiple dependent variables. The underlying principle is to develop a linear combination of each set of variables (independent and dependent) to maximize the correlation between the two sets (Hair *et al.*, 2009). We used the canonical correlation to identify the relations between the variables of each construct of the model.

- Scale and Sample

The scale has been developed according to the recommended procedures and steps by DeVellis (2017): (1) determine clearly what is it that you want to measure and generate an item pool; (2) determine the format for measurement and have the initial item pool reviewed by experts; (3) consider the inclusion of validation items and administer items to a development sample; and (4) evaluate the items and optimize scale length.

The scale, developed based on the literature review, was sent to companies that collaborate with universities via e-mail and LinkedIn® to the scale pretest, in which

10 Brazilian firms, that have formalized collaboration projects, answered the questionnaires.

In the pretest we analyzed the Cronbach Alpha with the SPSS® software. The data obtained is shown in Table 6.

Table 6 - Cronbach alpha

Cronbach's Alpha	Cronbach's Alpha based in standardized items	N of items
,931	,932	24

Source: Research data (2021).

According to Almeida *et al.* (2010), Cronbach's Alpha is a statistical tool that measures the reliability of a questionnaire on a scale of 0 to 1. For a reliable questionnaire, 0.7 is the minimum appropriate value. As the value obtained in Cronbach's Alpha (0.931) was much higher than the minimum value (0.7), the questionnaire was accepted to analyze the phenomenon.

The survey was sent to the ranking of the 1,500 largest companies in Brazil organized by the Institute of Management Foundation (FIA) and Austin Consulting "*Ranking 1500 – Empresas + Estadão*". The questionnaires were sent along 5 months (from October 2020 to February 2021). We collected 210 complete and valid responses from the companies' innovation managers, businesses that had formalized collaborations with universities.

5.4 Results

Most respondents are innovation managers for the companies (68%) which have global sales, 27% national sales, and 6% regional sales. According to the data: 85% of the innovation managers work for companies that have more than 500 employees, and 98% have more than 50 employees; 94% of them have more than 14 years on the market; 74% have formalized collaborations with universities for more than 4 years (Appendix).

The JMP® (SAS) software was used for data processing, in which Factorial Analysis was performed, obtaining the results:

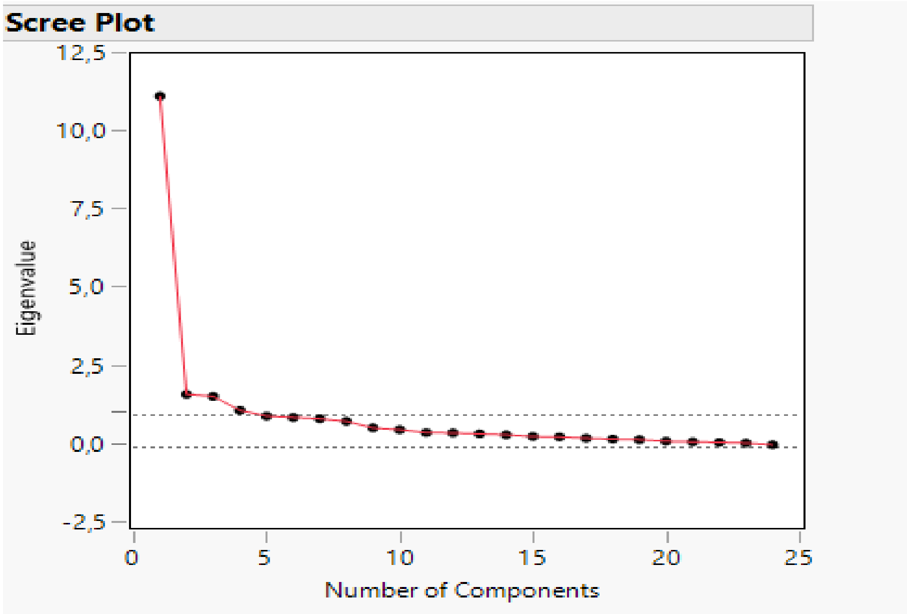

Figure 16 - Eigenvalues

Source: Research data (2021).

Table 7 - Factors

Eigenvalues

Number	Eigenvalue	Percent	Cum Percent
1	11,1986	46,661	46,661
2	1,6675	6,948	53,609
3	1,6014	6,672	60,281
4	1,1579	4,825	65,106
5	0,9727	4,053	69,159
6	0,9279	3,866	73,025
7	0,8865	3,694	76,719
8	0,8048	3,353	80,072
9	0,5962	2,484	82,557
10	0,5368	2,237	84,793
11	0,4456	1,856	86,650
12	0,4372	1,822	88,472
13	0,4064	1,693	90,165
14	0,3741	1,559	91,724
15	0,3219	1,341	93,065
16	0,3085	1,285	94,351
17	0,2672	1,113	95,464
18	0,2402	1,001	96,465
19	0,2210	0,921	97,386
20	0,1727	0,720	98,105
21	0,1506	0,628	98,733
22	0,1331	0,555	99,288
23	0,1126	0,469	99,757
24	0,0584	0,243	100,000

Source: Research data (2021).

To select the number of factors to be extracted, the latent root criterion was used. The latent root criterion considers that only factors that have latent roots or eigenvalues greater than 1 are deemed significant, thus, all factors with latent roots lower than 1 are considered insignificant and are discarded. Using the eigenvalue to establish a cutoff is more reliable when the number of variables is between 20 and 50 (Hair *et al.*, 2009). As the research has 24 variables, this criterion was reliably used.

Four factors were selected for presenting an eigenvalue greater than 1, as shown in Figure 16 and Table 7. In addition, the criterion of percentage of variance was verified, in which a value greater than 65% was obtained. According to Hair *et al.* (2009) in social science studies, solutions that often explain 60% of the total variance (and in some cases even less) can be considered satisfactory.

It's important to highlight that according to Brazilian large firms analysis, the greatest impacts from the collaborations with universities is the Financial Benefits (approx. 47%) follow the Technological Innovation and the Social and Community (both factors approx. 7%), at last Management of External Resources (approx. 5%).

The orthogonal rotation of factors was put in place using the Varimax method. According to Hair *et al.* (2009) this method has been very successful as an analytical approach to obtain an orthogonal rotation of factors, being more widely accepted than the Quartimax and Equimax method.

The factor extraction criteria were latent root, factor loadings and communality. Hair *et al.* (2009) state that, considering the practical significance of the analysis, factor loadings in the range from ± 0.3 to ± 0.4 are considered to meet the minimum level for interpretation of the structure. Factor loadings of ± 0.5 or greater are said to have practical significance. In our study, we used 0.545 as factor loadings because it was higher than the minimum value (0.5), described by Hair *et al.* (2009) as practical significance, and capable to explain our model. Thus, two variables with factor loadings less than 0.545 were identified. The variables were: “investment in the company's infrastructure” (approx. 0.334) and “external investment” (approx. 0.430), which were removed from the analysis. On the other hand, we identified that the variable “public or private financing for the company” with a factorial load of 0.551 was conceptually able to explain the removed variables in Table 8.

Table 8 - Factor loads

Rotated Factor Loading

	Factor 1	Factor 2	Factor 3	Factor 4
Revenue increase	0,847126			
Profit increase	0,819951			
Sales increase	0,754840			
Exportations increase	0,687420			
Commercial and corporate/shareholder value	0,687079			
Public or private financing increase	0,551628			
External investment on the company (0,43)				
Development of new technologies		0,776531		
Development of new products, processes and services		0,764096		
New technologies commercialization		0,746789		
Release of new products		0,697829		
Products, processes and/or services improvement		0,669169		
Patent licensing		0,576614		
Generation of intellectual property		0,549680		
Purchase of goods and services from local suppliers			0,748000	
Purchase of goods and services from national suppliers			0,732985	
Salary increase of employees who participated in the university collaboration			0,686768	
Employment generation			0,603220	
Creation of new high technology workstations			0,579164	
Creation of new companies			0,545361	
Investments in the company infrastructure (0,33)				
Network with other institutions (national or international)				0,689468
Professional workforce qualification				0,639652
Resources sharing and/or universities laboratories				0,587159

Source: Research data (2021).

As we already mentioned, factor loadings of 0.7 or higher are considered indicative of a well-defined structure and are the goal of any factor analysis (Hair *et al.,* 2009).

In this study, we identified 7 factor loadings greater than 0.7 referring to the variables that best represent the model. “Increase in revenue” (approx. 0.847), “increase in profit” (approx. 0.819), “increase in sales” (approx. 0.754), “development of new technologies” (approx. 0.776), “development of new products, processes and services” (approx. 0.764), “commercialization of new technologies” (approx. 0.746), “purchase of goods and services from local suppliers” (approx. 0.748), “purchasing goods and services from national suppliers” (approx. 0.732). Additionally, the variable launching new products presented a value very close to 0.7 (approx. 0.697).

Table 9 - Commonality

Final Communality Estimates	
Investments in the company infrastructure	0,30194
Resources sharing and/or universities laboratories	0,54533
Products, processes and/or services improvement	0,60937
Development of new technologies	0,76120
New technologies commercialization	0,75365
Development of new products, processes and services	0,75542
Release of new products	0,78631
Creation of new companies	0,46103
Generation of intellectual property	0,61547
Patent licensing	0,56555
Sales increase	0,78275
Exportations increase	0,65754
Commercial and corporate/shareholder value	0,71899
Network with other institutions (national or international)	0,60829
Employment generation	0,70981
Creation of new high technology workstations	0,70992
Salary increase of employees who participated in the university collaboration	0,58915
Professional workforce qualification	0,55902
Purchase of goods and services from local suppliers	0,69582
Purchase of goods and services from national suppliers	0,64134
External investment on the company	0,53917
Public or private financing increase	0,60904
Revenue increase	0,84794
Profit increase	0,80138

Source: Research data (2021).

In the analysis of the commonality present in Table 9, we observed that the variable “investment in the company's infrastructure” had a value of less than 0.5 in addition to the low factor loading presented.

The “creation of new companies” had a value of less than 0.5. The large companies have a solid infrastructure, not being necessary to create a new company to sell newly developed products.

Consequently, 3 variables were removed from the model: “external investment” (factor loading analysis), “investment in the company's infrastructure” (factor loadings and communality analysis), and "company creation" (commonality analysis).

Factor analysis identified the grouping of data into 4 factors instead of the initial 3 Factors (economic, financial, and social). The 4 factors were categorized into financial benefits; social and community; technological innovation and management of external resources. The factors’ names were defined according to the main subject in the variables of each factor.

Factor 1 – Financial Benefits is best represented by the variables “increase in revenue” (approx. 0.847), “profit increase” (approx. 0.819), and “increase in sales” (approx. 0.754). Factor 2 – Technological Innovation best represented by the variables “development of new technologies” (approx. 0.776), “development of new products, processes, and services” (approx. 0.764), and “commercialization of new technologies” (approx. 0.746).

Factor 3 – Social and Community Innovation best represented by the variables “purchase of goods and services from local suppliers” (approx. 0.748) and “purchasing goods and services from national suppliers” (approx. 0.732). Factor 4 – Management of External Resources best represented by the variable “network with other institutions (national and international)” (approx. 0.689).

We built a socioeconomic impact model of collaborations with universities for large companies based on data analysis, shown in Figure 17.

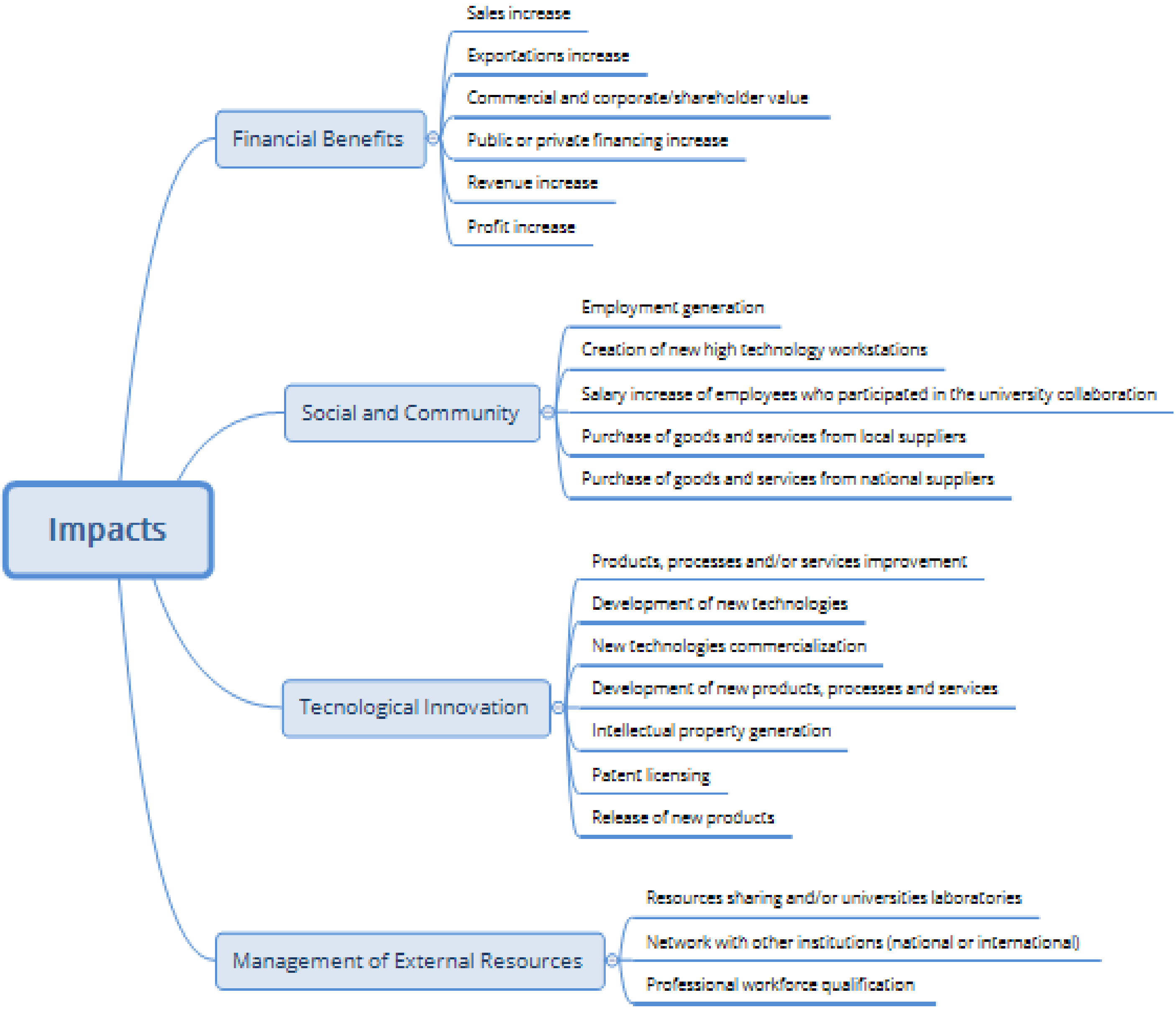

Figure 17 - Socioeconomic impacts of university-industry collaborations to large firms
Source: Research data (2021).

We also performed a canonical correlation analysis to quantify the relationships between the sets of variables in Statistica® Statsoft software, considering correlation values between variables greater than 0.53. The canonical correlation considers all the variables in each factor, identifying the correlation between variables of 2 factors in every turn. Positive correlations were identified between Technological Innovation and Financial Benefits, also Social and Community with External Resource Management, at last, Social and Community with Financial Benefits. These correlation values within the variables are shown in Figure 18.

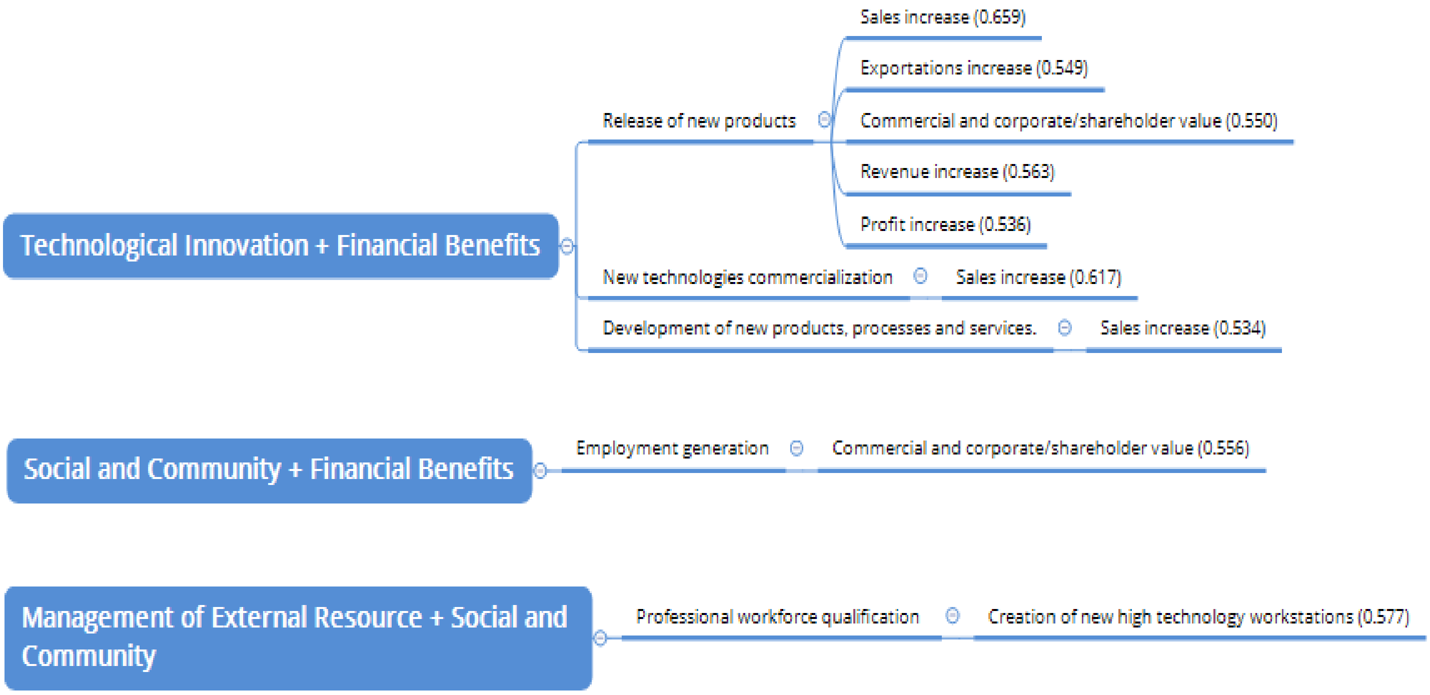

Figure 18 - Canonical correlation

Source: Research data (2021).

The canonical correlation analysis presented information of high strategic value for the socioeconomic impact of university-industry collaborations. We identified the positive correlation between Technological Innovation and Financial Benefits. The "release of new products" is correlated with "sales increase" (approx. 0.659), "exportations increase" (approx. 0.549), "commercial and corporate/shareholder value" (approx. 0.550), "revenue increase" (approx. 0.563), and "profit increase" (approx. 0.536). The "sales increase" also is correlated with "new technologies commercialization" (approx. 0.617) and "development of new products, processes, and services" (approx. 0,534). We also found a positive correlation between the Social and Community, and Management of External Resource, "professional workforce qualification" correlated with the "creation of new high-tech workstations" and between Social and Community, and Financial Benefits, the "employment generation" is correlated with "commercial and corporate/shareholder value" (approx. 0.556). (Appendix).

From the results obtained, it can be considered that every investment in research and development (R&D) is consolidated in technological innovation as it results in the launch and commercialization of new products with new technologies that generate financial benefits for companies, "rewarding" the dedicated efforts of the companies to innovation. Another result found is the correlation between qualified professionals and new high-tech jobs. Currently, new job positions are created with the most varied nomenclature, requiring diverse skills and knowledge. There is a tendency towards a high level of specialization, thus, most of the high-tech jobs are associated with specific qualifications, for example, experience in PHP language, mobile programming, nanotechnology, data science, polymers, among others, that requires a high professional qualification to occupy these high-tech jobs.

The Figure 19 presents the results of the analysis.

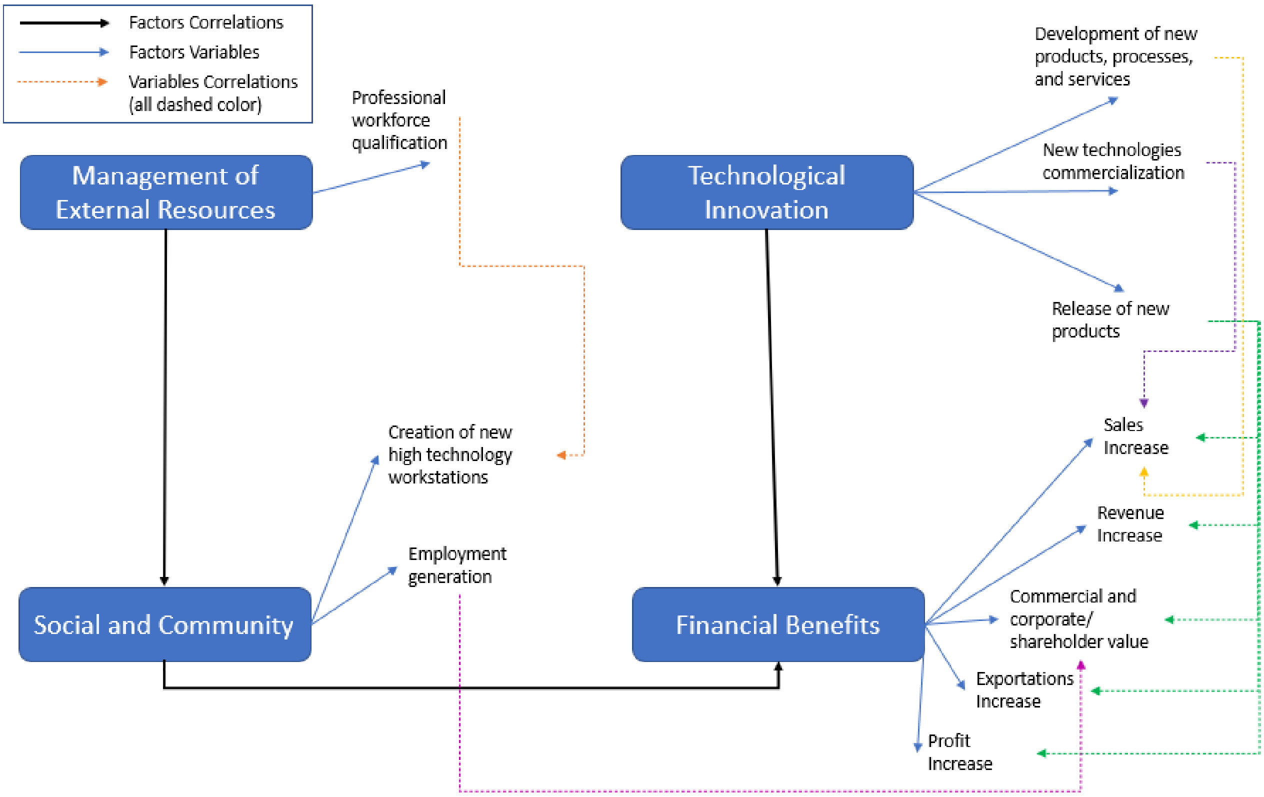

Figure 19 - Results of the analysis

Source: Research data (2021)

5.5 Conclusions

Although university-industry collaborations are considered to provide the ability to increase socioeconomic growth, there is a literature gap in the field of comprehensive metrics to measure these collaborations' socioeconomic impacts. This work achieved the goal of evaluating the socioeconomic impacts of large Brazilian firms that carry out formal collaborations with universities.

The most representative variables of the constructs, the ones with greater ability to explain the model from the large firms perspective of the socioeconomic impacts of university-industry are, in order: revenue increase; profit increase; sales increase; development of new technologies; development of new products, processes and services; commercialization of new technologies; purchase of goods and services from local suppliers; purchasing goods and services from national suppliers, and launching new products.

The professional workforce qualification is positive correlated with the creation of new high-tech workstations. New technologies commercialization and development of new products, processes and services are positive correlated with increased sales. Release of new products is positive correlated with increased: sales, exports, revenue, profit, commercial and corporate/shareholder value. The employment generation also is positive correlated with commercial and corporate/shareholder value.

- Theoretical Contributions

The literature points to the need to use more comprehensive metrics capable of measuring the socioeconomic impact of university-industry collaborations with authors such as Audretsch *et al.* (2019), Galan-Muros and Davey (2019), Alessandrini *et al.* (2013) and Etzkowitz *et al.* (2018).

This article performed a comprehensive analysis of the socioeconomic impacts of large Brazilian firms using multivariate statistical techniques to analyze the collected data. The analysis allowed the construction of a model of socioeconomic impacts from the perspective of large Brazilian companies. This work also found a relationship between the "qualification of the workforce" and the "creation of new high-tech workstations". The research and development (R&D) investments are consolidated in technological innovation with the launch and commercialization of new products with new technologies that generate financial benefits for companies that made innovation. The employment generation contributes to elevate the commercial and corporate/shareholder value.

It's important to highlight the impacts from the intersections on the socioeconomic triple helix with high factor loadings which are "increase in sales", “commercialization of new technologies”, “purchase of goods and services from local suppliers”, “purchasing goods and services from national suppliers” and “network with other institutions”.

- Managerial Contributions

In addition to its theoretical contributions, this research of socioeconomic impact model benefits the companies that will be sure of a way forward to obtain great financial results from investment in R&D and technological innovation with collaborations and universities that will be sure of where to put their greatest efforts so that the results are meaningful for companies and thus, enhance their own results according to your best interests.

The indicators can be applied individually to each company so that they can comprehend their position in the collaborations, comparing them with the results presented in this article. Universities, governments and public agents will also be able to use the initiators to assess the collaborations they participate. So, it serves all stakeholders involved.

- Research Limitations

The limitation of this research is that the final model obtained from the statistical analyzes is focused on large companies, thus, it is important to consider all the initial variables when analyzing other types of companies such as the variable “creation of new startups/spinoffs companies” because it can be essential when analyzing small businesses and academic entrepreneurship. Furthermore, it is a generic model depending on the type of collaboration, the type of market of the companies and the characteristics of the universities. Therefore, it may be interesting to add or reduce the number of indicators. The study presents the large Brazilian firm's perspective although the results also can be applied to other emerging economies.

- Future Research Directions

For future studies, it is recommended to implement the analysis in other groups of companies, both regional and Brazilian, as well as studies in other countries, to compare the results obtained with the ones presented in this research. Furthermore, additional models may be proposed to assess the impact of collaborations in cities, the quality of life of the population, and interaction with public agents to improve regional infrastructure.

Development of the metrics to the other Triple helix actors (Government and University). Numerical analysis of the investments in science, technology, and innovation and the benefits of these investments.

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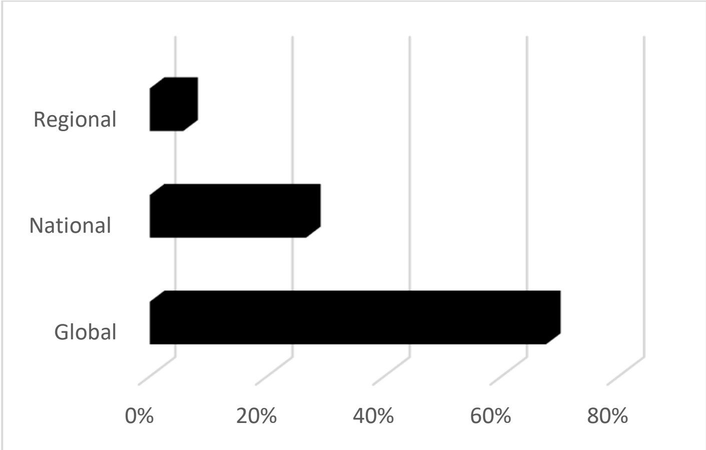
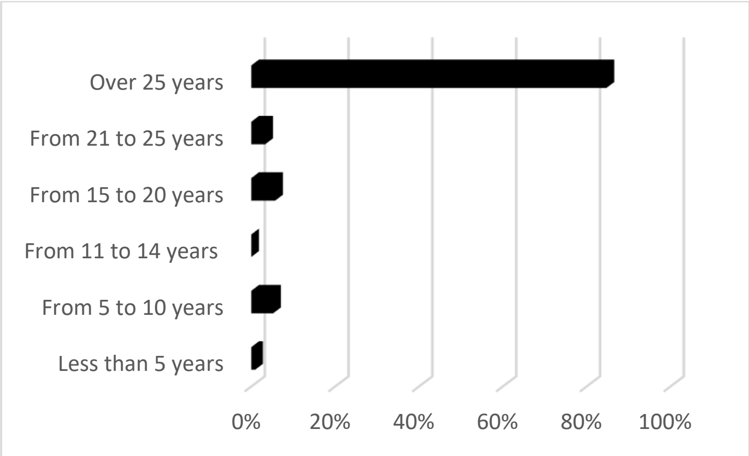
Appendix

A1: Sales areas of the firms



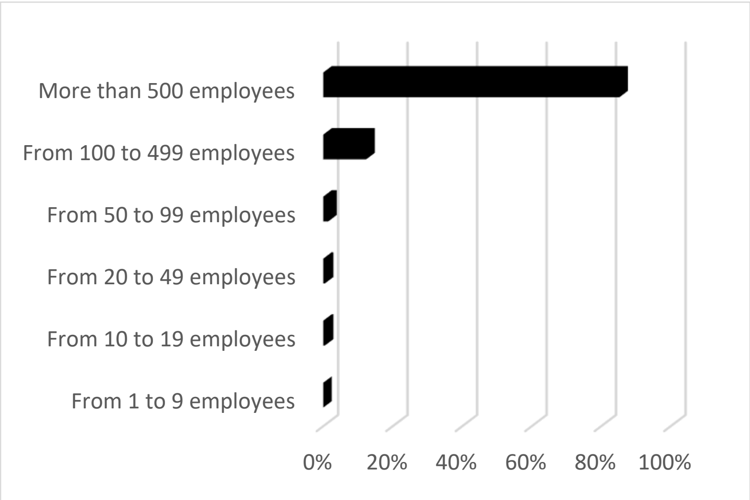
Source: Research data (2021).

A2: Time of existence of the companies



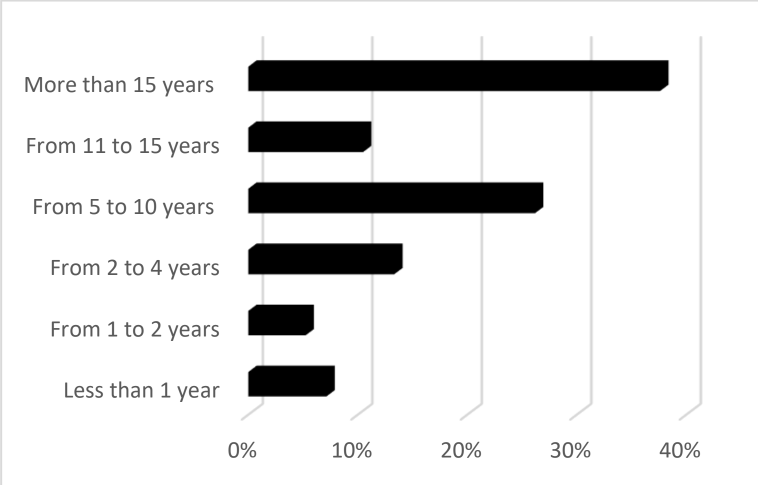
Source: Research data (2021).

A3: Number of employees



Source: Research data (2021).

A4: Time of the first one university collaboration



Source: Research data (2021).

A5: Canonical correlation analysis

Canonical R: ,7029797
Chi-Square: 158,6338 df = (25) p = 0,000000
Number of valid cases: 205

	No. of vars.	Variance extracted	Total redundancy given the other set
Left set:	5	100,00000000%	36,455592822%
Right set:	5	100,00000000%	34,392728732%

	Root 1	Root 2	Root 3	Root 4	Root 5
Value	0,494180	0,065555	0,031510	0,014490	0,003167

	Canonicl	Canonicl	Chi-sqr.	df	p	Lambda
0	0,702980	0,494180	158,6338	25	0,000000	0,449705
1	0,256037	0,065555	23,3411	16	0,105000	0,889063
2	0,177511	0,031510	9,8824	9	0,360126	0,951434
3	0,120374	0,014490	3,5270	4	0,473799	0,982389
4	0,056278	0,003167	0,6297	1	0,427473	0,996833

C1C3	V3	V4	V5	V6	V7	V9	V10
V11	0,466971	0,496819	0,617266	0,534449	0,659729	0,395110	0,421948
V12	0,379173	0,434078	0,473955	0,426731	0,549743	0,337422	0,365020
V13	0,465289	0,509310	0,495193	0,501886	0,550436	0,429917	0,428650
V22	0,343181	0,419127	0,346218	0,407079	0,429717	0,425706	0,368052
V23	0,425059	0,437892	0,494444	0,496726	0,563394	0,339753	0,369297
V24	0,436793	0,411925	0,496333	0,473362	0,536006	0,316142	0,364554

C1C2	v15	v16	v17	v19	v20
v11	0,472609	0,443241	0,418673	0,459400	0,406096
v12	0,410579	0,401581	0,477791	0,451801	0,375454
v13	0,556131	0,496810	0,381009	0,489263	0,405992
v22	0,398440	0,417549	0,321854	0,365595	0,275278
v23	0,484693	0,475283	0,409339	0,434185	0,384118
v24	0,458697	0,446108	0,426137	0,458163	0,438610

C1C4	V2	V14	V18
V11	0,383591	0,405920	0,343793
V12	0,275786	0,315151	0,319353
V13	0,323490	0,524588	0,340734
V22	0,353004	0,528838	0,386013
V23	0,318689	0,382601	0,352933
V24	0,318095	0,334048	0,356093

C2C3	V3	V4	V5	V6	V7	V9	V10
V15	0,443336	0,406839	0,365137	0,417643	0,407949	0,527980	0,489164
V16	0,433756	0,445140	0,450652	0,444703	0,400750	0,514618	0,493859
V17	0,237101	0,319182	0,344997	0,284801	0,391769	0,307736	0,302830
v19	0,392307	0,425113	0,384665	0,432377	0,456953	0,412511	0,422220
v20	0,373217	0,382373	0,310451	0,394947	0,373708	0,424628	0,424470

C2C4	V2	V14	V18
V15	0,418339	0,421631	0,509316
V16	0,408685	0,440868	0,577539
V17	0,202208	0,258466	0,433756
v19	0,256323	0,333429	0,393124
v20	0,311002	0,350629	0,392987

C3C4	V2	V14	V18
v3	0,483060	0,365583	0,351466
v4	0,446527	0,399026	0,395455
V5	0,337989	0,267964	0,309296
V6	0,375867	0,419846	0,393888
V7	0,309834	0,332030	0,287946
V9	0,432871	0,396944	0,366070
V10	0,346691	0,284312	0,244860

Source: Research data (2021).

A6: Questionnaire

IMPACTOS SOCIOECONÔMICOS DAS COLABORAÇÕES UNIVERSIDADE-EMPRESA

Bloco 1: Informações gerais

*** 1. Sua empresa realiza ou já realizou algum tipo de colaboração formalizada com alguma universidade?**

- ○ Sim
- ○ Não

IMPACTOS SOCIOECONÔMICOS DAS COLABORAÇÕES UNIVERSIDADE-EMPRESA

*** 2. Qual o segmento (ou quais segmentos) de atuação da sua empresa?**

*** 3. Qual seu mercado de atuação?**

- ○ Global
- ○ Nacional
- ○ Regional (Especificar os Estados)

*** 4. Sua empresa tem quanto tempo de existência?**

- ○ Menos de 5 anos
- ○ De 5 a 10 anos
- ○ De 11 a 14 anos
- ○ De 15 a 20 anos
- ○ De 21 a 25 anos
- ○ Mais de 25 anos

* 5. **Quantos colaboradores sua empresa tem?**

- De 1 até 9 colaboradores
- De 10 até 19 colaboradores
- De 20 até 49 colaboradores
- De 50 até 99 colaboradores
- De 100 até 499 colaboradores
- Mais de 500 colaboradores

* 6. **Com qual universidade (ou quais universidades) nacionais ou estrangeiras sua empresa já realizou ou realiza colaboração?**

* 7. **Há quanto tempo sua empresa realizou a primeira colaboração com universidade?**

- Menos de 1 ano
- De 1 a 2 anos
- De 2 a 4 anos
- De 5 a 10 anos
- De 11 a 15 anos
- Mais de 15 anos

* 8. **Qual a área (ou quais as áreas) de pesquisa da colaboração da sua empresa com universidade?**

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IMPACTOS SOCIOECONÔMICOS DAS COLABORAÇÕES UNIVERSIDADE-EMPRESA

Bloco 2: Impactos socioeconômicos

Pense na realidade geral das colaborações com universidade(s) que a sua empresa realiza e considerando os itens a seguir, indique o quanto você concorda com cada afirmação, variando de 1 = não concordo até 10 = concordo totalmente

* 9. Indique o quanto você concorda com cada afirmação **(variando de 1 = não concordo até 10 = concordo totalmente)**

	1	2	3	4	5	6	7	8	9	10
A parceria da nossa empresa com universidade(s) resulta em mais investimento em infraestrutura da empresa	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta em compartilhamento de recursos e/ou laboratórios da universidade	○	○	○	○	○	○	○	○	○	○

* 10. Indique o quanto você concorda com cada afirmação **(variando de 1 = não concordo até 10 = concordo totalmente)**

	1	2	3	4	5	6	7	8	9	10
A parceria da nossa empresa com universidade(s) resulta em melhoria de produtos, processos e/ou serviços	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta no desenvolvimento de novas tecnologias	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta na comercialização de novas tecnologias	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta no desenvolvimento de novos produtos, processos e serviços	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta no lançamento de novos produtos	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta na criação de empresas	○	○	○	○	○	○	○	○	○	○

* 11. Indique o quanto você concorda com cada afirmação **(variando de 1 = não concordo até 10 = concordo totalmente)**

	1	2	3	4	5	6	7	8	9	10
A parceria da nossa empresa com universidade(s) resulta na geração de propriedade intelectual (depósito e pedido de patente, registro de marca, registro software, ou algum outro tipo de proteção de propriedade intelectual)	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta no licenciamento de patentes	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta no aumento das nossas vendas	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta no aumento das nossas exportações	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta na criação de valor comercial e societário da nossa empresa	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta na criação de redes com outras instituições e/ou associações nacionais ou internacionais	○	○	○	○	○	○	○	○	○	○

* 12. Indique o quanto você concorda com cada afirmação **(variando de 1 = não concordo até 10 = concordo totalmente)**

	1	2	3	4	5	6	7	8	9	10
A parceria da nossa empresa com universidade(s) resulta na criação de empregos	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta na criação de novos postos de trabalho de alta tecnologia	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta no aumento do salário de funcionários que participam da colaboração universidade-empresa	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta na qualificação profissional da nossa força de trabalho	○	○	○	○	○	○	○	○	○	○

* 13. Indique o quanto você concorda com cada afirmação **(variando de 1 = não concordo até 10 = concordo totalmente)**

	1	2	3	4	5	6	7	8	9	10
A parceria da nossa empresa com universidade(s) resulta na compra de bens e serviços de fornecedores locais	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta na compra de bens e serviços de fornecedores nacionais	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta no aumento da quantidade de investimento externo na empresa	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta no aumento da quantidade de financiamento público ou privado para a empresa	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta no aumento de receita da empresa	○	○	○	○	○	○	○	○	○	○
A parceria da nossa empresa com universidade(s) resulta no aumento do lucro da empresa	○	○	○	○	○	○	○	○	○	○

* 14. **Diante desse contexto, nos fale mais sobre a experiência da sua empresa, dificuldades e sugestões, em relação as colaborações com universidade**

6. CONCLUSIONS

Although university-industry collaborations are considered to provide the ability to result in socioeconomic benefits, there is a literature gap in the field of comprehensive metrics to measure these collaborations' socioeconomic impacts.

This work achieved the goal of identifying and evaluating those socioeconomic impacts. It was used a systematic review to identify the impacts and build the conceptual model (Article 1), the scale developed to measure the impacts according to the firm’s perspective (Article 2), the model to large firms and the analysis of the Brazilian large firms, and the report of the results (Article 3). Through these all the specific objectives were accomplished.

Collaboration with universities is essential for the socioeconomic development of regions, companies, and countries, university resources have great potential to benefit the economy and nations, these resources need to be properly managed to generate improvements in society.

6.1 Theoretical contributions

The literature points to the need of using more comprehensive metrics capable of measuring the socioeconomic impacts of university-industry collaborations through authors such as Audretsch et al. (2019), Galan-Muros and Davey (2019), Alessandrini et al. (2013) and Etzkowitz et al. (2017).

According to Zhou and Etzkowitz (2021) the creation of more helices does not help the comprehension of the phenomenon. Many studies add more helices to make it more complex, but that is an ineffective method. It may be more efficient to analyze the triple helix upon different perspectives to raise the research level and the understanding of global sub-regions reality with build coalitions and resources aggregation. Developing countries have a role to play in constructing relevant knowledge spaces.

This study contributes to knowledge creation by building a model, the Socioeconomic Triple Helix, that analyzes the socioeconomic impact of triple helix actors. Additionally, the study evaluated the Brazilian large firms.

The developed model enables the comparison between countries, regions, and sub-regions.

6.2 Managerial Contributions

In addition to its theoretical contributions, this research of socioeconomic impact model improves the companies that will be sure of a journey forward to achieve great financial results from R&D and technological innovation with collaborations and universities that will be certain of where to focus their greatest efforts so that the results are important for the companies and thus enhance their results according to their best interests. The indicators may be used by each company individually so that they can understand their position in the collaboration by comparing them to the findings provided in this article. Universities, governments, and public institutions will be able to utilize the model to evaluate the collaborations in which they engage. As a result, it is beneficial to all involved parties. Zhou and Etzkowitz (2021) point out the importance of the emerging countries' studies of the triple helix, as it brings out a different perspective. This study analyzed Brazilian firms.

6.3 Research Limitations

The research limitation is that the socioeconomic triple helix model and scale are generic.

The types and areas of university–industry collaboration and their specific characteristics for each one must be considered in order to understand which indicators have the greatest strategic value in their institution’s spot. Another important aspect to observe is the phase of university–industry collaboration, applying the most significant, important indicators and with the greatest variations in impact on that phase (Lima et al., 2021).

Because the model derived from statistical analyses focused on large corporations, it is important to consider all of the initial variables when evaluating other kinds of firms, such as the variable “creation of new startups/spinoffs companies,” which can be critical when analyzing small businesses and academic entrepreneurship. The study presents the large Brazilian firm's perspective although the results also can be applied to other emerging economies.

6.4 Future research directions

Based on the results and the discussion on the socioeconomic impact of university–industry collaborations, we offer a few suggestions for future research: (1) an application of an evaluation model, (2) development of the scale to the other Triple helix actors (Government and University), (3) development of methods for the indirect impact assessment in local communities (Lima et al., 2021). It is recommended to apply the tool to assess the socioeconomic impact on the perspective of companies that will serve as a support for strategic decision making to improve the results in innovation and research.

It is suggested that the analysis be carried out in other groups of firms, both regional and Brazilian, as well as studies in other countries, to compare the results obtained with those provided in this study. Furthermore, other models may be suggested to measure the influence of city partnerships, population quality of life, and interaction with public agents to improve regional infrastructure.

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