

**THE QUINTUPLE HELIX MODELING TECHNOLOGICAL INNOVATION:
CHARACTERIZATION AND THE STATUS OF BUSINESS ACCELERATORS
IN A METROPOLITAN REGION**

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ARTICLE INFO	<u>ABSTRACT</u>
<p>Article history:</p> <p>Received 09 April 2021</p> <p>Accepted 08 September 2021</p>	<p>Purpose: The theme of technological innovation, especially in the context of the Fourth Industrial Revolution, has generated significant turbulence both in literature and in executive business practices. Among the various explanatory models of the development context in the area, the Quintuple Helix emerges.</p> <p>Objective: This study aims to describe and analyze the current state of business accelerators in the metropolitan region of Belo Horizonte - MG (Brazil).</p> <p>Methodology: A qualitative research was carried out, in which 6 executives of business accelerators and 4 representatives of institutions that support innovation were interviewed. These institutions were characterized as a control group, but they contribute to the evolution of the Minas Gerais innovation ecosystem. A literature search was carried out to identify constructs and variables applicable to the proposed model as a study reference.</p> <p>Results: The main results showed the relevance of the constructs and variables, demonstrating the convenience of the model to study and plan its applicability, both academically, in the evolution of knowledge, and in the executive function, since it approaches the current reality of the accelerators of business studied here.</p> <p>Contribution to the evolution of the knowledge: Analysis of an emerging model and proposition of validations compatible with the need for its consolidation as a theory.</p> <p>Executive contribution: Offering an evolving model, but interesting as a structure applicable to the evolution of institution development.</p>
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A HÉLICE QUÍNTUPLA MODELANDO A INOVAÇÃO TECNOLÓGICA: CARACTERIZAÇÃO E ESTADO DAS ACELERADORAS DE NEGÓCIOS EM UMA REGIÃO METROPOLITANA

RESUMO

Fundamento: O tema da inovação tecnológica, sobretudo no contexto da Quarta Revolução Industrial, tem gerado significativa turbulência tanto na literatura, quando nas práticas executivas de negócios. Entre os diversos modelos explicativos do contexto do desenvolvimento na área, emerge o da Hélice Quíntupla.

Objetivo: Este estudo objetiva descrever e analisar o estado atual das aceleradoras de negócios da região metropolitana de Belo Horizonte – MG (Brasil).

Metodologia: Foi realizada uma pesquisa qualitativa, em que foram entrevistados 6 executivos de aceleradoras de negócios e 4 representantes de instituições de suporte à inovação. Estas instituições foram caracterizadas como um grupo de controle, mas que contribuem com a evolução do ecossistema mineiro de inovação. Foi realizada uma busca na literatura, para identificar construtos e variáveis aplicáveis ao modelo proposto como referência de estudo.

Resultados: Os principais resultados mostraram a pertinência dos construtos e variáveis, demonstrando a conveniência do modelo para se estudar e planejar a sua aplicabilidade, tanto acadêmica, na evolução do conhecimento, quanto na função executiva, já que se aproxima da realidade atual das aceleradoras de negócios aqui estudada.

Contribuição à evolução do conhecimento: Análise de um modelo emergente e proposição de validações compatíveis com a necessidade de sua consolidação como teoria.

Contribuição executiva: Oferta de um modelo em evolução, porém interessante como estrutura aplicável à evolução do desenvolvimento de instituições.

Palavras-Chave: Inovação, Quarta Revolução Industrial, Aceleradora de negócios, Hélice Quíntupla.

LA HÉLICE QUINTUPLE MODELANDO LA INNOVACIÓN TECNOLÓGICA: CARACTERIZACIÓN Y ESTADO DE LAS ACELERADORAS EMPRESARIALES EN UNA REGIÓN METROPOLITANA

RESUMEN

Fundamento: El tema de la innovación tecnológica, especialmente en el contexto de la Cuarta Revolución Industrial, ha generado importantes turbulencias tanto en la literatura como en las prácticas empresariales ejecutivas. Entre los diversos modelos explicativos del contexto de desarrollo en el área, surge la Quintuple Helix.

Objetivo: Este estudio tiene como objetivo describir y analizar el estado actual de las aceleradoras empresariales en la región metropolitana de Belo Horizonte – MG (Brasil).

Metodología: Se realizó una investigación cualitativa, en la que se entrevistó a 6 ejecutivos de aceleradoras de empresas y 4 representantes de instituciones de apoyo a la innovación. Estas instituciones se caracterizaron como un grupo de control, pero contribuyen a la evolución del ecosistema de innovación de Minas Gerais. Se realizó una búsqueda bibliográfica para identificar constructos y variables aplicables al modelo propuesto como referencia del estudio.

Resultados: Los principales resultados mostraron la relevancia de los constructos y variables, demostrando la conveniencia del modelo para estudiar y planificar su aplicabilidad, tanto académicamente, en la evolución del conocimiento, como en la función ejecutiva, ya que se acerca a la realidad actual de los aceleradores de negocios estudiados aquí.

Contribución a la evolución del conocimiento: Análisis de un modelo emergente y propuesta de validaciones compatibles con la necesidad de su consolidación como teoría.

Contribución ejecutiva: Ofrece un modelo en evolución, pero interesante como estructura aplicable a la evolución del desarrollo institucional.

Palabras clave: Innovación, Cuarta Revolución Industrial, Acelerador de Negocios, Quintuple Helix.

1. INTRODUCTION

Innovation is of recognized importance as a condition worldwide for economic and social development and the well-being of people, companies and nations (Oslo Manual, 2018). At the same time, the benefits of men's efforts and genius have been significantly uneven, also across most of the world Schwab (2018). It is exactly this context that has inspired the literature critical of certain impacts of innovation on economies and societies. In this sense, the literature has been prodigal in offering analytical content, increasingly robust on the hyper-concentration of economic and technological development, social inequality, environmental impacts and difficulties in absorbing the costs of progress, accentuated from the Fourth Industrial Revolution.

This study aims to describe and analyze the current state of business accelerators in the metropolitan region of Belo Horizonte in a comparative analysis and their alignments, in the Quintuple Helix (QH) context. The choice of the research theme is justified by the fact that the Quintuple Helix Model has been emerging in Minas Gerais through research and innovation development entities, government actions, the actions of institutions representing sectors, such as Federations of Industries, Commerce, Universities Federal and private, Innovation Hubs, Business Accelerators, Technology Parks, Startups and other actors that make up the innovation ecosystem in Minas Gerais.

It is considered that this study on the themes of business accelerators and the Quintuple Helix Model is relevant to the academic world, as they are emerging phenomena and are related to innovative aspects of society, organizations, the economy and people, particularly. Actors in this ecosystem need to understand their strengths and limitations, both cultural and execution capacity, and learn from each other; thus, performing an authentic articulation, they will be contributing to a competitive economy at a regional and global level (Sakuda & Campos, 2018).

2. THEORETICAL FOUNDATION

2.1 The evolution and relational models of technological innovation

In companies, the responsibility for innovation, until the beginning of the 20th century, was exclusive to the Research and Development department as almost all innovations (Rafael & Lopes, 2020) were technological, but evidence indicated that such responsibilities should be shared with other departments involved in the process as well as with the external environment Martinuzzi, Blok, Brem, Stahl & Schönherr (2019). This gives rise to the concept of open

innovation, which translates into generating ideas for new products or services in tune with the market, in addition to preparing preliminary projects, feasibility studies, development research and implementation.

Nowadays, innovation is directly related to the creation of a network of organizations and people within an economic system (Lima, Borini & Santos, 2020), with the objective of creating, diffusing and applying scientific and technological knowledge for social and economic advancement within a society (Baber, Waymon, Alphonso & Wylde (2015) With the advancement of studies on the subject, the Triple Helix Model (TH) Model emerges, developed by Etzkowitz & Leydesdorff, (1995), focusing on university-industry-government relations as a strategy to encourage innovation dynamics. The TH model emerged for the analysis of knowledge-based innovation systems, emphasizing the multiple and reciprocal relationships between the three main actors in the process of knowledge creation and capitalization (Bueno, 2018). Recent changes in the scenario have expanded the form of relationship between these actors. The already traditional triad formed by university-industry-government has been strengthened with new propositions and ap-lessons of constructs added to the original model, from the inclusion of society, converging to the so-called Quadruple Helix Model - QH, and especially with the evolution of the model, aggregating the environmental conditions, resulting in the model called the Quintuple Helix Model, constituting as important propellers in the dynamics of innovation and economic, social and environmental development (Carayannis & Rakhmatullin, 2014).

As a historical reference for the basis of this research, the emergence in the USA - California, in the 1950s, specifically in Silicon Valley, is emphasized here, a significant emergence of innovative actions, coming to constitute organizations that began to develop products with technical attributes and radical electronics, providing consumers and customers with hitherto unusual experiences. These organizations provided the world with the idea that it is possible to offer innovations that significantly facilitate the way companies work and can evolve in a different way, being profitable to their entrepreneurs (Blank & Dorf, 2012; Ries, 2012). The media itself named this type of organization startups. Thus, they were even characterized as temporary and fraught with uncertainties in their development trajectories, due to the natural conditions of risk at a critical moment in the history of the United States, in addition to being susceptible to the natural risks characteristic of nascent businesses.

Given this, organizational models of innovation already show that the approximation of organizations, governments and society with startups makes it possible to contribute to the sharing of the culture of start-up companies with other driving forces of development, creating

an attitude of reflection on traditional organizations (Kohler, 2016). The integration between system, purposes, processes, innovation environments and startups is currently known as “acceleration”. Thus, business/startups accelerators have stood out in the creation and training of a new generation of entrepreneurs in Brazil. According to Pauwels, Clarysse, Wright & Hove (2016), acceleration activity can be considered a recent phenomenon in the world. The first accelerator, called “Y Combinator”, was created in 2005 in Cambridge, Massachusetts, around the Massachusetts Institute of Technology and has since been a source of inspiration for other business accelerators around the world. These organizations aim to help the development of Startups, through training, mentoring, investment and networking, in a limited period of time, so that they can develop and survive in competitive markets. They can belong to one or more corporations and usually have their goals derived from those of responsible corporations that offer programs for startups (Heinemann, 2015). In addition, for this author, acceleration programs have an intermittent selection process, seek startups at an early or growth stage, have a limited duration and may require equity participation.

Business accelerators are a type of open innovation program that aims to internalize technologies and, in return, offer technical support, financial resources and physical space (Weiblen & Chesbrough, 2015). This innovation model seeks, in the external environment, partners, technologies and resources that can generate synergy with its innovation projects for future products and services (Birdsall, Jones, Somerset & Takaki, 2013; Gopak, 2018).

2.2 The Quintuple Helix Model

The knowledge economy is organized in a network, and institutional actors, such as the University, companies in the productive sector of goods and services and the Government, perform their innate roles, corresponding to the generation and transmission of knowledge, production of goods and services and regulation of economic activity. From multiple interactions, they assume new roles, with overlapping, feedback and the emergence of non-linear dynamics in hybrid and consensus spaces (Audy, 2017). At the origin of this development system, the product resulting from the relationships, is reflected in the emergence of innovation mechanisms and environments, such as business incubators, business accelerators, science, technology and innovation parks, in addition to transfer and commercialization offices technology, collaborative research networks, regional economic development projects (local productive and innovative arrangements and systems), among others (Amaral, 2015).

The growing importance of the Triple Helix Model has led to the emergence of a rich body of theoretical and empirical research to discuss new models for the creation of innovation

(Lombardi et al., 2012), emerging new approaches, called Quadruple Helix – QH, with the inclusion of Society and the Quintuple Helix, with the Environment context (Carayannis & Rakhmatullin (2014). Figure 1 shows the Quintuple Helix Model, which contemplates the environmental forces determining scientific, technological and innovation development, which emerges as a guideline for the most developed economies in the world.

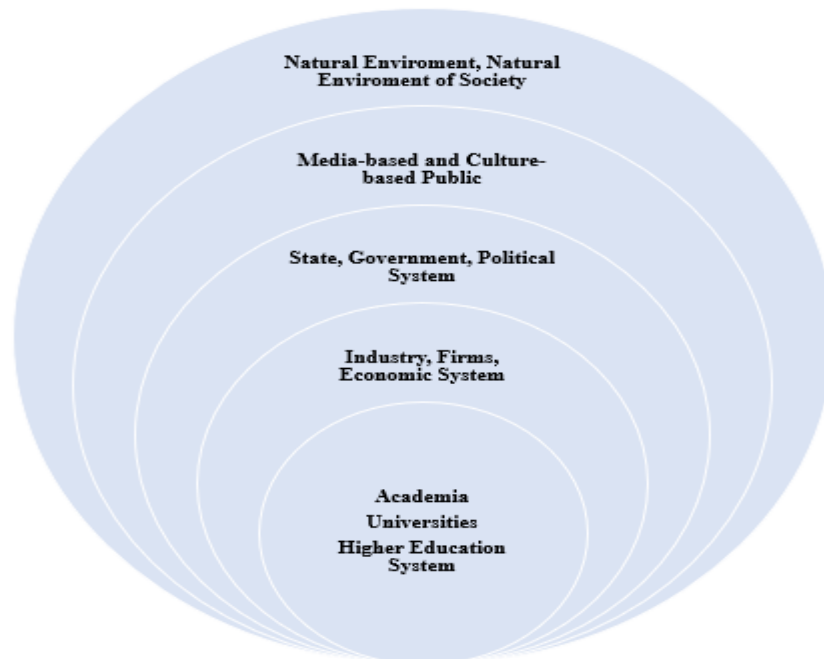


Figure 1: The subsystems of the Quintuple Helix Model. Modified from Etzkowitz and Leydesdorf (2000, p. 111) and Carayannis and Campbell (2009, p. 207)

Figure 1- Original model of the Quintuple Helix (Carayannis & Campbell, 2011)

The development model advocated by the World Economic Forum (WEF), through its Global Competitive Report 2019, highlights the importance of expanding and integrating the constructs of world development, in all its indicators, such as: Elements of the Environment (Institutions , Infrastructure, Adoption of Science, Technology and Innovation and Macroeconomic Stability), Human Capital (Health and Capabilities), Markets (Products, Labor, Market Size and Financial System) and Innovation Ecosystem (Business Dynamism and Innovation Capacity) (Global Competitive Report, 2019), strengthening the characterization of the Quintuple Helix Model.

In the conception of the model, it is responsible for the roles of magnitude, “whether as a structuring agent of the productive forces or as a driver and guide of their diffusion through the economy and society”. The Government must be the articulator in the innovative process, being able to strongly induce the behavior, strategies and business decisions related to innovation. It

is in the Government's interest to develop a framework that allows the creation of new knowledge and new technologies with a competitive environment capable of innovation (Etzkowitz & Zohou, 2017). For these authors, the Government has three responsibilities to achieve an adequate institutional structure for the innovative process. First, as an articulator, it is necessary to align the public with the private interest. The second is in determining public funding, that is, where it will be allocated so that it results in technological development. Finally, look after intellectual property. With this set of actions, it is possible for the Government to play its role in a consistent industrial and innovation policy.

Regarding universities, Baccarne et al. (2016) state that they represent the cornerstone of innovation systems, as they are responsible for the qualification of researchers and workers in higher education, and for basic research. However, the growth of links with the use of applied research, the frontier between science and technology, the need for interdisciplinary approaches in solving complex problems and the volume of resources needed for scientific projects represent new challenges to university management and lead to the establishment of new institutional approaches (Etzkowitz & Zohou, 2017). Universities have a responsibility to generate new knowledge, seek relationships between government and companies, seek new research gaps and lead change processes. Its limitations lie in its dependence on funding agencies to conduct research, in the limited view of labor training and professional training, and in the weak links with society and companies (Camboim, 2013).

In relation to industrial businesses, empirical research carried out by Botelho, Carrijo & Kamasaki (2007) and Baber et al. (2015) found that a web of relationships established by companies influences productive activities, in general, and innovative ones, in particular. Thus, relationships with customers and suppliers, with competing companies (especially in pre-competitive stages) and with research institutes and/or universities figure in the surveys as the most important (Park & Leydesdorff, 2010). Industry, represented by both large and small companies, needs to develop innovative products or services, seek interaction with research centers and lead change processes. Among its limitations are the limited investment capacity in R&D and the lack of preparation for research development (Camboim, 2013).

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While the traditional Triple Helix Model focuses on government, university and industry relations, the extended model for the Quadruple Helix adds perspectives from media and culture as well as society. This Quadruple Helix Model links the media to the creative industries, culture, values, lifestyles, art and creative class Carayannis & Rakhmatullin, (2014). In this fourth helix, knowledge and innovation policies and strategies must recognize the important role of society in achieving goals and objectives. Society is built and communicated by the media and influenced by culture and values (Nordberg, 2015). In this helix, civil society can also be perceived as a user of innovation. From this perspective, new products, services and innovative solutions are developed with the involvement of users in their role as leading users, co-developers and co-creators (Carayannis & Rakhmatullin, 2014 and Baccarne et al., 2016). Users can be defined in various ways, including: common or amateur users, professional users, consumers, employees, residents, citizens, companies, organizations or civil society associations (Arnkil et al., 2010). This helix empowers and connects co-creators of innovation, such as entrepreneurs, inventors, artists and other value generators that will strengthen the ecosystem. In this model, there are principles of broad cooperation in innovation, the process of developing products and services can exist at different levels of co-production with consumers, customers and citizens (Arnkil et al., 2010 and Nordberg, 2015).

The Quintuple Helix Model, in turn, emphasizes society's natural environments, through environmental issues, which become increasingly serious, which has led several countries to develop strategies and plans on the issue of the planet's sustainability (Chen, Chien & Hsieh, 2013). In this process, the environment needs to be included in regional development policies Carayannis, Cherepovitsyn & Ilinova (2017). The design of the Quintuple Helix Model is based on society that demands sustainable solutions and exposes a growing concern with ecological aspects. The challenge of global warming is accompanied by the challenge of sustainability in the 21st century. The Five-fold Helix represents a model between theory and practice offered to society to understand the link between knowledge and innovation, in order to promote lasting development (Carayannis, Barth & Campbell, 2012). This helix represents an engine of new knowledge and innovations in response to environmental challenges, being a broader perspective of socio-ecological transformations and natural environments (Grundel & Dahlstrom, 2016) and Lara, Jeckel, Silva & Bahia (2020).

2.3 The business accelerators

Especially in the last twenty years, much has been discussed about how to effectively support the development of innovative projects (Mello, Marques and Salerno, (2012). On this perspective, a new concept has gained great prominence in the venture capital industry, the “seed accelerators”, which are responsible for providing support through their own initial capital or partner investors (Kulkov, Hellstrom & Wikstrom, 2020) According to Miller & Bound (2011), the concept behind the acceleration programs emerged as a new method for incubating technology-based startups. According to Barrehag (2012), the development of a startup in an incubation process was extensive, and it could take several years for new companies to develop the pre-necessary requirements to establish themselves in the market. Thus, there is a need to develop shorter incubation cycles, with lower investment costs and lower structures. and model attracted the attention of investors who were looking for a more effective format for the development of digital startups (Barrehag, 2012). From this perspective, the foundations for the formation of the first business accelerators emerged. According to Polo García-Ochoa, De-Pablos-Heredero & Jiménez (2020), business accelerators are institutions composed of groups of people, usually experienced entrepreneurs, who provide much more than space rental and management services.

In practice, acceleration programs are a combination of distinct services or functions that were individually expensive for an individual entrepreneur to find and obtain, such as: seed capital, value-added guidance and advice, coworking, building networks and the opportunity to meet many investors (Christiansen, 2009; Hochberg, 2016). Business accelerators provide assistance to entrepreneurs, with regard to the construction and definition of their initial products, identification of customers and obtaining resources, both financial and intellectual (Abreu; Campos, 2016). Although the phenomenon of acceleration is new, bringing with it several uncertainties about the future success of business accelerators, it is argued that the economic logic that justifies its existence is convincing (Pauwels et al. 2016). The same author also states that research also points to the accelerator as a new incubation generation model, becoming a generic term for any program that provides guidance structure, networking opportunities and service access to financing for business reinforcement Startups.

Corporate business accelerators are an even more recent phenomenon and can be described, in short, as start up business accelerators maintained by corporations, which develop a program to support a certain number of promising startups (Weiblen & Chesbrough, 2015). Little research has explored whether these programs are effective and can yield results; even descriptive research on these programs is scarce (Cohen & Hochberg, 2014). On the other hand,

the different ways of conceptualizing business accelerators and their programs do not prevent us from identifying the general purposes of these ventures: to provide support to emerging businesses. In addition, business accelerators play a very important role in stimulating, acting as true centers of entrepreneurship, helping to create and train a new generation of entrepreneurs in Brazil.

Assuming as the purpose of this research to study the startups business accelerators in their conceptual dimensions, as well as the constraints, strategies, structures and their results, in the context of the Quintuple Helix Model, we sought, in the literary contributions of this research, the fundamental references for the characterization of such institutions. Effectively, the approach to these themes, due to the fact that some of them are still emerging, both in academic literature and in technical and executive contributions, is still incipient. Some of them still present definitions and concepts in formation, being susceptible to natural controversies of themes with a high rate of turbulence. On the other hand, the conjunction of these themes becomes exciting and inspiring with the immersion in investigations of literature and empiricism. This is exactly the context, purpose and challenge of studying the connections of themes that lead to the characterization and explanation of the phenomenon of business accelerators.

Next, the analytical model of the research will be presented, formed by a set of variables and their interrelationships, which was adapted to represent, in whole, or in part, a real process.

2.4 The analytical model of research

This model aims to investigate the characterization and alignment of business accelerators and institutions that contribute to the evolution of the Minas Gerais innovation ecosystem (control group) to the Quintuple Helix Model, which was adapted, as shown in Figure 2. In this context, the constructs are the same as in the original model, that is: governments, companies, educational and research institutions, society and the orientation to sustainability, as determinants of economic, social, technological and innovative progress of an economy.

The model variables were adapted to the conditions of these emerging institutions, which are business accelerators, as well as to those of the other actors in this research. Thus, for each construct, specific variables were created to define the knowledge that one intends to obtain, with the scope, density, importance and contemporaneity required of an investigation of this nature. For each construct of the model, several questions were created, which characterize the variables under study. It is with this procedure that the completeness of the study is intended,

in accordance with its objectives. Thus, the analytical model of this research is shown in the figure below.

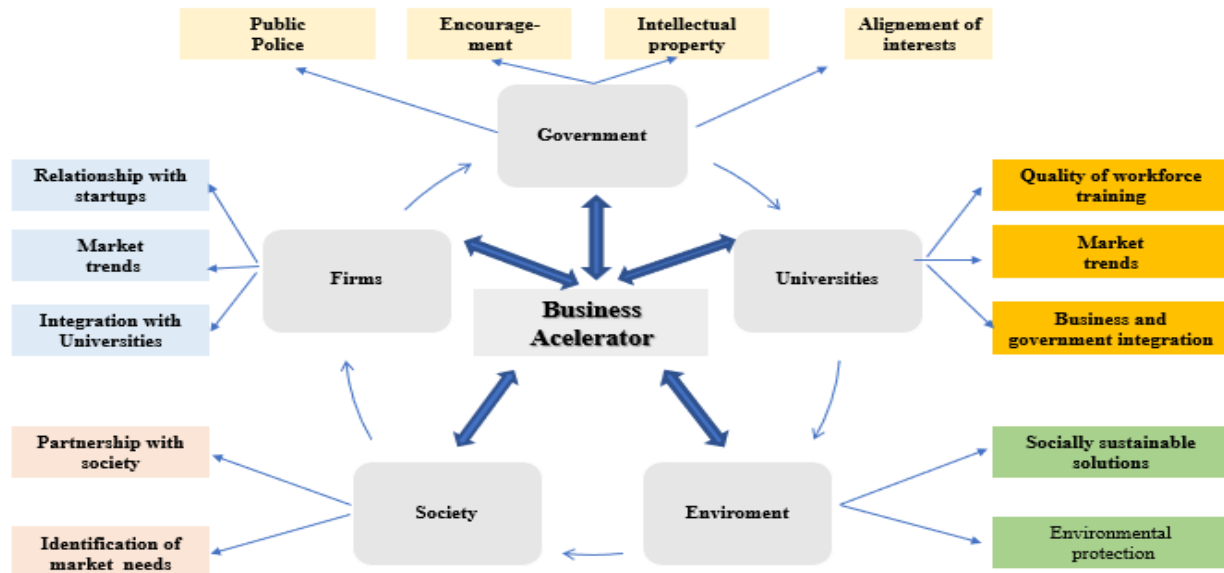


Figure 2: Relationships between business accelerators and Quintuple Helix agents

Source: Research authors (2021).

In the government construct, the following variables were established for this research: public policies, development, intellectual property and alignment of interests. The government has the role of stimulating, leading, fostering innovation. These variables are the foundation for building a strong and consistent innovation ecosystem. With regard to educational institutions, the focus was on the quality of the workforce, the alignment of research and development actions with market needs, and integration with the government and the private sector. In general, the variables created are focused on the themes of education and technology. The variable “integration with companies and government” explains the need to develop technology-based research that is essential for differentiating countries. Alignment with the private sector is fundamental for an understanding of the demands, providing opportunities for efficient and effective research, in order to add value to both the Universities and the market, generating wealth for the countries.

In the “companies” construct, the variables used in this research are related to Startups, market view and relationship with research centers. The innovation movement has been developing a new look from the private sector to topics such as startups, HUB's, business accelerators, venture capital and is stimulating discussions on forms of interaction between companies and Startups. Agility and risk are issues that the private sector is beginning to

understand as part of their daily lives in this new World 4.0. The variable “relationship with ICTs” is motivated by the need to bring the private sector closer to these institutions, which are the basis for the technological development of research.

In the “society” construct, partnerships and the identification of needs were defined in this research as the most relevant among the authors surveyed. The client has its role expanded, its participation in the creation of new products/services with companies being fundamental. In the “environment” construct, the variables “sustainability” and “environmental protection” were established in this research. These are sensitive issues for humanity, and a challenge for developing and developed nations. There is a need for a conversion of interests at the global level in this direction.

Once the variables were defined, a script of open questions was built, providing the possibility of a greater explanation of the content of the answers, seeking to capture the view of the respondent organizations' managers about each one of them, seeking convergence of opinions and the detailing of practices about each one of the variables presented in the model. From this stage, a subjective logic was followed, establishing subcategories named as “desirable commitments of the actors”, which will contribute to the construction of the resulting model, complementing the initially defined variables. Table 1 explains this structure:

Table 1
Content Analysis Structure

Category	Variable Stimulus to actors	Subcategories Desirable Actors' Commitment
Government	Government public policy Promotion of initiatives Intellectual property Alignment of interests	Example: encouraging entrepreneurship
University	Quality in professional training Market trend training Business and government integration	Example: Networking/Partnerships
Companies	Relationship with Startups Market tendencies Integration in research centers and HEIs	Example: Develop solutions for the core business of companies society partnership with society
Society	Partnership with society Need identification	Example: Technology impacts
Environment	Sustainable solutions for development Environmental protection	Example: Prioritizing environmental protection

Source: Survey Informations (2021).

3. METHODOLOGY

A descriptive research with a qualitative approach was developed, aiming to describe, analyze and present the context and business practices used by the business accelerators and the control group in a comparative analysis and their alignments in the context of the Quintuple Helix in the macroregion of Belo Horizonte (Brazil). The research method was that of multiple case studies, which is one of several ways to carry out research in the social sciences. It is exploratory, as it allows familiarization with people and their concerns, and can also serve to determine impasses and blockages, capable of limiting large-scale research (Deslauriers & Kérisit, 2010). Six business accelerators from various sectors and sizes were surveyed. According to the report Liga Insights Ecosistema Minas Gerais, developed and released by the Minas Gerais State Development Secretariat and the company Liga Ventures in July 2020, a total of 18 accelerators were mapped at Metropolitan Region of Belo Horizonte. These 6 units were chosen because of their willingness and interest in answering the interview script and because they believe they are contributing to the evolution of the innovation ecosystem in Minas Gerais.

To make the research more robust, a control group was composed of four institutions that actively participate in the innovation ecosystem in Minas Gerais. The choice of these institutions was based on the degree of credibility and influence in the Minas Gerais innovation environment, being considered technical references in this subject. This group was also interviewed and contributed information and data about the environment of the Quintuple Helix in Minas Gerais. Thus, it was possible to identify the vision of the executives of the accelerator group and the control group, on each of the fundamentals of the Quintuple Helix Model, which contributed to the construction of a resulting model that exposes the desirable commitments of these actors.

The script was divided into three blocks. The first one is focused on the structure of the accelerators, with the objective of understanding the organizational context. In the second block, the focus was on the Quintuple Helix model. The executives' view of each of the Helix of the QH model (University – Government – Companies – Society – Environment) was mapped, seeking to capture the view of these organizations on each of the variables presented in the model. The third block dealt with the results obtained. This article will focus on the second block of the interview, as it contains questions related to the Quintuple Helix Model, enabling the construction of an analysis compared to the reference model of this research, bringing it closer to the current reality of business accelerators. For the application of the questionnaire, a contact was made with the directors of these business accelerators and

institutions of the control group, to explain the objective of the study and to validate the interest in participation. Subsequently, meetings with their directors were scheduled or interview scripts sent by email. It is noteworthy that, due to the phenomenon of the pandemic, there were any difficulties in accessing and obtaining answers from the interviewees. Below is the interview control table:

Table 2
List of Accelerators and Control Group Interviewed

ACCELERATORS	Sector	CONTROL GROUP	Sector
AÇO LAB	Industry	EPAMIG	Agricultural research
COTEMIG Startups	Education	FDC	Executive Education
Neo Venture	Services	BH TEC	Innovation and Research Center
Wylinka	NOG	Innovation Specialist	Federal University
Lemonade	Services and Government		

Source: Survey Informations (2021).

The virtual interviews lasted an average of one hour and were held in September and October 2020, remotely, using the Meet virtual meeting tool, due to the Covid 19 pandemic. Overall, despite the use of tools for a virtual meeting, the interviewees demonstrated that they were comfortable in exposing the information/opinions, often expanding the content of the answers.

Content analysis was used as a data treatment technique in order to meet the objectives of this research. In this method, the starting point is the message, but the contextual conditions of its producers must be considered and it is based on the critical and dynamic conception of language (Bardin, 2016). In this research, all protocols and rituals of a scientific investigation were fulfilled. The research findings are presented below.

4. ANALYSIS AND DISCUSSIONS

In line with the purposes of a scientific work, which is oriented towards contributing to advances in knowledge, this research effectively proposes to study startup accelerators through the Quintuple Helix model. As it is an emerging model, studies with its applicability are rare. This results in the difficulty of comparing the findings between similar studies, with the same research processes. However, studies addressing the Triple Helix model are abundant and

approach theoretical saturation in the literature. For this reason, some comparisons in this study will find greater support in the second model. In essence, this study applies and discusses the model proposed by Carayannis, & Rakhmatullin (2014), but advances in comparisons with other references, notably the Quadruple Helix (Grundel, & Dahlstrom, 2016 and Lara et al., 2020).

In this study, the testimonies considered relevant, collected in interviews with the executives of the business accelerators and the participants of the control group about each of the Quintuple Helix fundamentals, were analyzed each of the fundamentals or constructs of the model (Government, Educational Institutions, Companies, Society and the Environment) is important for the social, economic and technological development of peoples, as well as for the creation of more intelligent and sophisticated jobs, income and occupations, especially for young people. This session presents a comparative analysis of the findings of the interviews carried out in the business accelerators and in the control group, allowing the identification of common points and those that were identified in only one of the groups. In this sense, this work can be considered, despite new information, as unprecedented in this subject.

4.1 The Government's roles and commitments in relation to startup accelerators.

On the desirable commitments of the government, regarding the ideas, purposes and processes in relation to the stimulus to startup accelerators, there is a summary of the positioning of representatives of the accelerators and the control group, as shown in Table 3.

Table 3
Perception of desirable Government commitments in relation to accelerators and startups

Variable	Subcategories	Business Accelerators Group	Control Group
Public Policies	Encourage entrepreneurship, reaching different layers of society	X	X
	Ensure legal security for Startups	X	X
	Increase investment in grassroots innovation	X	X
	Continuously encourage innovation	X	X
	Expand understanding of the Legal Framework for Innovation	X	X
Incentives	Disseminate information on access to development	X	X
	Bureaucracy reduction	X	X
	Incentive to innovation through tax deductions	X	

	Expansion of resources for technological development in Universities		X
Intellectual Property	Evolution of the Intellectual Property Theme		X
	Demystify the issue of Intellectual Property between Accelerators and Startups	X	
Alignment of Interests	Promotion of interaction, alignment and dialogue between actors	X	X
	Prioritization of the innovation theme in the spheres of power		X
	Development of a medium/long-term planning for innovation	X	X
	Expansion of workforce training in the TI area		X

Source: Survey Informations (2021).

Regarding the commitments that could stimulate the innovation ecosystem in Minas, the ambiguous view on the issue of Intellectual Property (IP) stands out. The group of accelerators understands that this is a matter that deserves to be better understood and debated. As for the control group, IP has been showing a good level of maturity among startups and companies, even though they agree that it should be better disseminated. The incentive to innovation through tax deductions and the expansion of resources destined to technological development by the government were desirable commitments that could contribute to the strengthening of companies, since the idea of promoting the technological development of companies is aligned with the level of maturity and growth of the country. The expansion of workforce in the IT area arises as a demand in the control group. It can be inferred, observing the context of Cotemig Startups, that the shortage is a fact and that the training of these professionals has presented a strong market demand, considering that the improvement solutions presented by Startups often use information technology. Another important point was the non-prioritization of the theme innovation in the spheres of power, pointed out by the control group as a political issue. Investment in innovation cannot be realized in the short term. Thus, government changes can bring with them little investment in innovation, which contributes to the country's low technological development. Some of these results are in line with studies by Baccarne et al. (2016), Carayannis & Rakhmatullin (2016) and Etzkowitz, & Zohou (2017).

4.2 The roles and commitments of Universities (Higher Education Institutions - HEIs) and Research Centers with development through accelerators

The contribution of universities (Higher Education Institutions – HEIs) and research centers to the development of a region or country has been widely studied in academic literature, as emphasized by Audy (2017), Botelho et al. (2007) and Rego (2020), among many others. The summary of the desirable commitments of higher education institutions, expressed by representatives of the accelerators and the control group, in relation to accelerators and startups, is presented in Table 4.

Table 4

Perception of desirable commitments of HEIs and Research Centers in relation to accelerators and startups

Variables	Subcategories	Business Accelerators Group	Control Group
Quality of Labor Training	Expansion of entrepreneurial movements in HEIs	X	X
	Improved curriculum	X	
	Enable students and teachers to know the market	X	X
	Prepare teachers and students for the universe of innovation	X	X
	Develop "innovative" skills in students		X
	Technological preparation of students		X
Market Tendencies	Expand connections between business challenges and academic research	X	
	Expand the relationship with the private sector to raise funds and co-develop solutions	X	X
	Expand relationship between HEIs	X	
Business and Government Interaction	Define technology transfer policies		X
	Alignment between Research Institutes and Government		X

Source: Authors (2020).

In relation to the HEIs, the comparison carried out between the researched groups showed great alignment on issues considered crucial for the development of the ecosystem, that is: entrepreneurship, knowledge of the market, preparation of teachers and students, expansion of the relationship between the parties. Dissenting points should be considered complementary. Among them, the improvement of curricula emerged in the group of accelerators, but it has a causal relationship with the preparation of students for the universe of innovation. Thus, it appears that the themes “developing innovative skills” and “technological preparation of students” complement this desirable commitment of the accelerators and the control group. “Expanding connections between business challenges and academic research” emerged in the group of accelerators as a demand for opening HEIs to market demands. It is noteworthy that,

in the Control Group, the reports are of an ongoing approach and that the relationships are more fluid.

Another point that deserves attention emerged in the accelerators group and deals with the expansion of the relationship between HEIs. This commitment is based on the exchange of knowledge between institutions and the potential result of these relationships. The relationships between HEIs must be complementary. The non-existence of a technology transfer policy between the HEI and the market has impacted the speed of implementation of these technologies in organizations. The lack of alignment between Research Institutes and Government also reinforces, once again, the need for investment/implementation of a structured plan for science and technology at the national level to guide actions.

4.3 The roles and commitments of Companies with development through accelerators

The desirable commitments of the companies, expressed by the respondents, are presented, in summary, in Table 5.

Table 5:
Perception of desirable commitments of companies in relation to accelerators

Variable	Subcategories	Business Acelerators Group	Control Group
<i>Startups Relationships</i>	Partnership with Startups's	X	X
	Adapt legislation to facilitate hiring startups		X
Market Trends	Encourage the approximation of medium-sized companies with Startups	X	
	Encourage mentoring focused on customers' "pains"		X
	Technical profile of companies facilitating connection with ICT		X
Integration between Research Centers and Universities	Improve the technological development of companies	X	X
	Decrease CTI's bureaucracy		X

Source: Survey Informations (2021)

When comparing the results of the companies between the accelerator and control groups, two commitments emerge as a common point: the partnership with startups and the improvement of the companies' technological development. Regarding the partnership, both the accelerators and the control group believe that this is the path to innovation, but they also agree that there are points of conflict that need to be resolved, and the main ones are: the legal and cultural issues of organizations, especially the large ones. Both groups understand that, for us to have greater technological strength, this proximity needs to be prioritized, thus improving the competitiveness of companies and the country. One point that emerged from the group of

accelerators was the difficulty in bringing Startup's closer to medium-sized companies, making evident the difficulty for the development of these companies, since there are difficulties in fostering actions by the government, or due to lack of an association that represents them.

The other points arose from the control group and show the need for improvement in the technical training of employees of the private sector and the "starter's", either to understand the "pains" of the customers, that is, to be able to "translate" an order demand technology for a Research Institute. Finally, this group brought the desirable commitment of reducing bureaucracy in CTI's, which can contribute to a greater demand for technical work. These results make up the resonance already analyzed in many other works, such as Smith (2017) and Friedman (2014), but also more contemporary ones, such as Arnkil et al. (2010), Barrehag (2012), Birdsall et al. (2013), Grundel (2016) and Martinuzzi et al. (2019).

4.4 The roles and commitments of society in relation to accelerators

In this sense, the contributions of society to development, playing roles and fulfilling specific commitments, the academic literature has not been so prodigal in contributions regarding the contributions of startup accelerators. Except for the works of Baccarne (2016), Carayannis, Barth & Campbell (2012) and Roffoni, Fischer and Amaral (2021), among few others. Literature contributions are, in general, very dispersed in several areas.

In this work, respondents provided arguments that can be summarized in Table 6, about society's desirable commitments to development through startup accelerators.

Table 6

Perception of the Society's desirable commitments in relation to development through accelerators

Variable	Subcategories	Business Acelerators Group	Control Group
Partnership with society	Building partnerships	X	
	Generate legitimacy to remain in the market		X
	Leave a legacy for society		X
Identification of needs	Understand customer needs by being close	X	X
	Technology impacts on society		X

Source: Survey Informations (2021)

When comparing the results of the fourth helix of the proposed model, the common commitment that brings the two researched groups together is the understanding of customer needs. In all the reports on this theme, it became evident that this is the reason for the existence of Startups and for the improvement of society with their innovations. The other commitments that the groups suggest are complementary to the theme and explain that this helix goes beyond

understanding the customer's need and brings important points such as: building partnerships with suppliers, customers, companies in the same sector to improve products and carry out actions for the development of society, as identified by Lara et al. (2020); also that organizations must leave a legacy for society, generating technological solutions that contribute to the improvement of society as a whole.

4.5. The roles and commitments in relation to sustainable development

Commitments to the environment have been protagonists in academic and business literature, as well as in the media in general and in public policy decisions, as addressed by Carayannis & Cherepovitsyn (2017), Cohen & Hochberg (2014), Barrehag (2012), Birdsall et al. (2013) and Tioosi and Simon (2021), specifically in Circular Economy. In this survey, respondents expressed their perspectives, which are summarized in Table 7.

Table 7
Perceptions about the desirable commitments of accelerator promoters in relation to the environment

Variable	Subcategories	Business Accelerators Group	Control Group
Sustainable solutions for the development of society	Involvement of Small and Medium Organizations in Sustainability Actions	X	X
	Encourage the development of solutions to environmental problems	X	X
Environmental protection	Prioritize environmental protection	X	X

Source: Survey Informations (2021)

The Quintuple Helix focuses on the environment. Although few commitments expressed by respondents emerged, they are of considerable relevance. It was observed during the interviews that large corporations find it easier to carry out actions on this topic due to the contribution of resources and visibility in the market. When comparisons are made between the reports in general, everyone shares that it is an extremely relevant topic in several aspects – sustainability of the planet, possibility of reaching other customers and markets, contribution to society. However, all were unanimous in reporting that it is a subject that is not yet internalized in the business world and in startups. Even less, due to the size of the structures and also the low investment of companies in sustainability actions.

These results find content and parallel and confirming evaluations with previous studies, in the most general aspects of the theme. As references, there are the specific contributions of Miller & Bound (2011), Pauwels et al. (2016), Hochberg (2016), Martinuzzi et al. (2019) and Gopak (2021).

4.6 The synthesis of research contents

As a synthesis of the Quintuple Helix model, applied to the status quo of business accelerators, in the interviewees' perception. The purpose of this model adjusted to the panoramic configuration of the Quintuple Helix is to provide a contribution to the evolution of academic knowledge, through substantive analytical contrasts, as well as to public policy makers and executives, consulting firms and managers about the panorama and borders influence that startup accelerators can contribute. It is for this purpose that the consolidation of the study is presented in Figure 3.

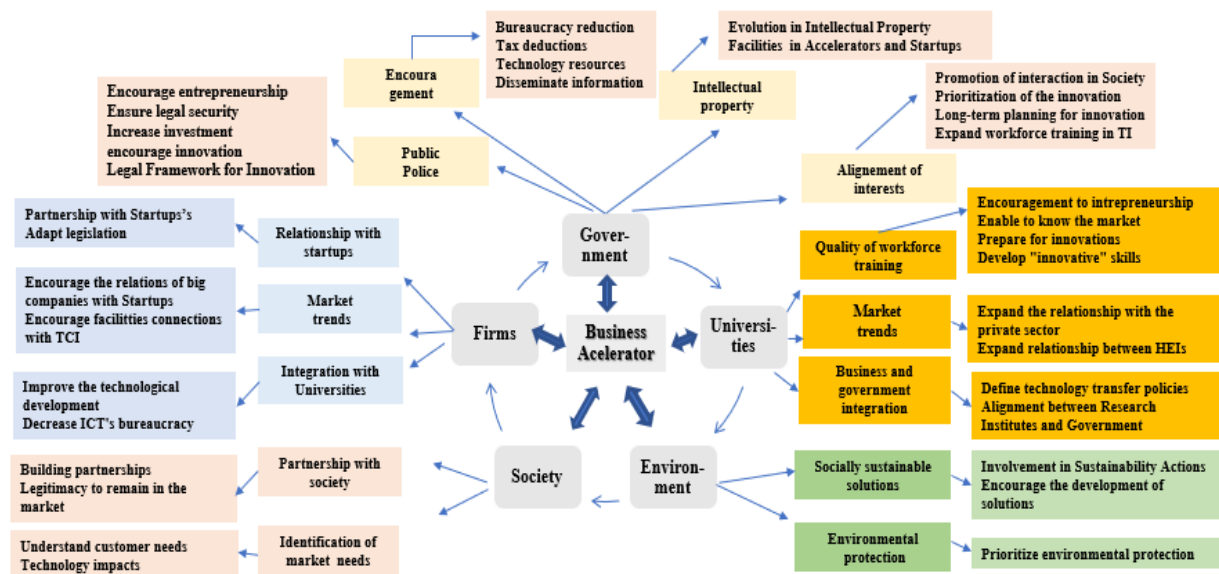


Figure 3 – Model Resulting from the research on the Quintuple Helix
Source: Survey Informations (2021)

The model seeks to present, based on its original configuration, the constructs of the Quintuple Helix and its variables, or indicators, allowing for adaptations, including contents specific to each situation that one intends to apply it. Therefore, it results in an open model, typical of open innovation models, already widely explored in contemporary literature.

5. FINAL CONSIDERATIONS

The innovation of products, processes and organizations is essential for the development of nations. Several scholars have dedicated their lives to understanding how actors who participate in innovation ecosystems in various countries develop projects, interact and establish their relationships. An Innovation ecosystem is made up of startups, business accelerators, Innovation Hubs, Science and Technology Institutes, research laboratories, government, universities and society in general. At any moment, other agents may appear, as it is an ecosystem in constant evolution. A joint work between these actors will culminate in developed and technologically advanced nations.

This research aimed to describe and analyze the current state of business accelerators (one of the actors in the innovation ecosystem) and a control group in the metropolitan region of Belo Horizonte, in a comparative analysis and their alignments, in the Quintuple Helix environment. In this sense, it is possible to consider that its objective was fully achieved, despite some external limitations to the program and to the conditions of the investigation.

Essentially the research findings are more consistent in:

- 1) The model is widely applicable to scientific and technological investigations, as it establishes defined constructs and variables to be adjusted to studies of different natures;
- 2) As this is a study of a perceptual and unstructured nature, the answers may be incomplete, dispersed and even dissonant from the purposes of the investigation;
- 3) Respondents are more demanding in relation to government roles than to other constructs;
- 4) Regarding the roles of society and the environment, respondents present a more generic view of contributions to development than to other constructs;
- 5) The control group (external analysts) presents a clearer and more objective view of the roles of all stakeholders than the accelerator managers, especially in relation to the Society and Sustainability agentes;
- 6) The accelerator managers are more easily analytical compared to the Triple Helix agents (Government, Companies and Universities and Research Centers).

The resulting model, and the most substantive contribution to the advancement of knowledge in this field, has the purpose and characteristic of analyzing determinant elements of the performance of the Quintuple Helix agents applied to accelerators, providing

contributions to advanced academic studies. In summary, it was possible, as defined in its objectives:

- a) Present a mapping of the interviewees' positions on the research contents, in a general model;
- b) Present a graphical configuration of the model allowing a broad view of the constructs and variables, which can inspire new studies and research on the contents;
- c) Highlight wide applicability to the most diverse subjects and research objects;
- d) Provide public policy makers with the definition of objectives, strategies, structures and monitoring of public resources applied to technology-based businesses;
- e) Provide the model agents with a robust reference to describe intelligent, complex, dense and relevant to economic and social development systems;
- f) Demonstrate that the model has a pedagogical characteristic: it is easy to explain, demonstrating the pertinence, consistency and convergence of the actors in the sense of orientation to the context of the Fourth Industrial Revolution.

This study has some limitations. Its findings cannot be generalized, as it is a qualitative research. It was also observed that some researched accelerators did not fulfill all the requirements for a complete answer to the proposed script. Despite not having affected the results, some constructs could be better detailed. The control group could have been expanded, better demonstrating all the actors that make up the Minas Gerais innovation ecosystem. There were difficulties in getting answers online through the meet. Many potential respondents were unwilling to attend the interview.

As propositions for future studies, the following hypotheses associated with the Quintuple Helix Model can be recommended in quantitative studies:

H1: The performance of corporate business accelerators equally depends on the contribution of constructs: government, companies, higher education and research institutions, forces of society and actions for the environment;

H2: The contribution of the government, companies and educational and research institutions are more evident and robust than the forces of society and actions for the environment, according to the Triple Helix model, for business accelerators;

H3: The determinant variables of evolution referring to social forces are less diversified and contribute less to the explanation of convergence to the success of accelerators in relation to other factors;

H4: The model demonstrates robustness in explaining the agents' contribution to the evolution of business accelerators.

It is also highlighted the importance of each agent to encourage, foster and sustain the hopes of youth in search of building new economic and social realities in a context of many uncertainties, whose opportunities lie in the potential of new businesses and based entrepreneurship in technology. Finally, as an example of the practical use of research in organizations, it is recommended to expand discussions on the feasibility of implementing desirable commitments among agents, thus contributing to the robustness of the innovation ecosystem in various systems.

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