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INITIAL ACTIONS OF THE BRAZILIAN REGIONAL INNOVATION ECOSYSTEM AGAINST THE COVID-19 PANDEMIC

AÇÕES INICIAIS DO ECOSSISTEMA REGIONAL BRASILEIRO DE INOVAÇÃO CONTRA A PANDEMIA DA COVID-19

ACCIONES INICIALES DEL ECOSISTEMA REGIONAL BRASILEÑO DE INNOVACIÓN FRENTE A LA PANDEMIA DE LA COVID-19

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Abstract

Objective: We have analyzed Brazil's initial COVID-19 combat actions by the regional innovation ecosystem actors.

Methodology/approach: This is a descriptive and qualitative study using documentary research. In total, 471 reports collected via web scraping were submitted to content analysis (using a codebook and intercoder test) and correspondence analysis.

Originality/relevance: From an innovation ecosystem perspective, this study fulfills an identified need to understand how different actors have proposed initial solutions to the COVID-19 pandemic, considering different geographic regions.

Main results: According to the seminal literature, in the more economically and socially favored regions, the government-industry dyadic model was corroborated, while in the less favored regions, the most innovative actors were universities and society. Our results have not shown the quintuple helix's performance, which leads us to ponder the use of this model in crises. Furthermore, although the quadruple helix model was observed in our analyses, in the Brazilian geographic regions the helices were not designed in a transversal way.

Theoretical contributions: We propose that the geography of a pandemic combat occurs unevenly by the innovation ecosystem actors. Moreover, the helices ordering refers to the theoretical development process and not to the complementarity of the role between actors.

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Practical implications: This article highlights the need for integrated management of the innovation ecosystem's initial actions in a pandemic, preventing regions from being neglected, especially those with lower levels of wealth or quality of life.

Keywords: COVID-19. Innovation. Innovation ecosystem. Quadruple Helix. Triple Helix.

Resumo

Objetivo: Analisamos as ações iniciais de enfrentamento à COVID-19 no Brasil pelos atores do ecossistema regional de inovação.
Metodologia/abordagem: Trata-se de um estudo descritivo e qualitativo, utilizando pesquisa documental. No total, 471 reportagens coletadas via *web scraping* foram submetidas à análise de conteúdo (com uso de um livro de códigos e de teste intercodificador) e à análise de correspondência.
Originalidade/relevância: Do ponto de vista do ecossistema de inovação, este estudo atende a uma necessidade identificada de entender como diferentes atores propõem soluções iniciais para a pandemia de COVID-19, considerando diferentes regiões geográficas.
Principais resultados: Nas regiões mais favorecidas econômica e socialmente, o modelo diádico governo-indústria foi corroborado, segundo a literatura seminal, enquanto nas regiões menos favorecidas, os atores mais inovadores foram universidade e sociedade. Nossos resultados não evidenciaram a atuação da quíntupla hélice, o que nos leva a ponderar esse modelo em situações de crise. Ademais, embora o modelo da quádrupla hélice tenha sido corroborado em nossas análises, o modo como as hélices se arquitetaram nas regiões geográficas brasileiras não foi transversal.
Contribuições teóricas: Propomos que a geografia de um enfrentamento pandêmico ocorre de forma desigual pelos atores do ecossistema de inovação. Além disso, a ordenação das hélices refere-se ao processo de desenvolvimento teórico e não à complementaridade do papel entre os atores.
Implicações práticas: Este artigo destaca a necessidade de gestão integrada das ações iniciais do ecossistema de inovação em uma pandemia, evitando que regiões sejam negligenciadas, especialmente aquelas com níveis mais baixos de riqueza ou qualidade de vida.

Palavras-chave: COVID-19. Inovação. Ecossistema de inovação. Quádrupla Hélice. Tripla Hélice.

Resumen

Objetivo: Analizamos las acciones iniciales para enfrentar el COVID-19 en Brasil por parte de los actores del ecosistema regional de innovación.
Metodología/enfoque: Hicimos un estudio descriptivo y cualitativo, utilizando la investigación documental. En total, 471 reportajes recopilados a través de web scraping se sometieron a análisis de contenido (con libro de códigos) y análisis de correspondencia.
Originalidad/relevancia: Desde la perspectiva del ecosistema de innovación, este estudio aborda una necesidad identificada de comprender cómo los actores proponen soluciones iniciales para la pandemia de COVID-19, considerando diferentes regiones geográficas.
Principales resultados: En las regiones más favorecidas económica y socialmente se corroboró el modelo diádico gobierno-industria, según la literatura seminal, mientras que en las regiones menos favorecidas los actores más innovadores fueron la universidad y la sociedad. Nuestros resultados no apoyaron la quíntuple hélice, lo que nos lleva a cuestionar este modelo en crisis. Además, aunque el modelo de hélice cuádruple fue corroborado, la forma en que las hélices fueron diseñadas en las regiones geográficas brasileñas no fue transversal.
Contribuciones teóricas: Sugerimos que la geografía del enfrentamiento a una pandemia se da de manera desigual por los actores del ecosistema de innovación. Además, la ordenación de las hélices se refiere al proceso de desarrollo teórico y no a la complementariedad del rol entre los actores.
Implicaciones prácticas: Resaltamos la necesidad de una gestión integrada de las acciones iniciales del ecosistema de innovación en una pandemia, evitando que las regiones queden desatendidas, especialmente aquellas con menores niveles de riqueza o calidad de vida.

Palabras clave: COVID-19. Innovación. Ecosistema de innovación. Cuádruple Hélice. Triple Hélice.

Introduction

An innovation ecosystem may be understood as a system in which actors from different social sectors and their environments interact, with legal and cultural resources, norms, and support infrastructure, among other elements, aiming at innovation development (Butzin & Terstriep, 2018; Granstrand & Holgersson, 2020; Howaldt et al., 2016). Different approaches may be adopted when analyzing innovation ecosystems (Foguesatto et al., 2021). The triad of university, industry, and government, widely known as the triple helix (Etzkowitz & Leydesdorff, 1995), prevails in the literature (Doloreux & Gomez, 2017) but it does not minimize the relevance of society's engagement of and the environmental context in proposing innovative solutions to emerging challenges. Given the relevance of these last actors in the innovation ecosystem, the quadruple helix model (Carayannis & Campbell, 2009) and the quintuple helix model (Carayannis & Campbell, 2010) were proposed.

The literature has pointed out the role of actors in the innovation ecosystem, the knowledge generation process, the innovation dynamics (Doloreux & Gomez, 2017; Granstrand & Holgersson, 2020), and in overcoming shocks, such as the COVID-19 pandemic (Park et al., 2021). The disease has spread around the world in a dizzying way. While scientists and researchers strive to find out a vaccine, policymakers are embarking on the search for measures—moderate and audacious ones—capable of controlling the disease's spread without slowing down the economy. Despite the efforts made, there are predictions of recession and even global economic depression.

Betting on innovation to fight pandemics (Azoulay & Jones, 2020) is not new, given the experience with smallpox and Severe Acute Respiratory Syndrome (SARS), among others. The case of smallpox is quite emblematic because, in the 1980s, it was the first disease considered eradicated in the world by human action (OPS, 1980), which required, in addition to scientific engagement, the active role of different actors in the fight against the disease (PAHO, 1960). Likewise, the extinction of the SARS epidemic was due to innovative actions resulting from the synergistic action amongst different actors in regional systems (Kamradt-Scott, 2009). Despite the evidence on the role of different innovation ecosystem actors in combating crises, the actions in which these actors engage in response to crises still lack studies (Park et al., 2021), especially considering the different regional contexts (Bogers et al., 2019).

Based on this gap and because Brazil has been one of the countries most affected by the consequences of COVID-19 (Pinheiro et al., 2020), the present study aims to analyze Brazil's initial COVID-19 combat actions by the regional innovation ecosystem actors. Through

descriptive research, reports from national newspapers of large circulation in each Brazilian geographic region were used, once they show the actions to combat the coronavirus in the country. We have collected these reports via web scrapper, analyzed them with a codebook, performed an intercoder test, and created a perceptual map, illustrating steps that may function as good practices for further research. Furthermore, the achievement of the aim allows the understanding of how different innovation ecosystem actors were triggered in the Brazilian regions and which actions they got involved in.

We argue that the role of the innovation ecosystem in the COVID-19 initial response did not occur uniformly, nor did it have a single protagonist in the Brazilian geographic regions. We also demonstrate that the COVID-19 pandemic's consequences have motivated the actors' multifunctional performance in the country. For instance, although the theoretical model of the innovation ecosystem recommends universities in the frontline, especially in research activities and solutions development (Etzkowitz & Leydesdorff, 1995), the pandemic scenario has highlighted the relevance of academia also acting as a civic engager (Panizzon et al., 2020). On the one hand, we have detected recurrent activities of Brazilian universities in research actions across all geographic regions in the country. On the other hand, in some geographic regions, we have not found recurrent actions of this actor related to assistance, guidance, and awareness of the civil society with respect to dealing with the consequences brought by COVID-19.

Our findings have not revealed the performance of the quintuple helix (Carayannis & Campbell, 2009) and suggest that an innovation ecosystem analysis model should not consider the society helix as additional to the role of government, industry, and university actors (e.g., Carayannis et al., 2018). The quadruple helix model assumes that the society actor performs in a complementary way to the other triple helix actors (Carayannis & Campbell, 2010), as was the case of that actor's performance in the Brazilian Southern region. However, the results found for the Northern region suggest that the actor *society* can lead innovation actions in the absence or lesser participation of others, not being conditioned to the performance of university, government, and industry actors. Hence, the proposal of society as the fourth helix is due, from our point of view, especially to issues of developing the innovation ecosystem theoretical model—and not necessarily to a supposed hierarchy amongst the referred model's actors.

Theoretical background

Ecosystem innovation as a Helix

The concept of *ecosystem* has its origin in biology (Moore, 1993, 1996, 1998) and may be understood as a logical unit of analysis focused on business opportunities, which are permeated by the interactions of cooperation and competition among the participating actors (organizations, suppliers, producers, competitors, and other stakeholders), which jointly develop their capabilities and functions in search of an alignment to the direction of one or more organizations.

The use of the phrase *business ecosystem* as organizations that interact with each other aiming at developing specialized products, services, and technologies started in the studies by Schön (1984), Nelson and Winter (1982), Astley and Fombrun (1983), and Rothschild (1990). This analogy was adopted by other authors in the form of metaphors that address ecosystems of innovation, business, entrepreneurship, knowledge, and technology, among others, as interchangeable phrases (Adner, 2006; Adner & Kapoor, 2010; Gawer & Cusumano, 2014; Gomes et al., 2018; Kapoor & Lee, 2013; Nambisan & Baron, 2013; Overholm, 2015; Thomas & Autio, 2020).

In addition to the organizational perspective, the literature presents the innovation ecosystem construct in a context of national (Lundvall, 1992; Freeman, 1989) and regional (Asheim & Gertler, 2005; Thomas et al., 2021) innovation systems. National systems are related to factors of economic and institutional structures, such as production, marketing, finance, etc. On the other hand, regional systems deal with aspects of institutional infrastructure that support the development of innovations in the productive structure of a given region (Granstrand & Holgersson, 2020).

However, the concept of *innovation ecosystem* has become subject to much debate due to its various approaches found in the literature (Bogers et al., 2019; Foguesatto et al., 2021). Oh et al. (2016) criticize the concept when it comes to the usefulness and distinction of existing definitions of innovation systems, in addition to the fact that biological inspiration is an imperfect analogy for addressing ecosystems. Ritala and Almpanopoulou (2017) reinforce the criticism that the concept is used ambiguously, but understand that this plurality can add to the discussion on innovation management, as long as scientific and empirical rigor is valued.

Among the approaches presented in the literature and based on a systemic perspective, innovation may be understood from an ecosystem context (Carayannis et al., 2018), which refers to the components, limits, and functions of a socioeconomic system. It may also be seen

as a tool to stimulate policies that promote development and generate scientific and technological knowledge (Etzkowitz & Leydesdorff, 1995; Etzkowitz & Zhou, 2017).

The seminal triple helix model, proposed by Etzkowitz and Leydesdorff (1995), refers to the innovation initiatives in a given ecosystem undertaken by the university-industry-government triad. This framework was proposed based on New England's context in the 1920s, aiming to renew the declining industrial economy at the time. The purpose was to establish an innovation dynamic based on strategic and reciprocal interactions amongst between industry, government, and university actors (Etzkowitz & Leydesdorff, 1995).

According to Etzkowitz and Zhou (2017), the triple helix model provides an opportunity to identify local strengths and weaknesses and fill gaps in the relationships among universities, industries, and governments, in order to develop a successful innovation strategy. In this sense, since the 18th century, industry and government have been considered primary institutional spheres of society, especially concerning economic and social development.

Nonetheless, contrary to theories that emphasize the role of government and society in innovation development, the triple helix model highlights that university does no longer has a secondary role of providing only teaching and research: it begins to assume a protagonist role, where advanced knowledge is put into practical use. This is supported by Rosa et al. (2021), who point out that, in order to deal with situations of public emergency, countries have organized a flow of production and innovation aimed at reducing the impact on health; to this end, the Brazilian scientific community has produced extensive proposals for research, development, and innovation.

However, given the accelerated changes in the global scenario, the relationships among these actors have been changing and strengthening with new interactions in innovation ecosystems, namely: the inclusion of civil society and the perspectives of media and culture (quadruple helix) and, ultimately, the environment perspective (quintuple helix) (Carayannis et al., 2018; Carayannis & Campbell, 2009).

In the quadruple helix model, Carayannis and Campbell (2009) point out that civil society is considered the user of innovation. Therefore, it should be at the center of the model, encouraging innovation development in addition to the role played by the other three helices, in the sense of supporting citizens in innovation activities through the development of tools, information, and forums (Carayannis & Rakhmatullin, 2014).

The literature shows that there is a need to implement the quadruple helix model to generate sustainable innovation and growth (Ivanova, 2014; Miller et al., 2018; Yawson, 2012).

Moreover, this model can be used to strengthen governance and decision-making processes in regional strategies of research, development, and innovation (Cavallini et al., 2016; Deakin et al., 2018); it also plays a leading role in promoting the shift from technological innovation to social innovation (Carayannis & Rakhmatullin, 2014).

With respect to the quintuple helix model, it aims to explain in an interdisciplinary way the aforementioned actors' social interactions, in order to promote and view a cooperation system of knowledge, know-how, innovation, and the environment, aiming at sustainable development (Carayannis & Campbell, 2010; Carayannis et al., 2021).

Considering that regions are increasingly seen as ecosystem agglomerations of several stakeholders with socio-technical, socio-economic, and socio-political conflicts, the choice of the quintuple helix innovation system model or framework (government, university, industry, civil society, and environment) is justified in this study (Carayannis & Campbell, 2010). This is due to the fact that it is proposed as an enabler and a stimulating factor of co-opetitive regional business ecosystems that Carayannis et al. (2018) define as fractal, multi-level, multi-modal, and multi-lateral configurations of dynamic tangible and non-tangible assets within the resource-based view and the new theory of firm growth.

The triple, quadruple, and quintuple helix models also provide opportunities for identifying people and relationships, institutional arrangements, and dynamic mechanisms, which are essential for innovation and entrepreneurship (Carayannis et al., 2018). A priori, the triple helix model discusses the innovation theoretical structure. It originated in industry and is strengthened by the inclusion of the government's role, which takes it a step further and links innovation and entrepreneurship to the university as a vital source of "the new" (Etzkowitz & Leydesdorff, 1995). Subsequently, Carayannis and Campbell (2012) understand society and the environment as actors that can play a direct role in innovation and entrepreneurship, in addition to interacting between themselves to create sustainable innovation resources through hybrid existing organizations or recently-created ones (Carayannis et al., 2021).

Furthermore, the systematic review on this subject carried out by Doloreux and Gomez (2017) points out that the relationships amongst the several actors are considered strategic in order to accelerate the process of knowledge generation and innovation dynamics. Hence, according to these authors, it is crucial to understand how these relationship dynamics established among the innovation ecosystem actors can help produce the ability to deal with external shocks, adopting new means of growth aimed at overcoming crises (Doloreux & Gomez, 2017).

Method

Research design

To answer our research questions about the innovative performance of systemic actors in atypical contexts—such as the current crisis resulting from the COVID-19 pandemic—, we have used descriptive research with a qualitative approach. We have used electronic media as data, in particular news published on websites of Brazilian newspapers with large regional circulation. As documents, news represents potential sources to address specific research questions (Charmaz, 2014) and is made up of a multitude of events ranging from simple ones, such as an individual's speech about a topic, to complex ones, such as a war (Caswell & Dörr, 2019). In addition, events are specific activities made up of actors, things, and concepts from a particular place and time.

Data collection and sample

We have used search engines on newspaper websites using the keyword "COVID-19" to find reports related to this topic. In line with the research question and considering that the first recorded case of COVID-19 infection in Brazil occurred on February 26, 2020, we have selected reports published from March to June 2020. Each researcher was responsible for a Brazilian geographic region and their respective newspapers.

We have applied the web scraping technique, from text mining, using the Web Scraper tool to extract reports' headlines and front pages found by scanning each newspaper website. The Web Scraper tool captures and organizes selected website content into a table. All the reports extracted, in a total of 652, were compiled in a spreadsheet. Once compiled, we analyzed the extracted reports' data to filter out those relevant to the research question. After exploratory readings, we selected 471 reports, each representing the unit of sampling (Neuendorf, 2002) and the whole set representing the sampling of material (Flick, 2009) for this study. Table 1 shows the newspapers consulted as a data source and the number of reports collected from each one.

Table 1

Newspapers consulted as sources of reports

Geographic region	Newspapers consulted	Number of analyzed reports	
		Per newspaper	Per geographic region
Midwest	*Correio Braziliense*	92	92
Northeast	*Diário de Pernambuco*	16	72
	O Estado	27	
	O Povo	29	
North	*Em Tempo*	27	51
	O Rio Branco	24	
Southeast	*Estadão*	122	122
South	*O Sul*	134	134
Total			471

Source: Elaborated by the authors.

Qualitative data analysis

We have subjected the 471 reports—namely qualitative data—to content analysis in a quantitative approach; according to Neuendorf (2002, p. 44), its "goal is a numerically based summary of a chosen message set." Each unit of sampling could have one or more text units. These units were classified simultaneously into categories of three different themes, namely, "geographic regions", "regional innovation ecosystem actors", and "initial actions to combat COVID-19", and were quantified according to their frequency of occurrence.

In the cross-matrix between "geographic regions" and "regional innovation ecosystem actors," 570 text units were found simultaneously to these themes. Regarding the "initial actions to combat COVID-19" theme, 600 text units related to their categories were found. Classification into themes was based on a combination of manifest (directly observable in the information) and latent coding (underlying the phenomenon), according to Neuman (2013).

We have adopted the official geographic division of the Brazilian territory into North, Northeast, Midwest, Southeast, and South as categories of the geographic regions' theme. Concerning the theme "regional innovation ecosystem actors", we have adopted the quadruple helix model with the categories "government," "industry", "society", and "university" (Carayannis & Rakhmatullin, 2014). The categories pertaining to the "initial actions to combat COVID-19" theme were developed using an emergent-coding scheme based on qualitative data content analysis. The categories belonging to these three themes are mutually exclusive because there was only one appropriate code for each coded case (Neuendorf, 2002).

It is worth making additional observations regarding the "initial actions to combat COVID-19" theme. Based on Braun and Clarke (2006), we have conducted six steps: i)

exploratory reading of data; ii) generating initial codes, summarizing raw data; iii) searching for broader level categories; iv) reviewing categories; v) defining and naming categories (as well as writing and rewriting a codebook in our study); and vi) producing the report (our last opportunity to analyze data). It was a recursive process whose steps "iv" and "v," in particular, were frequently reviewed to achieve the intercoder reliability mentioned in the next section.

Reliability

We have developed codebooks applying theory-driven codes to the theme "regional innovation ecosystem actors" and data-driven codes to the theme "initial actions to combat COVID-19." The data-driven codes were developed in successive stages, in a circular fashion, according to the reports' reading and analysis. Faced with text excerpts that could be classified in more than one code, we have reconstructed the set of codes to make them conform to the criterion of mutual exclusion or non-redundancy of categories. The main strategies used in this stage of data-driven codes were the creation of codes to contain text excerpts that could not be classified in the existing ones and the flexibility of existing codes to cover them.

To verify the reliability of the coding, we have used simple random samples with 70 different reports selected through the random number table in each circular process of coding (DeCuir-Gunby et al., 2011). Intercoder reliability was calculated with the Krippendorff alpha test (Krippendorff, 2010) using the ReCal 3 tool (Freelon, 2010). After four rounds of testing and adjusting the codebooks with simple random samples, an intercoder reliability of .83 was achieved. Table 2 shows the final codebook versions, elaborated according to the layout of DeCuir-Gunby et al. (2011).

Table 2

Sample Theory-Driven Codes and Sample Data-Driven Codes, definitions, and examples

Code	Description	Example
Theme: "Regional innovation ecosystem actors" (Theory-Driven Codes)		
Government	It refers to political and legal capital (norms, laws, plans, and programs) and is related to how the government defines, organizes, and manages general conditions.	"The State Government issued a new decree establishing that in-person classes must remain suspended in all public and private teaching units, including colleges and universities."
Industry	It refers to economic capital (machinery, production, entrepreneurship, technology, and financial capital) and is represented by industries, companies, and banks.	"The company informed that it will donate 3 million liters of gasoline and diesel to contribute to the fight against the coronavirus. The fuel will supply public ambulances and hospitals, increasing the agility of patient care."
University	It refers to human capital (students, professors, scientists, and researchers) inserted in the educational system.	"The Health Research Institute will start carrying out COVID-19 diagnoses. The university space will have the capacity to carry out up to 50 daily tests, using the RT-PCR method."
Society	It refers to social and civic capital (culture, tradition, and values) as well as information capital (media, communication, and social networks).	"Almost 2 thousand people have already volunteered to work in the fight against the COVID-19 epidemic."
Theme: "Initial actions to combat COVID-19" (Data-Driven Codes)		
Hospital infrastructure expansion	It refers to the creation of new spaces to receive patients infected by COVID-19, such as intensive care unit beds, field hospitals, and mobile health units.	"The Emergency Room, called the Red Room, will have one more space to assist people who eventually arrive in serious condition due to COVID-19 contamination. The space will serve to assist victims in critical condition."
Physical resources	It refers to the production or distribution of physical resources for the prevention of COVID-19, as well as the physical resources used to treat symptoms of COVID-19.	"The Department of Transport and Mobility has already distributed more than 90,700 face masks for individual protection to users of public transport."
Testing and diagnosis	It refers to testing and diagnosing COVID-19, monitoring infected people, and controlling new cases.	"The expansion of COVID-19 testing with a daily application of up to 580 tests, which will qualify the investigation about the pandemic extent in the capital."
Preventive measures	It refers to coercive measures for preventing COVID-19 contagion, such as laws requiring the use of personal protective equipment and laws restricting social mobility.	"The government keeps classes suspended in schools and universities."
Assistance, guidance, and awareness	It refers to non-coercive measures for preventing COVID-19 contagion, such as educational actions to raise awareness of preventive care against COVID-19.	"A citizen created a COVID-19 electronic game whose strategies were based on guidelines from international health authorities such as the WHO."
Research and development	It refers to scientific research and the development of technology aimed at the prevention and treatment of COVID-19.	"The company created an artificial intelligence algorithm to detect COVID-19 through imaging tests."
Workforce provision	It refers to the hiring and training of health professionals to work to combat the COVID-19 pandemic.	"The government will increase the hiring of health professionals to meet the demand for new cases of COVID-19 and also request universities to anticipate the graduation of medical students in their courses' final stages."

Source: Elaborated by the authors.

Quantitative analysis of categorical data

After the content analysis reliability test, we have used the multivariate and exploratory statistical technique of simple correspondence analysis, through the symmetric normalization method. Our goal was to verify possible links between the categorical variables "geographic regions" and "actors of the innovation ecosystem". All assumptions for the application of the simple correspondence analysis technique, which can be found in Doey and Kurta (2011), were met. Supported by the SPSS program, we used the following criteria for analysis: two dimensions in solution, chi-square as a measure of distance, and symmetrical as a standardization method. We justify the use of the chi-square distance, as it is "the key to many favorable properties of correspondence analysis" (Greenacre, 2007, p. 25), in addition to complying with the principle of distributive equivalence.

Findings and discussion

Despite the role of many actors in the innovation ecosystem in combating COVID-19 (Park et al., 2021), our results have not shown the presence of the environment helix in the initial actions to fight the pandemic in the Brazilian context—although this helix is pointed out as necessary for the socio-ecological transition of society and economy in the 21st century (Carayannis & Campbell, 2012). From this perspective, the natural environments in society and the economy are also seen as drivers of production and innovation, thus defining opportunities for the knowledge economy (Carayannis & Campbell, 2012), which was not evidenced in the reports collected on the initial actions to combat COVID-19 in Brazil.

Hence, in this section, we present results and discussions based on the performance of the actors: (i) government, (ii) industry, (iii) university, and (iv) society. The contingency table (Table 3) presents the values of the cross-tabulation between the categorical variables "geographic regions" (first column) and "regional innovation ecosystem actors" (first row), resulting from the quantification of the content analysis encodings.

Table 3

Contingency table of cross-tabulation between categorical variables

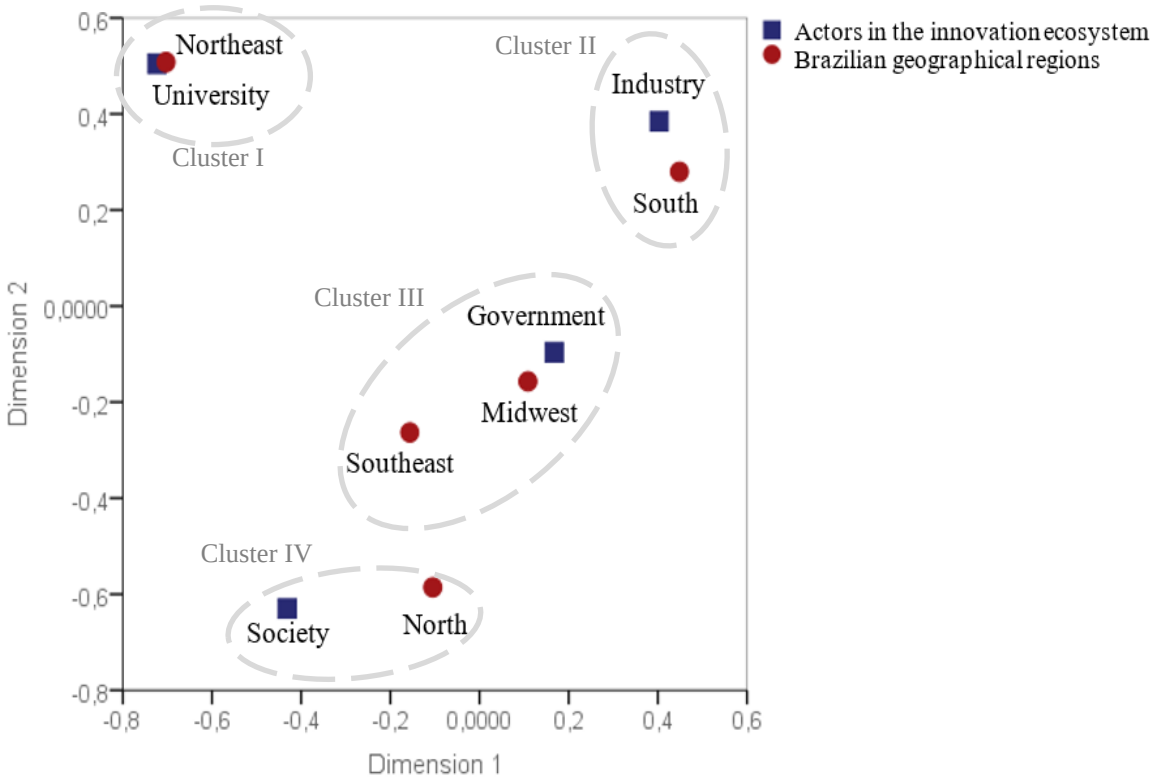
Brazilian geographic regions	Innovation ecosystem actors				
	Government	Industry	University	Society	Total
Midwest	63	15	13	13	104
Northeast	38	13	21	11	83
North	30	9	6	12	57
Southeast	88	20	22	24	154
South	99	38	20	15	172
Total	318	95	82	75	570

Source: Elaborated by the authors.

A chi-square test was performed to verify the independence between these two categorical variables through the null hypothesis (H_0: there is no correspondence between the categorical variables) and the alternative hypothesis test (H_1: there is a correspondence between the categorical variables). The results revealed the rejection of the null hypothesis. The chi-square value (χ^2: 21.475, d.f. 12) is statistically significant (p-value 0.044), which allows us to accept the alternative hypothesis of correspondence between the categorical variables. In order to explore how this correspondence occurs, our analysis was based on a graphic illustration (Figure 1) known as “perceptual map” (Greenacre, 2007).

Figure 1

Perceptual map between the categorical variables "Brazilian geographic regions" and "Innovation ecosystem actors"



Source: Elaborated by the authors.

According to the perceptual map, it is possible to identify four distinct clusters, considering the code disposition of the categorical variables "Brazilian geographic regions" and "Innovation ecosystem actors." The links suggested by the correspondence analysis are: Northeast and University (Cluster I); South and Industry (Cluster II); Southeast, Midwest, and Government (Cluster III); and North and Society (Cluster IV).

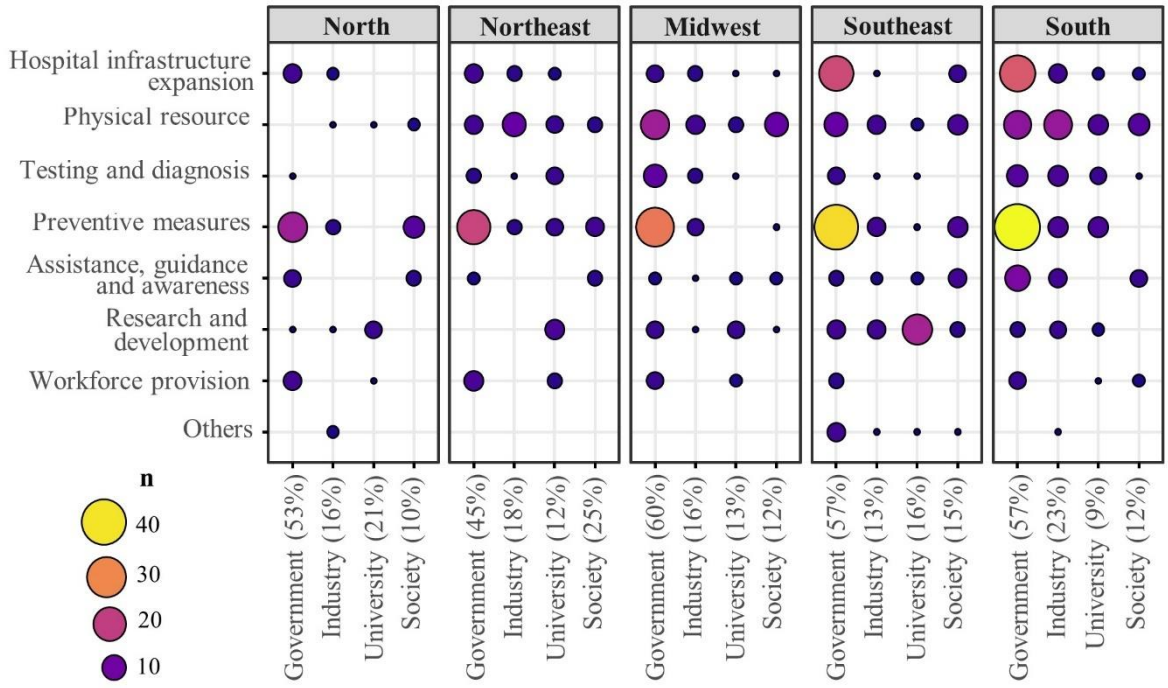
The accumulated data reveals that the most significant role in the entire national territory was played by the actor *government* (55.35%). In most actions, the government faced COVID-19 mainly through the creation and issuance of legal instruments, which refers to the question guiding the study by Azerrat et al. (2021): "Governing is caring?". The actors *industry* (17.22%), *university* (14.38%), and *society* (13.04%) followed next. More than just quantifying the actions led by each actor in the innovation ecosystem model, it is important to qualify them.

Hence, Figure 2, elaborated through the R language, specifies the initial actions to combat COVID-19 carried out by these actors in their respective geographic regions and illustrates their frequency, considering data from the whole Brazilian scenario. Thus, frequency

is expressed both by size (the larger the diameter, the larger the action recurrence) and by color (the larger the recurrence, the warmer the colors in the heat map).

Figure 2

Balloon plot of the initial actions to fight COVID-19 in Brazil, by actor and region



Source: Elaborated by the authors.

According to the evidence found, Cluster I suggests that the initial COVID-19 fight in the Brazilian Northeast region was more strongly associated with the actor *university* (Figure 1), considering the entire national scenario (Figure 2). However, in absolute frequency, the performance of the actor *government* in this geographic region was the most recurrent one (45%), followed by university (25%), while the other actors presented a lower frequency of actions: industry (18%) and society (12%).

Although the South and Southeast regions presented higher frequencies of COVID-19 combat actions led by the actor *university*, in absolute terms, the Northeast region presented greater consistency in university performance (similarity in the circles' size) in almost all study categories (Figure 2). The Northeast region concentrates about 18% of Brazilian higher education institutions, second only to the Southeast region, with 49% (INEP, 2019).

In the Northeast region of Brazil, the main initial action to fight COVID-19 led by the actor *university* was related to research, development, and solution proposition. This is aligned

with the innovation ecosystem theoretical model, according to which the actor *university* is considered a source of entrepreneurship, innovation, research, and education (Etzkowitz & Zhou, 2017). Our analyses of the collected reports reinforce the findings of Rosa et al. (2021), who found that 14% of Brazilian research projects aimed at COVID-19 were concentrated in the Northeast region in the initial period of the pandemic. Also according to Rosa et al. (2021), in mid-May 2020, this percentage represented the second-highest in Brazil, only behind the Southeast region (56%).

Furthermore, in the Brazilian Northeast region, the university was the only actor that performed actions in the category "research, development, and solution proposition"—unlike other geographic regions, where at least three of the four actors were present in the referred category (Figure 2). Examples of actions led by universities within this category were: call for researchers to present solution proposals to combat COVID-19; financing of scientific research; approval of research by the national ethics committee on COVID-19 treatment protocol and the disease clinical severity among different groups; projections of the number of cases and deaths; and dissemination of scientific research results, for instance, on the factors influencing COVID-19 contagion in Fortaleza city.

In addition to these actions, the COVID-19 pandemic scenario has demanded other attributions from universities, turning them into multi-dimensional actors (Napolitano, 2020). According to this author, one of the new roles expected from universities has been civic engagement to deal with the consequences brought by COVID-19. Nonetheless, in our analyses, we have not identified combat actions led by universities in the Northeast region related to the category "assistance, guidance, and awareness of civil society".

Therefore, one may notice a misalignment. On the one hand, research actions stood out in this geographic region during the initial COVID-19 combat in Brazil. On the other hand, we have not identified university extension practices with the collected data, which is a means of interaction with social actors (Panizzon et al., 2020) linked to this category. Concerning the actions of other actors in the region, Pessoa et al. (2020) mention the Northeast Interstate Sustainable Development Consortium, which enabled, for instance, the synergistic implementation of public policies and political force in negotiating resources with the federal administration.

Cluster II suggests that the COVID-19 initial fight in the Southern region of Brazil was more strongly associated with the actor *industry*, considering the whole national scenario (Figure 1). We have found that 23% of all initial COVID-19 combat actions in the Southern

region, regardless of category, were led by this actor. This percentage was also the highest regarding the actor *industry* performance in other Brazilian regions, above the national average of 17%. Nevertheless, as in other geographic regions, the actor *government* also presented the highest absolute frequency of initial COVID-19 combat actions in the Southern region (57%). The actors with less frequent initial fight actions in this region were university (12%) and society (9%). The greater performance of the actor *industry* in the Southern region was also identified by Arruda and Ferreira (2014), even though the results found by these authors refer to a context before the consequences brought by the COVID-19 pandemic. Moreover, based on official data from the Brazilian government, the three states that comprise the Southern region were among the five Brazilian states with the lowest unemployment rate in November 2020 (Penna et al., 2020).

Although there is a higher frequency of actions related to physical resources provided by the actor *industry* in the Southern region of Brazil, this actor performed in all other initiatives—except in workforce provision. For instance, research, development, and solution proposition, such as the creation of decontamination equipment, COVID-19 tests with immediate detection, and the use of connectors to increase the number of outlets for respiratory equipment show this actor's contribution to the adaptation and production of new knowledge-based methodologies (Carayannis et al., 2018). Regarding workforce provision in the initial COVID-19 combat, although this was a typical action of the government and university actors (as shown in Figure 2), the actor *society* also performed in this initiative in the Southern geographic region. Workforce provision took place through voluntary work.

Cluster III suggests that the initial COVID-19 fight in the Midwest and Southeast regions of Brazil was more strongly associated with the actor *government*, considering the entire national scenario (Figure 1). In absolute frequency, the role of the actor *government* in the Midwest region was the most recurrent one (60%), followed by industry (16%), society (13%), and university (12%). In the Southeast region, a higher frequency of actions by the government was also identified (60%), but it was followed by the actors *university* (16%), *society* (15%), and *industry* (13%).

As shown in Figure 2, government actions were mostly focused on COVID-19 preventive measures. These actions took place mainly in the form of legal instruments determining, for instance, the use of protective equipment, the reduction or restriction of social mobility, and operating rules for commerce, classes, and cultural events. We assume that the government's role increases in times of national emergency as a means of accelerating the

innovation ecosystem, and, as a consequence, providing quick solutions to society's concerns (Carayannis & Campbell, 2010). This may occur, for instance, when the government acts as a source of contractual relations and a space for consensus to bring together relevant stakeholders to design and implement innovation projects (Carayannis & Campbell, 2010).

Nonetheless, the performance of the Brazilian governmental actor in the face of the COVID-19 crisis has been fragmented at different levels of administration (federal, state, and municipal) and institutionally dispersed amongst the powers (Executive, Legislative, and Judiciary), through conflicting and creative actions (Pinheiro et al., 2020). Once the present paper does not focus on the analysis of these conflicts, we highlight the actions taken by this actor as a whole, although we acknowledge divergences, misinformation, and lack of coordination in the fight against COVID-19 in Brazil (e.g., Lotta et al., 2021; Pinheiro et al., 2020).

Hence, it is worth highlighting some actions carried out by the actor *government*. Regarding hospital infrastructure expansion, the following actions can be mentioned, for instance: proposing the use of financial resources from traffic tickets for the construction of field hospitals; authorizing the use of a pledged hospital to create a COVID-19 specialized unit; and coordinating a joint action with industry and civil society to repair ventilators. Concerning research, development, and solution proposition, it is worth highlighting: the use of artificial intelligence to analyze infected patients' lungs; research on possible treatments for COVID-19; adoption of geolocation, in partnership with industries, to measure social distance; and launch of calls and financing notices.

According to Silva et al. (2020), despite the limited available resources, the research and development funding opportunities for actions to combat COVID-19 covered several areas of knowledge. Regarding workforce provision, it is worth mentioning the creation of a simulation center in a hospital, equipped with medical dummy mannequins that simulate breathing and heartbeat. Among the COVID-19 preventive measures, we mention the regulation of telemedicine, the adoption of home-office work in other areas to reduce contagion, and use of hotels to shelter the elderly or military professionals working to combat the pandemic.

Such results are consistent with innovations identified in the literature. Pinheiro et al. (2020) highlight the role of the Legislative Power, specifically the National Parliament, which adapted its activities to a remote deliberation system and, as a consequence, made decisions faster. Penna et al. (2020) highlight the National Household Sample Survey (*Pesquisa Nacional por Amostra de Domicílios* – PNAD), an instrument commonly used for health surveillance in

Brazil, as a tool for identifying, consolidating, and monitoring COVID-19 cases through telephone interviews.

Lastly, Cluster IV points out that the initial COVID-19 fight in the Northern region of Brazil was more strongly associated with the actor *society*, considering the whole national scenario (Figure 1). In absolute frequency, however, the performance of the actor *government* in this geographic region was the most recurrent one (53%), followed by society (21%), while the other actors presented a lower frequency of actions: industry (16%) and university (10%). The most recurrent role between government and society may be related to what Azerrat et al. (2021) found: the management models and vision that governments transmit in their messages and actions to society influence the number of new daily COVID-19 cases.

Hence, the role of the actor *society* in the Northern region may have been influenced by the initial COVID-19 combat behavior assumed by the region's local governments. According to our analyses, the main combat actions led by the actor *society* were related to assistance, guidance, and awareness of civil society; physical resources provision; and implementation of COVID-19 preventive measures. On the other hand, we have not found a recurrence of actions in this region aimed at identifying, consolidating, and monitoring cases.

Going beyond the triple helix model (Etzkowitz & Leydesdorff, 1995)—characterized by the performances of government, industry, and university, our analyses regarding the innovation ecosystem in the Northern region of Brazil in relation to COVID-19 fighting actions reinforce the theoretical approach of the quadruple helix (Carayannis & Campbell, 2009)—with the distinction of the actor *society* as a protagonist, not as a supporting actor.

According to Park et al. (2021), these initiatives performed by the actor *society* can be called "bottom-up solutions," as they originate from the periphery of traditional innovation ecosystems. According to Andion (2020), a prerequisite for the fourth helix preponderance (society) was the pandemic emergency situation, where there is a production of pulverized actions in the areas of social assistance and health support—especially for the most vulnerable populations and communities, a fact that is confirmed in this Brazilian region's context.

Although data from the present study do not allow inferences about the civic capital of the Brazilian geographic regions, we assume, based on results found by Lima et al. (2021), that the greater preponderance of the actor *society* in the Northern region can be explained by the absence of COVID-19 fighting actions led by other actors in the innovation ecosystem. Given this point, we highlight a paradox between our results and the quadruple helix model.

According to the model, the actor *society* sustains an institutional order that improves conditions to promote innovation (Carayannis et al., 2021) through individuals and groups that create organizations and movements—which may transcend institutional categories of the triple helix model (Etzkowitz & Zhou, 2017). On the one hand, the theoretical model assumes the performance of the fourth helix as a complementary force to the other helices in the innovation ecosystem (university, government, and industry). On the other hand, our results suggest that society acts almost alone in the Northern region of Brazil. In addition to being a region geographically distant from the country's major decision-making centers, it has historically presented lower social and quality of life indices than other Brazilian geographic regions (Mendonça et al., 2020).

Conclusions and future research

This paper aimed to analyze the initial COVID-19 combat in Brazil by the actors of the regional innovation ecosystem model, according to media reports. The motivation of this study was the need to verify how these actors performed in different Brazilian geographic regions. The geographically segmented analysis was motivated by the fact that Brazilian regions are heterogeneous in socioeconomic terms (IBGE, 2020b). We reached the paper's purpose from documentary research with web scraping, content analysis, codebook, intercoder testing, and correspondence analysis with perceptual mapping. When combined, these adopted procedures comprise a desired methodological contribution.

From our findings in absolute frequency, the *government* was the leading actor in all Brazilian geographic regions, responsible for more than half of the initial actions against COVID-19, followed by the actor *industry*. The preponderance of these two actors alludes to the classic government-industry dyadic interactions aimed at innovation and entrepreneurship, which preceded the proposition of the more complex triple helix model, also involving *university* (Etzkowitz & Zhou, 2017). As expected, based on the literature (Belenzon & Schankerman, 2009; Borges et al., 2020; Kolympiris & Klein, 1996), *university* was the actor with the third-highest frequency of COVID-19 initial combat actions, followed by the actor *society*.

According to the analyzed reports, we have not found empirical evidence for the actor *environment*, which did not allow us to address the quintuple helix. The other actors (government, university, industry, and civil society) are expected to take a proactive stance toward the creation, production, application, diffusion, and use of knowledge and innovation in

confronting the pandemic. All these elements are involved in the aspirations of sustainable development, conceptually relating knowledge and innovation to the environment (Carayannis & Campbell, 2010).

From a panoramic perspective, considering the actions relatively distributed throughout the Brazilian scenario, the correspondence analysis made between the categorical variables "geographic region" and "innovation ecosystem actors" revealed statistical significance. Based on this, the evidence found suggests that the COVID-19 initial combat in Brazil does not have a protagonist, as a joint analysis of all regions would suggest. In the richer regions—taking into consideration the Gross Domestic Product (GDP)—and with higher quality of life indices, such as the Human Development Index (HDI), the most active actors in relative terms regarding the entire national scenario were the *government* and the *industry*. On the other hand, in poorer regions and with lower quality of life indices, the actors *university* and *society* stood out.

Hence, we suggest that the role of innovation ecosystem actors in fighting the COVID-19 pandemic takes place unequally amongst the different regions, as well as that the helix ordering is related to the theoretical development process, not to the complementarity of these actors' actions. In practice, this paper draws attention to the need to manage the actions of the innovation ecosystem actors in an integrated way in a pandemic initial combat, thus avoiding the absence or scarcity of actions in some regions, especially those with lower wealth and quality of life levels.

Lastly, it is worth mentioning some study limitations and suggestions for future research. First, the fact that certain COVID-19 combat actions were not identified in some geographic regions does not mean that the actors have taken no action in a definite and absolute way—even though we used as data source for our analyses, reports from newspapers of large local and regional circulation in Brazil. Another limitation is related to the fact that we have not explored government levels (federal, state, and municipal). In addition to considering these levels, future studies may apply the method adopted in other countries to reinforce or contrast our findings. Another promising possibility would be to complement the analysis of combat actions with the COVID-19 regional consequences. Future research may also consider actions related to the United Nations' Sustainable Development Goals (SDGs) and its corresponding responsible actors. Moreover, the methodological procedures used in this paper may be applied to different research goals.

Authors' contributions

Contribution	Miranda Jr., N. S.	Viana, L. F. C.	Carneiro, D. K. de O.	Filgueiras, R. C.	Goulart, G. da S.
Conceptualization	X	–	–	–	–
Methodology	X	X	–	–	–
Software	–	–	–	–	–
Validation	X	X	–	–	–
Formal analysis	X	X	–	–	–
Investigation	X	X	X	–	–
Resources	X	X	X	X	X
Data curation	X	X	X	X	X
Writing – original draft	X	X	X	–	–
Writing – review & editing	X	X	X	–	–
Visualization	X	X	–	–	–
Supervision	X	–	–	–	–
Project administration	X	X	X	–	–
Funding acquisition	–	–	–	–	–

References

Adner, R. (2006). Match your innovation strategy to your innovation ecosystem. *Harvard Business Review*, *84*(4), 98.

Adner, R., & Kapoor, R. (2010). Value creation in innovation ecosystems: how the structure of technological interdependence affects firm performance in new technology generations. *Strategic Management Journal*, *31*(3), 306-333. https://doi.org/10.1002/smj.821

Andion, C. (2020). Atuação da sociedade civil no enfrentamento dos efeitos da COVID-19 no Brasil. *Revista de Administração Pública*, *54*(4), 936–951. https://doi.org/10.1590/0034-761220200199

Arruda, E. F., & Ferreira, R. T. (2014). Dinâmica intrarregional do Brasil: Quem dirige o crescimento industrial das regiões brasileiras? *Economia Aplicada*, *18*(2), 243–270. https://doi.org/10.1590/1413-8050/ea404

Asheim, B. T., & Gertler, M. S. (2005). The geography of innovation: regional innovation systems. In *The Oxford handbook of innovation*.

Astley, W. G., & Fombrun, C. J. (1983). Collective strategy: social ecology of organizational environments. *Academy of Management Review*, *8*(4), 576-587. https://doi.org/10.5465/amr.1983.4284657

Azerrat, J. M., Ratto, M. C., & Fantozzi, A. (2021). ¿Gobernar es cuidar? Los estilos de gestión de la Pandemia en América del Sur: los casos de Argentina, Brasil y Uruguay. *Trabajo y Sociedad*, *21*(36), 146–173. http://www.scielo.org.ar/pdf/tys/v21n36/1514-6871-tys-21-36-146.pdf

Azoulay, P., & Jones, B. (2020). Beat COVID-19 through innovation. *Science*, *368*(6491), 553. https://doi.org/10.1126/science.abc5792

Belenzon, S., & Mark Schankerman. (2009). University knowledge transfer: Private ownership, incentives, and local development objectives. *Journal of Law and Economics*, *52*(1), 111–144. https://doi.org/10.1086/595763

Bogers, M., Sims, J., & West, J. (2019). What Is an Ecosystem? Incorporating 25 Years of Ecosystem Research. *Academy of Management Proceedings*, *2019*(1), 11080. https://doi.org/10.5465/ambpp.2019.11080abstract

Borges, P. de A., Araújo, L. P., Lima, L. A., Ghesti, G. F., & Carmo, T. S. (2020). The triple helix model and intellectual property: The case of the University of Brasilia. *World Patent Information*, *60*(October 2019), 101945. https://doi.org/10.1016/j.wpi.2019.101945

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101.

Butzin, A., & Terstriep, J. (2018). Actors and roles in Social Innovation. In *Atlas of Social Innovation. New Practices for a Better Future*.

Carayannis, E. G., & Campbell, D. F. J. (2009). "Mode 3" and "Quadruple Helix": Toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management*, *46*(3–4), 201–234. https://doi.org/10.1504/ijtm.2009.023374

Carayannis, E. G., & Campbell, D. F. J. (2010). Triple helix, quadruple helix and quintuple helix and how do knowledge, innovation and the environment relate to each other? *International Journal of Social Ecology and Sustainable Development*, *1*(1), 41–69. https://doi.org/10.4018/jsesd.2010010105

Carayannis, E. G., & Campbell, D. F. J. (2012). *Mode 3 knowledge production in quadruple helix innovation systems: Twenty-first-century democracy, innovation, and entrepreneurship for development*. Springer. https://doi.org/10.1007/978-88-470-2658-2

Carayannis, E. G., Dezi, L., Gregori, G., & Calo, E. (2021). Smart Environments and Techno-centric and Human-Centric Innovations for Industry and Society 5.0: A Quintuple Helix Innovation System View Towards Smart, Sustainable, and Inclusive Solutions. *Journal of the Knowledge Economy*. https://doi.org/10.1007/s13132-021-00763-4

Carayannis, Grigoroudis, E., Campbell, D. F. J., Meissner, D., & Stamati, D. (2018). The ecosystem as helix: an exploratory theory-building study of regional co-opetitive entrepreneurial ecosystems as Quadruple/Quintuple Helix Innovation Models. *R and D Management*, *48*(1), 148–162. https://doi.org/10.1111/radm.12300

Carayannis, E. G., & Rakhmatullin, R. (2014). The Quadruple/Quintuple Innovation Helixes and Smart Specialisation Strategies for Sustainable and Inclusive Growth in Europe and Beyond. *Journal of the Knowledge Economy*, *5*(2), 212–239. https://doi.org/10.1007/s13132-014-0185-8

Caswell, D., & Dörr, K. (2019). Automating complex news stories by capturing news events as data. *Journalism Practice*, *13*(8), 951–955. https://doi.org/10.1080/17512786.2019.1643251

Cavallini, S., Soldi, R., Friedl, J., & Volpe, M. (2016). *Using the Quadruple Helix Approach to Accelerate the Transfer of Research and Innovation Results to Regional Growth*. https://doi.org/10.2863/408040

Charmaz, K. (2014). Gathering Rich Data - Documents as Data. In *Constructing Grounded Theory* (2nd ed., p. 746). SAGE Publications Ltd.

Deakin, M., Mora, L., & Reid, A. (2018). The research and innovation of Smart Specialisation Strategies: The transition from the Triple to Quadruple Helix. *Economic and Social Development: Book …*, *January*. https://www.academia.edu/download/55986336/Book_of_Proceedings_esd_Rome_2018_Online.pdf#page=105

DeCuir-Gunby, J. T., Marshall, P. L., & McCulloch, A. W. (2011). Developing and using a codebook for the analysis of interview data: An example from a professional development research project. *Field Methods*, *23*(2), 136–155. https://doi.org/10.1177/1525822X10388468

Doey, L., & Kurta, J. (2011). Correspondence Analysis applied to psychological research. *Tutorials in Quantitative Methods for Psychology*, *7*(1), 5–14. https://doi.org/10.20982/tqmp.07.1.p005

Doloreux, D., & Gomez, I. P. (2017). A review of (almost) 20 years of regional innovation systems research. *European Planning Studies*, *25*(3), 371–387. https://doi.org/10.1080/09654313.2016.1244516

Etzkowitz, H., & Leydesdorff, L. (1995). the Triple Helix---University-Industry-Government Relations: a Laboratory for Knowledge Based Economic Development. *EASST Review*, *14*(1), 14–19. http://ssrn.com/abstract=2480085

Etzkowitz, H., & Zhou, C. (2017). Hélice Tríplice: inovação e empreendedorismo universidade-indústria-governo. *Dicionário Crítico de Migrações Internacionais*, *31*(90), 273–278. https://doi.org/10.7476/9788523013400.0005.02

Flick, U. (2009). An introduction to qualitative research. In *SAGE Publications* (4th ed.). SAGE Publications Ltda.

Foguesatto, C. R., Santini, M. A. F., Martins, B. V., Faccin, K., De Mello, S. F., & Balestrin, A. (2021). What is going on recently in the innovation ecosystem field? A bibliometric and content-based analysis. *International Journal of Innovation Management*, *25*(07), 2130001. https://doi.org/10.1142/S1363919621300014

Freelon, D. G. (2010). ReCal : Intercoder Reliability Calculation as a Web Service. *International Journal of Internet Science*, *5*(1), 20–33.

Freeman. (1989). *Technology, Policy, and Economic Performance: Lessons from Japan.* Printer Publishers.

Gawer, A., & Cusumano, M. A. (2014). Industry platforms and ecosystem innovation. *Journal of product innovation management*, *31*(3), 417-433. https://doi.org/10.1111/jpim.12105

Gomes, L. A. V., Facin, A. L. F., Salerno, M. S., & Ikenami, R. K. (2018). Unpacking the innovation ecosystem construct: evolution, gaps and trends. *Technological Forecasting and Social Change*, *136*, 30-48. https://doi.org/10.1016/j.techfore.2016.11.009

Granstrand, O., & Holgersson, M. (2020). Innovation ecosystems: A conceptual review and a new definition. *Technovation*, *90–91*(June 2018). https://doi.org/10.1016/j.technovation.2019.102098

Greenacre, M. (2007). Correspondence Analysis in practice. In *Correspondence Analysis in Practice, Third Edition* (3rd ed.). Taylor & Francis Group. https://doi.org/10.1201/9781315369983

Howaldt, J., Kaletka, C., & Schroder, A. (2016). Social Entrepreneurs: Important Actors within an Ecosystem of Social Innovation. *European Public & Social Innovation Review*, *1*(2). https://doi.org/10.31637/epsir.16-2.4

IBGE. (2020a). *Divisão Regional do Brasil*. Instituto Brasileiro de Geografia e Estatística. https://www.ibge.gov.br/geociencias/organizacao-do-territorio/divisao-regional/15778-divisoes-regionais-do-brasil.html?=&t=o-que-e

IBGE. (2020b). *Síntese de Indicadores Sociais: uma análise das condições de vida da população brasileira. Rio de Janeiro*. Coordenação de População e Indicadores Sociais. https://www.ibge.gov.br/estatisticas/sociais/populacao/9221-sintese-de-indicadores-sociais.html?edicao=29143&t=downloads

INEP. (2019). Censo da Educação Superior - Notas Estatísticas. In *Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira*. https://download.inep.gov.br/educacao_superior/censo_superior/documentos/2020/Notas_Estatisticas_Censo_da_Educacao_Superior_2019.pdf

Ivanova, I. (2014). Quadruple Helix Systems and Symmetry: A Step Towards Helix Innovation System Classification. *Journal of the Knowledge Economy*, *5*(2), 357–369. https://doi.org/10.1007/s13132-014-0201-z

Kamradt-Scott, A. (2009). The WHO and SARS: The challenge of innovative responses to global health security. In A. F. Cooper & J. J. Kirton (Eds.), *Innovation in Global Health Governance* (pp. 81–98). Ashgate Publishing Group.

Kapoor, R., & Lee, J. M. (2013). Coordinating and competing in ecosystems: how organizational forms shape new technology investments. *Strategic management journal*, *34*(3), 274-296.. https://doi.org/10.1002/smj.2010

Kolympiris, C., & Klein, P. G. (1996). The Effects of Academic Incubators on University Innovation. *Strategic Entrepreneurship Journal*, *13*(3), 287–288. https://doi.org/10.1016/s0740-5472(96)90021-5

Krippendorff, K. (2010). Content Analysis: An Introduction to Its Methodology (2nd ed.). In *SAGE Publications* (2nd ed.). SAGE Publications.

Lima, E. E. C. de, Gayawan, E., Baptista, E. A., & Queiroz, B. L. (2021). Spatial pattern of COVID-19 deaths and infections in small areas of Brazil. *PLoS ONE*, *16*(2), 1–12. https://doi.org/https://doi.org/10.1371/journal.pone.0246808

Lotta, G., Coelho, V. S. P., & Brage, E. (2021). How COVID-19 Has Affected Frontline Workers in Brazil: A Comparative Analysis of Nurses and Community Health Workers. *Journal of Comparative Policy Analysis: Research and Practice*, *23*(1), 63–73. https://doi.org/10.1080/13876988.2020.1834857

Lundvall, B. A. (1992). National systems of innovation: towards a theory of innovation and interactive learning.

Mendonça, F. D., Rocha, S. S., Pinheiro, D. L. P., & Oliveira, S. V. de. (2020). North region of Brazil and the COVID-19 pandemic: socioeconomic and epidemiologic analysis. *Journal Health NPEPS*, *5*(1), 20–37. https://doi.org/10.30681/252610104535

Miller, K., McAdam, R., & McAdam, M. (2018). A systematic literature review of university technology transfer from a quadruple helix perspective: toward a research agenda. *R&D Management*, *48*(1), 7–24. https://doi.org/10.1111/radm.12228

Moore, J. F. (1993). Predators and prey: a new ecology of competition. *Harvard business review*, *71*(3), 75-86.

Moore, J. F. (1996). The death of competition: leadership and strategy in the age of business ecosystems. *Leadership*.

Moore, J. F. (1998). The rise of a new corporate form. *Washington quarterly*, *21*(1), 167-181.

Nambisan, S., & Baron, R. A. (2013). Entrepreneurship in innovation ecosystems: entrepreneurs' self-regulatory processes and their implications for new venture success. *Entrepreneurship theory and practice*, *37*(5), 1071-1097. https://doi.org/10.1111/j.1540-6520.2012.00519.x

Napolitano, M. R. (2020). The university as a catalyst of relationship for enhancing territorial capital. *Capitale Culturale - Studies on the Value of Cultural Heritage*, *11*(1), 143–156. https://doi.org/10.13138/2039-2362/2535

Nelson, R. R., & Winter, S. G. (1982). The Schumpeterian tradeoff revisited. *The American Economic Review*, *72*(1), 114-132. https://www.jstor.org/stable/1808579

Neuendorf, K. (2002). *The content analysis guidebook*. SAGE Publications.

Neuman, L. (2013). Social Research Methods: Qualitative and Quantitative Approaches. In *Pearson*. Pearson Education Limited. https://doi.org/10.2307/3211488

Oh, D. S., Phillips, F., Park, S., & Lee, E. (2016). Innovation ecosystems: A critical examination. *Technovation*, *54*, 1-6. https://doi.org/10.1016/j.technovation.2016.02.004

OPS. (1980). *Resoluciones de la 33a Asamblea Mundial de la Salud de Interes para el Comite Regional*. Organización Panamericana de la Salud. http://hist.library.paho.org/Spanish/GOV/CD/25210.pdf

Overholm, H. (2015). Collectively created opportunities in emerging ecosystems: the case of solar service ventures. *Technovation*, *39*, 14-25. https://doi.org/10.1016/j.technovation.2014.01.008

PAHO. (1960). Second International Conference on Live Poliovirus Vaccines. In *Pan American Health Organization* (Vol. 50, p. 552). Pan American Health Organization. https://doi.org/10.4269/ajtmh.1960.9.467

Panizzon, M., Costa, C. F. da, & Medeiros, I. B. de O. (2020). Práticas das universidades federais no combate à COVID-19: a relação entre investimento público e capacidade de implementação. *Revista de Administração Pública*, *54*(4), 635–649. https://doi.org/10.1590/0034-761220200378

Park, H., Lee, M., & Ahn, J. M. (2021). Bottom-up solutions in a time of crisis: the case of COVID-19 in South Korea. *R&D Management*, *51*(2), 211–222. https://doi.org/10.1111/radm.12449

Penna, G. O., Silva, J. A. A. da, Neto, J. C., Temporão, J. G., & Pinto, L. F. (2020). PNAD COVID-19: A powerful new tool for public health surveillance in Brazil. *Ciência & Saúde Coletiva*, *25*(9), 3567–3571. https://doi.org/10.1590/1413-81232020259.24002020

Pessoa, Z. S., Teixeira, R. L. P., & Clementino, M. do L. M. (2020). Interfaces between vulnerabilities, governance, innovation and capacity of response to COVID-19 in Brazilian Northeast. *Ambiente e Sociedade*, *23*, 1–15. https://doi.org/10.1590/1809-4422ASOC20200110VU2020L3ID

Pinheiro, V. M., Ilarraz, M., & Mestriner, M. T. (2020). The impacts of the COVID-19 crisis on the Brazilian legal system–a report on the functioning of the branches of the government and on the legal scrutiny of their activities. *Theory and Practice of Legislation*, *0*(0), 193–212. https://doi.org/10.1080/20508840.2020.1790104

Ritala, P., & Almpanopoulou, A. (2017). In defense of 'eco'in innovation ecosystem. *Technovation*, *60*, 39-42. https://doi.org/10.1016/j.technovation.2017.01.004

Rosa, M. F. F., da Silva, E. N., Pacheco, C., Diógenes, M. V. P., Millett, C., Gadelha, C. A. G., & Santos, L. M. P. (2021). Direct from the COVID-19 crisis: research and innovation sparks in Brazil. *Health Research Policy and Systems*, *19*(1), 1–7. https://doi.org/10.1186/s12961-020-00674-x

Rothschild, M. L. (1990). *Bionomics: the inevitability of capitalism*. New York: Henry Holt.

Saldaña, J. (2013). The Coding Manual for Qualitative Researchers. In J. Seaman (Ed.), *SAGE Publications Inc.* (Second Edi). SAGE Publications. https://doi.org/10.1017/CBO9781107415324.004

Schön, D. A. (1984). *The reflective practitioner: how professionals think in action.* 5126. London: Basic Books.

Silva, R. M. da, Caetano, R., Silva, A. B., Guedes, A. C. C. M., Ribeiro, G. D. R., Santos, D. L., & Paiva, C. C. N. de. (2020). Perfil e financiamento da pesquisa em saúde desencadeada pela pandemia da COVID-19 no Brasil. *Vigilância Sanitária Em Debate*, *8*(2), 28–38. https://doi.org/10.22239/2317-269x.01579

Thomas, L. D., & Autio, E. (2020). Innovation ecosystems in management: An organizing typology. In *Oxford Research Encyclopedia of Business and Management*.

Thomas, E., Faccin, K., & Asheim, B. T. (2021). Universities as orchestrators of the development of regional innovation ecosystems in emerging economies. *Growth and change*, *52*(2), 770-789. https://doi.org/10.1111/grow.12442

Yawson, R. M. (2012). The Ecological System of Innovation: A New Architectural Framework for a Functional Evidence-Based Platform for Science and Innovation Policy. *SSRN Electronic Journal*, 1–16. https://doi.org/10.2139/ssrn.1417676