Entrepreneurial orientation in joint projects in time of COVID-19 crisis: a fuzzy set QCA approach in Brazil.

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Abstract

This research explores the configurations of innovation practices ("recipes") that were at work for open innovation project developers during the first part of the COVID-19 pandemic crisis. Using a sample of 13 Brazilian projects, the research uses fuzzy qualitative comparative analysis (Fs-QCA) to identify how the three innovation practices - causation, effectuation, and bricolage - combined during the process. A context variable is added: the presence or lack of collaboration with the academic research community. The analyses identify two recipes for innovation success, both of which include a high level of effectuation. Depending on whether or not research is involved, a variant occurs: in the positive case it is causation that combines, whereas in the absence of research partnerships it is bricolage that is at work. This counter-intuitive result leads us to question from a new angle the mode of research collaboration in a crisis context where resilience is the objective.

Keywords : COVID-19, Brazil, Innovation, Fs-QCA, Research

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INTRODUCTION

Since the beginning of 2020, the global pandemic of COVID-19 has been causing organizations of all kinds to experience disruptions where uncertainty has taken precedence over risk. It is certainly the major event of the year 2020 that could be considered *"a Once-in-a-Century Pandemic"* (Gates, 2020), producing some of the most deleterious economic effects since the Great Depression[1] that have effects on consumer behavior, markets and education with lasting effects (Donthu & Gustafsson, 2020). These effects of the COVID-19 pandemic then challenge also organizations in the strategies to be implemented to best manage the crisis. One can highlight in the academic literature four strategic responses to a corporate crisis (Wenzel et al., 2020): retrenchment, perseverance, innovation, and exit. Under the pressure of a probable impossible return to a previous order and the constraints of the irrevocable traces that will be produced, innovation is perhaps the most non-natural response. But because crises trigger a way of thinking that allows managers and employees to transcend the limits of what they believe to be thinkable and feasible, innovating is certainly the most interesting strategic response.

If the choice of innovation is made, it is then interesting for researchers to question the practices that have been implemented by entrepreneurs especially when they are of the open type *i.e.*, based on sharing and collaboration between stakeholders; we speak then of open innovation (Chesbrough, 2003). If we know the list of possible innovation practices for conducting an entrepreneurial and/or innovation project (causation, effectuation, bricolage), and assuming that, in a context of crisis, there is no time to develop new practices, we do not know the final "recipe" that led to the

[1] *"The Great Lockdown: Worst Economic Downturn Since the Great Depression"* (April 14, 2020) by Gita Gopinath available at https://blogs.imf.org/2020/04/14/the-great-lockdown-worst-economic-downturn-since-the-great-depression/

emergence of an innovation project. For several years now, a major concern of governments has been to involve universities in collaborations with businesses in order to maximize and optimize the production of knowledge and thus potential future innovations (Henry Etzkowitz, 2002; Leydesdorff & Etzkowitz, 1996, 1998). We were then interested in whether, in the context of the COVID-19 crisis, working with universities and research institutions has made a difference. In other words, can this context variable (presence or not of research institutions in the innovation project) change something to the results in the practices implemented? The objective of this research will therefore be to answer the question:

what is the combination of practices and/or behaviors that lead to open innovation during a period of crisis such as that of COVID-19?

Some countries have been particularly affected by the crisis because of the political management choices they have made. In this case, Brazil can be considered as an extreme case, even if many open innovation initiatives were launched during this period, which makes it a particularly interesting and relevant field of research. Thus, we have two distinct issues that will be analyzed throughout the article, the combination of practices and behaviors that lead to open innovation during the Covid-19 period in Brazil; and the question of the role of research and the researcher in this context.

Following a review of the literature to identify theoretical contributions and gaps in research, we present the fuzzy-set Qualitative Comparative Analysis (Fs-QCA) method used. Developed in political science by Ragin (1987) in order to conduct a systematic analysis of an intermediate number of cases, this method combines the advantages of qualitative and quantitative methods and makes it possible to highlight several explanations for the phenomenon under study by identifying minimal combinations of sufficient causes.

We then present and discuss the results obtained for the study of 13 cases of open innovation projects in Brazil during the first months of the COVID-19 pandemic, whether or not involving collaborations with universities and research institutions. Finally, it discusses the results obtained and proposes in conclusions the limits and perspectives that this research supposes, as well as some managerial implications.

1. LITTERATURE REVIEW

In order to investigate the combination of innovation practices adopted in open innovation projects (U-I) at the beginning of the Covid-19 pandemic crisis, we divided the literature review into two topics. The first presents the practices of causation, effectuation, and bricolage, and the second evokes the theoretical framework relative to university-industry collaborations.

1.1 CAUSATION, EFFECTUATION AND BRICOLAGE

Entrepreneurial or innovation processes can follow two distinct and alternative logics: causation and effectuation (Sarasvathy, 2001). The first is the result of strategic planning, while the second is the result of an emerging strategy, taking into account the acceptability of losses, flexibility and experimentation. In the causal approach, the manager builds a sustainable competitive advantage by matching a set of present and known resources with an existing market opportunity. As *"causation processes take a particular effect as given and focus on selecting between means to create that effect"* (Sarasvathy, 2001, p. 245), the objectives are then clearly defined at the beginning of the process and the opportunities selected are those that maximize the final return in a logic of control of the achievement of predictable results. But the problem is not the same when the entrepreneur is subjected to an uncertain environment because, as Sarasvathy (2008, p. 69) questions: *"So the question is not whether an entrepreneur acts rationally or not, but how can an entrepreneur act rationally in the face of multidimensional uncertainties?"*. We then find ourselves in an effectual space where *i)* it is impossible to calculate probabilities to predict future consequences, *ii)* there is ambiguity in the objectives (preferences are neither ordered nor known *a priori*) and *iii)* the contingency elements to be taken into consideration are not obvious (isotropy) (Sarasvathy, 2008): the practice of effectuation then makes it possible to find a solution. In this effectual approach the manager, or rather the experimenter, builds a solution as the context is built by his intervention and guided by the acceptability of losses while building alliances (with customers, suppliers or competitors) in order to obtain prior commitments. Considering an uncertain (causation) vs. unpredictable (effectuation) future, four principles can then define the main differences between causation and effectuation:

1. Defined *a priori* final objective (causation) vs. experimentation (effectuation)

2. Maximizing yields (causation) vs. acceptable loss (effectuation)
3. Strategic planning and competitive analysis (causation) vs. pre-commitment and strategic alliances (effectuation)
4. Existing capacity and resources (causation) vs. Flexibility (effectuation)

Using these four principles, Chandler *et al* (2011) constructed measures that differentiate the two processes in order to identify the logic at work in a project taking into account that *"Causal problems are problems of decision; effectual problems are problems of design."* (Sarasvathy, 2008, p. 73). However, in more serious cases such as natural disasters (Nelson & Lima, 2020), or even epidemiological crises like and that we have been facing since March 2020, with the coronavirus COVID-19, practices of effectuation, based on experimentation and flexibility (Chandler et al, 2011) start to be challenged since in these contexts several interconnected uncertainties arise at the same time that disturbs the rhythm and pattern of the daily life of a large number of people. Issues such as the maximum acceptable loss become difficult to calculate when this loss relates to the very life or life of another person who is in danger. The suggestion of different combinations of alternative solutions to the demands is restricted to the immediate objective, which becomes survival, with little time to consider alternatives (Nelson & Lima, 2020).

This is the difference between crises that have as a primary impact the survival of people, in relation to others such as the economic crisis that started in 2007. In the global financial crisis, the effects were related to, for example, the closing of companies, outsourcing, austerity wage. These are effects that, in the medium and long term, have consequences, for example, in R&D investments by organizations and, consequently, in innovation strategies (Laperche et al., 2011). However, despite the deleterious economic and social effects on society, there is no imminent risk to life, which allows us to consider some alternative solutions. In crises like the current COVID-19, as the virus spreads between countries, governments take measures to suspend various economic activities to slow the spread of the virus and avoid overloading national health systems and saving people's lives. However, these actions are accompanied by the threat to the survival of several companies at a global level, which in addition to the economic repercussions generates social impacts such as the reduction of jobs (Wenzel et al, 2020). Thus, the current crisis brings with it

important questions about how companies can respond effectively to a scenario in which multiple interconnected uncertainties arise. In cases like these.

However, a third logic may be at work: that of bricolage which is defined as the use in clever way of resources at hand to achieve a desired goal (Lévi-Strauss, 1968; Weick, 1993), and also as *"making do by applying combinations of the resources at hand to new problems and opportunities"* (Baker & Nelson, 2005, p. 333). Fisher (2012) based on Baker and Nelson (2005) and Senyard et al. (2009) studies on bricolage theory- proposes a classification of actions or behaviors that managers will take to make bricolage. In fact, as explained by Fisher (2012, p. 1027) when managers are confronted with penurious (lack of resources) our difficult (crisis, volatile, never seen before, …) environments they need to choose between three choices: *i)* to seek resources from domains external to the firm; *ii)* to avoid new challenges by remaining inert, downsizing, or disbanding; or *iii)* to enact bricolage by making do by applying combinations of the resources at hand to new problems and opportunities.

Definition	Behaviors
Bricolage is making do by applying combinations of the resources at hand to new problems and opportunities.	Bricolage (adapted from Baker & Nelson, 2005; Senyard et al., 2009) Bricolage definition • Takes identifiable action to solve problems: ◦ Experiments to solve problems (instead of trying to figure it out conceptually) • Combines existing resources in creating solutions: ◦ Uses goods on hand to create solutions to solve problems ◦ Uses readily available skills to create solutions to solve problems ◦ Uses existing contacts to create solutions to solve problems • Reuses resources for purposes other than those for which they were originally designed. • Uses existing resources (rather than seeking resources from outside). Bricolage domains • Uses forgotten, discarded, worn, or presumed "single-application" materials to create new solutions (physical inputs): ◦ Uses physical goods for surprising purposes • Involves customers, suppliers, and hangers-on in projects (labor inputs): ◦ Regularly interacts with other stakeholders (physical presence at the venture; online interaction) • Encourages the use of amateur and self-taught skills that would otherwise go unapplied (skills inputs). • Works around rules and standards (institutional environment): ◦ Does things that surprise people, e.g., bumping up against norms or laws

Chart 1- Summary of individual behaviors underlying bricolage theory (Fisher, 2012)

The managers who follow the third choice need to enact bricolage in the following five domains (Fisher, 2012): *i)* physical inputs—imbuing forgotten, discarded, worn, or presumed single-

application materials with new use-value; *ii)* labor inputs—involving customers, suppliers, and hangers-on in providing work on projects; *iii)* skills inputs—permitting and encouraging the use of amateur and self-taught skills that would otherwise go unapplied; *iv)* customers/markets—providing products or services that would otherwise be unavailable; and *v)* institutional and regulatory environment—refusing to enact limitations with regard to many "standards" and regulations, and by actively trying things in a variety of areas. Fisher (2012) proposes a summary of individual actions that underlie the bricolage theory. These actions (i.e., individual behaviors) are explained in Chart 1.

1.2 University-Industry Collaboration

The role of universities has been extensively studied in recent years (Rucker Schaeffer et al., 2018; Thomas et al., 2020; Trippl et al., 2015; Youtie & Shapira, 2008). These studies are reflections of a set of social transformations that generated new demands for the university. The protagonism of teaching was, over the 19th and 20th centuries, being added to two other missions, scientific research and the production of knowledge capable of contributing to the understanding and development of social, technological, and environmental issues, as well as economic growth (Philpott et al., 2011; Schulte, 2004; Stokes et al., 2011). However, as a society and, consequently, its problems started to increase in complexity, open and collaborative practices began to be demanded, involving companies, public policy makers, members of civil society, and scientists from various institutions, who together were able to offer more creative solutions to these problems (Beck et al., 2020; H. Etzkowitz, 2003).

Thus, to contribute to the social demands resulting from globalization and technological changes, universities have become increasingly involved in innovation and industrial development (Wang et al., 2015). Knowledge came to be consensual as the main source of competitive advantage for organizations and one of the main drivers of economic growth (Mascarenhas et al., 2019; Schiuma et al., 2012). In this scenario, companies, especially those more involved in research and development, have sought to approach universities, since greater attention has been given to the creation and commercialization of the knowledge generated in this area (Audretsch et al., 2014; Lam, 2007) *"Particularly in high-tech sectors, alliances have become the cornerstone of innovation strategies of many companies"* (Nooteboom et al., 2006).

This search for external knowledge in collaborative relationships was called by Chesbrough (2003) as open innovation. For this author, the opening of companies to external environments would provide access to knowledge and technologies relevant to the innovation process, making it more agile (Chesbrough, 2003). In this sense, universities started to accumulate a range of new functions, such as technology transfer offices (TTOs), science parks and incubator facilities (Brown, 2016). In this context, studies on the topic (university role) have increased and collaboration between the industry (UIC) for the exchange of knowledge and technology has become one of the main topics of interest (Ankrah & Al-Tabbaa, 2015).

Hagen (2002) pointed out that the challenge of rising costs and funding problems, which have exerted enormous resource burdens on universities to seek relationships with firms to enable them to remain at the leading edge in all subject areas. Added to this is the social pressure for the university's contribution to local development (Heaton et al., 2019). It seems possible to say that, there is consensus in the academic literature, about the fact that the UIC can improve the results of innovation. Therefore, a series of studies have been developed to understand ways to improve this interaction. Studies such as those by Brueel, d'Este, and Salter (2010) have devoted themselves to explaining ways to reduce the barriers in UIC. Baba, Shichijo and Sedita, (2015) identified the effects of UIC on the innovative performance of firms and discovered through analyzing the different "types" of researchers. They discovered that the idea that engaging in research collaborations, measured as co-invention, with "Pasteur scientists" increases firms 'R&D productivity, measured as the number of registered patents. In contrast, this study found that firms 'collaborations with "Star scientists" exert little impact on their innovative output.

Other academics have dedicated themselves to identifying the organizational forms of UIC. In a literature review, Ankrah and Al-Tabbaa, (2015) present for us 6 different organizational forms of UIC already studied: *i)* personal informal relationships; *ii)* personal formal relationships; *iii)* third part (ex: institutional consultancy, liaison offices...); *iv)* formal targeted agreements; *v)* formal non-targeted agreements; and *vi)* focused structures (incubation centers, consortia…). Thus, the U-I collaborative process has revealed several predictors of the scientific and economic impact of this type of activity, showing itself shaped by a series of elements. Also, despite the exponential growth in the number of studies, registered mainly since 2005, the field has become evident, multifaceted,

using different theoretical perspectives and models, which reflects in a certain fragmentation of the construction of knowledge on the theme (Skute et al., 2019).

Besides, most studies are focused on American and European universities, so that little is known about the U-I relationship in emerging countries like Brazil (Santini et al., 2021). When the focus of the study is on a developing country, this relationship takes on other forms, as well. Thomas et al., (2020) argue that universities in emerging economies, due to many social challenges, must go beyond their missions of teaching, research, and collaboration with industry for innovation.

In part, this is due to the lack of dynamics of U-I interactions in national innovation systems. Added to that, in countries like Brazil, in which universities have developed under models of importing technology, collaborative practices with industry have proved to be a challenge, because just from the 2000s onwards did Brazilian universities begin to prepare to assume the role of "entrepreneurial universities". Furthermore, the fact that the largest universities are public and depend on public policies to develop collaborative activities with industry (Faccin et al., 2021). Thus, although U-I collaboration processes have intensified since then, the university model and the late search for interaction with companies still bring challenges to be overcome. Among them, the difficulty of communication, due to the historical cognitive gap between university and industry and the different views are still barriers to collaborative practices (Colyvas et al., 2002) .

For these reasons, developed country policies cannot be considered as guides for developing countries, without reservations (Rucker Schaeffer et al., 2018). Thomas et al (2020), for example, explain that there is a gap in the literature about the promotion of innovation and regional development in developing countries. In this sense, the contextual and institutional particularities of emerging countries must be better understood, more specifically regarding the role of universities and U-I collaboration on innovation. Considering this gap this study tests this framework (Figure 1) in the context of open innovation projects during COVID-19 crisis.

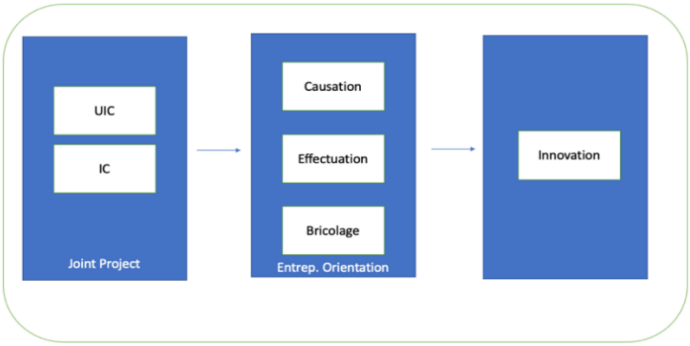

Figure 1 – Framework of the research

According to our framework, the entrepreneurial orientation adopted in the conduct of collaborative projects during the crisis was different considering two essential types of projects: those with the collaboration of universities and those without the presence of these actors. We used an asymmetric set-theoretic method that conceptualizes projects (i.e., cases of UIC an IC) as the combination of variant modalities. The general proposition made in this study is that not all of the three modalities (bricolage, causation and effectuation) are of equal significance (in terms of necessity) and that the value of modalities resides not in the individual modalities themselves, but in the proper configurations of these modalities, or "recipes".

2. DATA AND METHOD

This study tests this framework (figure 1) in the context of open innovation projects during COVID-19 crisis by using an asymmetric set-theoretic method that conceptualizes projects (i.e., cases) as the combination of variant modalities (causation, effectuation, bricolage).

2.1 DATA COLLECTION

The research considers case studies from open innovation projects in Brazil. COVID-19 presented many scientific and technological challenges, especially for developing countries, such as Brazil, where the challenges overcame epidemiological issues and presented economic and social impacts. The magnitude with which developing countries were socially affected by the Coronavirus crisis, caused a demand for new scientific knowledge, new technologies to face demands for *"auxiliary and pandemic support therapies, capable of helping countries to deal better with new protective*

equipment, respirators, faster and more efficient tests" said experts from the IPEA[2] (De Negri & Koeller, 2020). And, this was only possible thanks to the collaboration between the institutions, surpassing in most cases, the search for solutions such as the vaccine. The assistance of the scientific community has been essential in the definition of pandemic control and mitigation policies, as well as priority scientific and technological challenges (De Negri & Koeller, 2020).

"Brazil has transformed the health crisis into a political crisis" [3] - Statements like this are common on the Brazilian scene and appear in major national and international press vehicles. Considering that Brazil was one of the nations that responded later to the coronavirus - with support packages for companies, families, and organizations - a set of collaborative projects emerged from the social fabric to meet social demands. The first projects that emerge amid the pandemic present themselves as extraordinary cases to analyze how open innovation happens in times of crisis and, more than that, this scenario presents itself as an important opportunity to understand whether collaboration with universities makes the entrepreneurial orientation of the project when there is a collaboration between university-industry in times of crisis.

To meet the research objective, we started collecting data on significant collaborative projects in the Brazilian scenario. The choice of projects was made based on secondary data - news in national newspapers and magazines. As criteria for data collection, we used that news that presented information about the project's hub firm or partners, the results obtained by the project, time of activity, and place of performance. In this step, we list projects developed between March and May of 2020. After that, as a criterion for choosing projects, we asked the leaders of the special interest group on Science, Technology and Innovation Management at ANPAD[4] if they had any collaborative projects developed during the pandemic that they would like to indicate. This consultation was made in July. With the list of projects indicated by the specialists, we crossed the projects identified in newspapers and magazines, with the indicated projects and showed a match

[2] The Institute for Applied Economic Research (Ipea) is a public institution that provides technical support to the federal government with regard to public policies in Brazil: fiscal, social and economic

[3] https://saude.abril.com.br/medicina/coronavirus-o-brasil-transformou-a-crise-sanitaria-em-crise-politica/ by André Biernath published on May 22, 2020 10:25am and updated on September 5, 2020 12:56pm

[4] ITE- ANPAD : Inovação, Tecnologia e Empreendedorismo - Associação Nacional de Pós-Graduação e Pesquisa em Administração desenvolve (National Association of Postgraduation and Research in Administration in Brazil) http://anpad.org.br/sobre.php

between 36 projects (among those that were on our initial list and that were indicated by the researchers). This second search step served to confirm the importance and relevance of the projects that would be studied. In this step, we exclude from the analysis projects of donation, creation of podcasts, webcasts, a loan from banks. In the third stage, we selected among the 36 projects, only those that were collaborative (21 collaborative). Of this total, 16 were university-company partnerships.

#	Purpose	Start and end date	Nbr of people involved
P2	Teacher training in Education and Vocational Training (High school, Technical studies and Higher Education) in Building Learning Trails by Competencies and Skills using Digital Technologies (Robotic Simulators) focused on the quality of learning in distance education.	07/01/2020 to 09/03/2020	22
P3	To fund long-term researches to foster research, in addition to the production of COVID-19 testing kits, raising funds to finance research.	Until 02/2020	30
P4	the objective of significantly altering the evolution path of the new Coronavirus in the State of Santa Catarina and extensively and safely reestablish economic activities by means of molecular testing in groups of people and individuals.	Until 03/10/2020	60
P5	To develop and manufacture face shields to meet the urgent demand of health teams in the front of the COVID-19 pandemic.	April to June 2020	more than 100
P6	It checks the quality of the environment, seeking to mitigate the risk of contagion	04/01/2020 to 06/30/2020	7
P7	The lack of efficiency in production was identified, seeking an optimization in terms of time and cost.	03/11/2020 to 03/15/2020	15
P8	To diagnose COVID-19 cases in Brazil, as well as to adapt the WHO (World Health Organization) test protocol for the virus circulating in Brazil, which has undergone genomic mutations.	Until 03/2020	40
P9	to develop a simple respirator for field hospitals, seeking to keep those working.	Until 03/2020	30
P12	To deliver a digital solution for measurements of high voltage currents and voltages.	Until 03/2020	9
P13	To design, manufacture and distribute, through donations, an emergency transport ventilator.	15,/03/2020 to 15/03/2021	More than 200
P14	The creation of a less sophisticated COVID-19 test: they have two types of tests	Until 05/2020	16
P15	Support UNICAMP's actions to combat COVID-19	Until 03/18/2020	More than 50
P16	Mapping of activities against COVID-19 (120 projects) to work together. There are even universities around the world.	Until 04/2020	30

Chart 2 – The 13 projects

Concomitantly with this process of selecting the cases that would be studied, we prepared a questionnaire to be applied remotely (still in the middle of a pandemic) during August - by phone or video conference. For data collection, we have the support of 4 students, to speed up data collection. The collection of information took place during August 2020. The questionnaire for

data collection was prepared based on the articles by *i)* Faccin and Balestrin (2018) for open innovation variables; *ii)* Chandler et al. (2011) for the variables of causation and effectuation and *iii)* Fisher (2012) for bricolage variables. The final version of the questionnaire had 71 questions. At the end, considering the response rates and the findings about the projects, we conducted the analyzes with 13 projects. The projects studied are presented in chart 2.

Besides, we considered projects that showed some urgency for the delivery of innovation, considering the multiple needs of the Brazilian scenario, previously discussed. These characteristics of the scenario, associated with the criteria for choosing the projects, allowed us to case studies.

2.2 FUZZY-SET QUALITATIVE COMPARATIVE ANALYSIS

As explained, our research makes a general proposition that the three modalities (bricolage, causation and effectuation) are not equal in signification and that the value of each modality does not come from each modality individually but from their combinations (recipes). The study will analyze the impact of making (or not) collaboration with research institutes during the open innovation projects as a context variable.

In other words, we seek to identify possible combinations of causes that produce the same result. We then use the QCA (Qualitative Comparative Analysis) method, which is based on a ballistic minimization process to identify the minimal combinations of causes of a phenomenon observed from binarized data (Rihoux & Ragin, 2009). It should be noted that although the answers to the survey questions are binary (0 for no and 1 for yes), the very large number of questions on the different practices (50 questions in total) would require a calculation with too many variables for the crisp-set-QCA method to converge and give acceptable results. It was therefore necessary to reduce the number of variables by integrating and calibrating the answers to the questionnaire on each project on a reduced number of variables by constructing a fuzzy-set.

So, the research employs the fuzzy-set Qualitative Comparative Analysis (using Fs-QCA software[5]). Un-like the reliance of symmetric (correlation-based) methods on matrix algebra, fuzzy-set QCA uses Boolean algebra to specify and test recipes (Fiss, 2007; Ragin, 2008; Woodside, 2015). This method is suitable for analyzing complex and nonlinear relationships among variables (Ragin, 2008; Woodside, 2013). Fs-QCA is a set-theoretic analysis technique that analyzes in detail how causal conditions lead to a particular outcome (Ragin, 2008). In this study, all three modalities are assumed, based on a comprehensive review of the literature, to contribute to high (instead of low) open innovation. This study tests the following model:

Open-Innovation outcomes = existence (or not) of Research collaboration

+ Bricolage practices + Causation practices

+ effectuations practices

The key stage of Fs-QCA is to transform variables into calibrated sets by using at least three substantively meaningful thresholds: full membership (0.95), full non-membership (0.05), and a cross-over point (i.e. the point of maximum ambiguity – 0.5) (Woodside, 2015). Fuzzy-set QCA uses, first, a truth table function to generate configurations of conditions (Re-search, bricolage, causation, effectuation), that are sufficient for achieving high open innovation projects. The second step is to reduce the number of rows in the truth table to a minimum level of consistency that is greater than 0.80 (Ragin, 2008). This consistency establishes the necessary conditions for the outcome and highlights significant cases. The final step is to reduce and simplify the combinations from the truth table and minimizing the final solution.

3. RESULTS

In this section we will make two level of analysis with *i)* a macro analysis of each set of practices and/or modalities (bricolage, causation and effectuation) in link with the variable research in order

[5] Downloadable with the link: http://www.socsci.uci.edu/~cragin/fsQCA/software.shtml

to find the recipe for open innovation, and then *ii)* a micro analysis by looking inside the necessary condition what are the main practices that lead to achieve it.

3.1 LEVEL 1: MACRO ANALYSIS

3.1.1 Data and calibration

In fuzzy-set QCA, both the causal conditions (the three set of practices bricolage, causation, effectuation), the context variable research, and the outcome Open Innovation are represented using fuzzy membership scores (Ragin, 2008), which requires calibrating all variable scales to range from 0.00 for full non-membership to 1.00 for full membership. To perform fuzzy-set calibration, criteria are necessary for three breakpoints, set at 0.05 for the full non-membership threshold; 0.50 for the crossover point; and 0.95 for the full membership threshold (Ragin, 2008). As the study data are skewed (common in a large-N setting), it is not appropriate to use a conventional calibration method for a five-point scale (i.e. 1 = 0.05, 3 = 0.50, and 5 = 0.95). Following Woodside (2015), this study calibrates scores for cases in the lowest quintile at 0.05, cases in the middle quintile at 0.50, and cases in the highest quintile at 0.95. So, we made a calibration for all the components and open – innovation outcomes in order to test the following fuzzy-set QCA model:

Open-Inno = Research + Bricolage + Causation + All effectuation

Where:

- "Open-Inno" for open innovation outcomes; measured by the calibration of open innovation outcomes in the projects
- "Research" for collaboration with research institutes and universities; measured by the calibration of collaboration cases with research institutes during the projects of open innovation.
- "Bricolage" for the set of bricolage practices; measured by the calibration of bricolage practices during the projects of open innovation.
- "Causation" for the set of causation practices; measured by the calibration of causation practices during the projects of open innovation.
- "All effectuation" for all sets of effectuation practices; measured by the calibration of cases of all effectuation practices during the projects of open innovation

Table 4 includes the applicable data for 13 cases (i.e. projects) in the dataset. Table 1 illustrates the calibrated fuzzy sets.

	Research	Bricolage	Open-Inno	Causation	All-effecuation
P2	0.95	0.65	0.821429	0.821429	0.725
P3	0.05	0.65	0.757143	0.821429	0.65
P4	0.05	0.55	0.757143	0.95	0.71
P5	0.95	0.75	0.5	0.564286	0.77
P6	0.95	0.65	0.5	0.564286	0.575
P7	0.05	0.85	0.692857	0.435714	0.93
P8	0.95	0.45	0.435714	0.692857	0.59
P9	0.05	0.65	0.628571	0.821429	0.73
P12	0.05	0.75	0.5	0.307143	0.89
P13	0.95	0.65	0.757143	0.821429	0.77
P14	0.95	0.55	0.435714	0.692857	0.575
P15	0.95	0.85	0.757143	0.564286	0.815
P16	0.95	0.55	0.628571	0.95	0.56

Table 1 - Calibrated fuzzy sets of the 13 cases

3.1.2 Complex causal statements for open innovation projects outcome

Table 2 includes the results got from Fs-QCA software. This table illustrates, first, the means, standard deviations, and N cases of the variable that the three sets of practices and the context variable represent in this study. As the table shows, none of the variables have a missing case.

Variable	Mean	Std. Dev.	Minimum	Maximum	N Cases	Missing
Research	0.6038461	0.4378538	0.05	0.95	13	0
Bricolage	0.6576923	0.1140953	0.45	0.85	13	0
Open-Inno	0.6285714	0.133425	0.43571	0.82143	13	0
Causation	0.6928573	0.1886913	0.30714	0.95	13	0
All-effecuation	0.7146154	0.1164616	0.56	0.93	13	0

Table 2 - Descriptive statistics analysis

The analysis of necessary conditions (Table 3) shows that the effectuation is necessary condition because its consistency exceeds 0,95 but it is not sufficient. The other conditions research, bricolage and causation are not necessary because their consistency are below 0,95.

```
Analysis of Necessary Conditions

Outcome variable: Open-Inno

Conditions tested:
                  Consistency    Coverage
Research          0.622378       0.647862
Bricolage         0.917832       0.877193
Causation         0.921329       0.835844
All-effecuation   0.960927       0.845225
```

Table 3 - Analysis of necessary conditions

The study analyses open innovation projects outcomes and the combination of the three causal conditions besides the context variable research in a second phase. To reduce the number of rows in a QCA analysis of sufficiency, a selection of a consistency level and a frequency threshold is required to generate the truth table. Ragin (2008) suggests a consistency level of above 0.75 as a rough benchmark, while Rihoux and Ragin (2009) suggest using a frequency threshold of at least 5 cases in large-N settings. This study adopts a consistency cut-off of 0,75 and sets a frequency threshold of 5 cases. Output from fuzzy-set QCA includes three sets of solutions: complex, parsimonious, and intermediate. The consequential complex solutions demonstrate the alternative causal procedures that present high membership in each of the outcome conditions (Oyemomi et al., 2016). The paper focuses on the presentation of the complex solutions, contrary to the parsimonious and intermediate solutions; this solution makes no simplifying assumptions (Woodside, 2013). For this study, the complex solution is shown (Table 4) as it includes both easy counterfactuals, but excludes difficult counterfactuals (Rodríguez-Segura et al., 2016).

```
File:  C:/Users/amawadia/Documents/Doctorat & recherche/Recherche/articles/F
Model: Open-Inno = f(Research, Bricolage, Causation, All-effecuation)
Algorithm: Quine-McCluskey

--- COMPLEX SOLUTION ---
frequency cutoff: 1
consistency cutoff: 0.906574
                                      raw        unique
                                    coverage   coverage   consistency
                                   ----------  ----------  ----------
~Research*Bricolage*All-effecuation  0.418706   0.339161   0.888683
Research*Causation*All-effecuation   0.578584   0.499039   0.915744
solution coverage: 0.917745
solution consistency: 0.896737
```

Table 4 - Complex solution for the outcome coverage and consistency

The findings reveal two "equifinal" configurations of practices that lead to open innovation within projects (Open-Inno) :

1. **~Research ∗ Bricolage ∗ All-effectuation** (solution 1)
2. **Research ∗ Causation ∗ All-Effectuation** (solution 2)

The consistency values (indicating the degree to which the solutions are subsets of the outcome) for the two solutions and for the overall solution exceed 0.75, indicating that these recipes are sufficient to cause high open innovation projects (Ragin, 2008). The combined recipes (i.e. solution coverage) account for 92% of membership in the high open innovation projects outcome.

3.2 LEVEL 2: MICRO ANALYSIS

All effectuation is the necessary condition for open innovation projects and it is present in both recipes. But which practices make the effectuation a necessary condition ? To answer that question, we will make a micro analysis using FSQCA and following the same steps as in the macro analysis level.

3.2.1 Data and calibration

Table 5 includes the applicable data for 13 cases (i.e.,projects) in the dataset. Table 5 illustrates the calibrated fuzzy sets of each type of effectuation practices. To identify the practices that make effectuation a necessary condition, we made a calibration for all the effectuation practices to test the following fuzzy-set QCA model:

All effectuation = Research + Basic effectuation + experiment

+ Affor-Lose + Flexibility + Pre-com

Where:

- "All effectuation" for all sets of effectuation practices; measured by the calibration of cases of all effectuation practices during the projects of open innovation
- "Research" for collaboration with research institutes and universities; measured by the calibration of collaboration cases with research institutes.

- « Basic effectuation » for the set of basic effectuation practices; measured by the calibration of basic effectuation practices
- « Experiment » for the set of experimentation practices; measured by the calibration of experimentation practices
- "Affor – Lose" for the set of affordable lose practices; measured by the calibration of affordable -lose practices
- "Flexibility" for the set of flexibility practices; measured by the calibration of flexibility practices
- "Pre-com" for the set of pre-commitment practices; measured by the calibration of pre-commitment practices

	All-effecuation	Research	Basic-Effectuation	Experiment	Affor-Lose	Flexibility	Pre-com
P2	0.725	0.95	0.5	0.5	0.95	0.95	0.725
P3	0.65	0.05	0.5	0.5	0.95	0.5	0.725
P4	0.71	0.05	0.5	0.5	0.95	0.95	0.5
P5	0.77	0.95	0.725	0.275	0.95	0.95	0.95
P6	0.575	0.95	0.725	0.05	0.65	0.95	0.5
P7	0.93	0.05	0.95	0.725	0.95	0.95	0.95
P8	0.59	0.95	0.5	0.275	0.95	0.725	0.5
P9	0.73	0.05	0.95	0.275	0.65	0.725	0.95
P12	0.89	0.05	0.725	0.725	0.95	0.95	0.95
P13	0.77	0.95	0.725	0.5	0.95	0.725	0.95
P14	0.575	0.95	0.275	0.5	0.65	0.95	0.5
P15	0.815	0.95	0.725	0.725	0.95	0.95	0.725
P16	0.56	0.95	0.5	0.275	0.35	0.95	0.725

Table 5 - Calibrated fuzzy sets of the 13 cases for all effectuation sub components

3.2.2 Complex causal statements for open innovation projects outcome

Table 6 includes the results got from Fs-QCA software. This table illustrates, first, the means, standard deviations, and N cases of the variable that All-effectuation practices represent in this study. As the table shows, none of the variables have a missing case.

Variable	Mean	Std. Dev.	Minimum	Maximum	N Cases	Missing
All-effecuation	0.7146154	0.1164616	0.56	0.93	13	0
Research	0.6038461	0.4378538	0.05	0.95	13	0
Basic-Effectuation	0.6384615	0.1880097	0.275	0.95	13	0
Experiment	0.4480769	0.200351	0.05	0.725	13	0
Affor-Lose	0.8346154	0.1874778	0.35	0.95	13	0
Flexibility	0.8634615	0.1406084	0.5	0.95	13	0
Pre-com	0.7423077	0.1864096	0.5	0.95	13	0

Table 6 - Descriptive statistics analysis for all effectuation sub components

The analysis of necessary conditions (Table 7) shows that affordable -Lose and flexibility are necessary conditions because their consistency exceed 0,95 but are not sufficient. The other conditions effectuation, experimentation and pre-commitment are not necessary because their consistency are below 0,95.

Analysis of Necessary Conditions

Outcome variable: All-effecuation

Conditions tested:

	Consistency	Coverage
Research	0.606028	0.717197
Basic-Effectuation	0.851453	0.953012
Experiment	0.627018	1.000000
Affor-Lose	0.968784	0.829493
Flexibility	0.978472	0.809800
Pre-com	0.941873	0.906736

Table 7 - Analysis of necessary conditions

For this micro level analysis, the complex solution (Table 8) shows the recipe for a global effectuation.

Model: All-effecuation = f(Research, Basic-Effectuation, Experiment, Affor-Lose, Flexibility, Pre-com)
Algorithm: Quine-McCluskey

--- COMPLEX SOLUTION ---
frequency cutoff: 1
consistency cutoff: 1

	raw coverage	unique coverage	consistency
Basic-Effectuation*Affor-Lose*Flexibility*Pre-com	0.818622	0.818622	0.997377

solution coverage: 0.818622
solution consistency: 0.997377

Table 8 - Complex solution for the outcome coverage and consistency

The findings reveal the configuration that lead to a global effectuation (All effectuation):

Basic-Effectuation ∗ Affor-Lose ∗ Flexibility * Pre-com

The consistency value for this configuration and for the overall solution exceed 0.75, indicating that this recipe is sufficient to cause high global effectuation within open innovation projects (Ragin, 2008). The solution coverage account for 82% of membership in the high global effectuation outcome. The finding show that the variable research has no impact on the recipe. So, no matter if the project is done with or without collaboration with research institutes. The recipe stays the same and means that besides affordable lose and flexibility which are necessary conditions we need to combine them with effectuation and pre-commitment practices to achieve a high global effectuation (all effectuation).

4. DISCUSSION

The figure 2 summarize the findings of our study, where effectuation is a necessary condition for all open innovation projects but it is not sufficient. It should be combined with bricolage when the projects are done without collaboration with research institutes. Otherwise, it should be combined with causation for projects in collaboration with research institutes. Moreover, at effectuation level, flexibility and affordable lose are necessary condition for achieving a high effectuation in all type of projects.

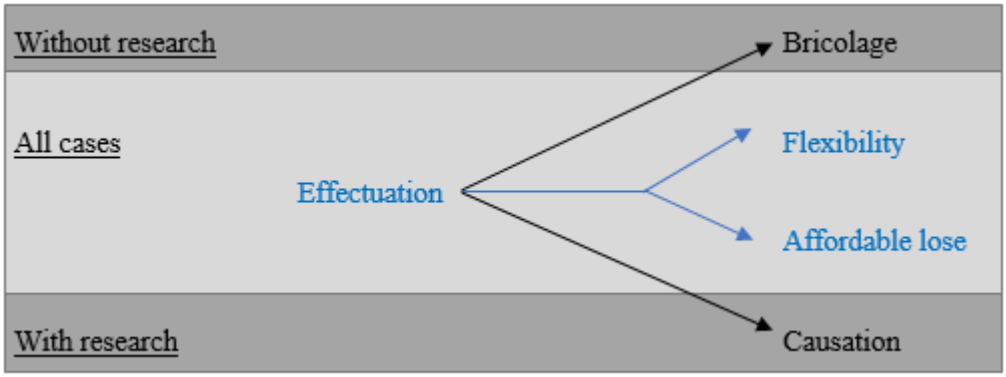

Figure 2 - Findings summary

We discuss in the next sections the three main results of this research.

4.1 EFFECTUATION AS A NECESSARY CONDITION PRESENT IN ALL PROJECTS

The results of the macro-analysis make it evident that effectuation is a necessary and present condition in all thirteen analyzed projects. Since effectuation is composed of a set of practices based on experimentation and flexibility (Chandler et al, 2011) it is expected that in a time of crisis such as that caused by Covid-19, several actors will seek to collaborate to develop possible solutions for the same.

As stated by Chandler et al (2011), conditions of uncertainty such as the one imposed in the year 2020, make experimentation and flexibility more feasible than drawing statistics and calculating the expected return on projects, as in addition to not having time for planning, it is a unique situation, which does not have previous experience that makes strategic planning viable. In cases like this, the entrepreneur develops an opportunity for experimentation and changes direction as new information becomes available (Chandler et al, 2011). Thus, trial and error, end up presenting themselves as the most common practices and the search for alliances, through collaborative projects, in addition to having the role of adding efforts and complementary resources, presents itself as a way of sharing the risks of initiatives. Also, the search for strategic alliances and pre-commitments are characteristic of the effectuation (Sarasvathy, 2008), which reinforces this set of practices that appeared as necessary for the analyzed projects

In the second part of the analysis, a microanalysis about effectuation showed what are the main practices that lead to achieving it. Thus, affordable-loss and flexibility appeared as a necessary condition for open innovation in crisis situations. The result is expected because, in the face of uncertainty, care for financial risk is a delicate issue, which can compromise the future plans of the actors involved and even their financial viability if the project does not present the expected result. Flexibility, as already mentioned, is essential for projects to evolve as new information and opportunities present themselves, allowing the adaptability of actions (Chandler et al., 2011; Sarasvathy, 2008).

Thus, as new information emerged about the virus, its transmissibility, the economic consequences, and necessary restrictive measures, for example, adaptations were shown to be necessary within

the scope of the projects. However, although necessary, affordable-loss and flexibility have not proved to be sufficient, which shows that they need to be added to other practices for the success of the open innovation project, , causation and bricolage practices, as we'll describe in the following topics.

Furthermore, this microanalysis revealed a global combination of effectuation, that is, a combination of effectuation practices that is sufficient for the high global effectuation in open innovation projects (figure 2).

4.2 BRICOLAGE IN PROJECTS WITHOUT RESEARCH COLLABORATION

The study results could imply that in case of crisis when facing new problems companies try to make do (Baker & Nelson, 2005) with resources at hand to survive. They do not follow a precise plan or protocol but improvise in form of emergent actions to make sense (Weick, 1993) and enable the assembly and combination of the resources to be effective (Fisher, 2012). This joins Lanzara (1999) and Weick (1993) stating that improvisation views action as a process of sense making that makes do with whatever materials at hand (bricolage). Bricoleurs cannot wait for optimal resources to be deployed, they need to tackle the issues at hand by making bricolage of currently available resources (Fisher, 2012; Weick, 1999). In projects without research collaboration, managers do not need to follow the plan or respect the constraints of the research protocol, they are free to act and will not hesitate to change their practices to work around rules to get a workable solution. This joins Fisher (2012) remarks that bricoleurs can work around rules and standards and may do things that surprise people (researchers, specialists…) to solve the issues.

Bricolage is also about using resources creatively without considering their previous use or design specifications (Fisher, 2012). The repackaging, transposition and recombination of existing objects can also be envisioned as acts of creative reinvention ((Penrose, 1959; Rice & Rogers, 1980) cited by fisher (2012)). A creativity that is not conditioned by a research protocol to be followed or intermediate or final results to be proven and which is stimulated by the urgency of the situation and the need to make do with means at hand (bricolage) to find new solutions even if they are workarounds, out of specifications and protocols, surprising or innovative solutions (Fisher, 2012).

A *"penurious environment"* (Baker & Nelson, 2005) or *"crisis environment"* (Weick, 1993) are the starting point for the process model of bricolage, and out of this environment a bricoleur can choose to *"make do by applying combinations of the resources at hand to new problems and opportunities"* (Baker & Nelson, 2005, p. 353) and get out of these "never seen" situations as *"bricoleurs remain creative under pressure, precisely because they routinely act in chaotic conditions and pull order out of them"* (Weick, 1993, p. 639).

4.3 CAUSATION IN PROJECTS INVOLVED WITH RESEARCH INSTITUTIONS

In addition to effectuation as a necessary condition, the macro analysis showed another interesting result, which is related to the presence or absence of at least one research institution in the project. When the presence occurred, it was noted that the practices included, in addition to effectuation, causality. Although this result was not expected, we seek some explanations for the presence of causation in joint projects, even in periods of crisis.

One of the reasons capable of explaining the need for planning - causation - when there were universities associated with collaborative projects, has already been explained by the studies by Sataoen (2018). The author noted that in the last decades, modes of engagement employed by universities are largely policy-driven (Sataoen, 2018). This specificity is linked to the Brazilian institutional context, in which the main research bodies are federal universities, which depend on public policies with a set of rules to be followed to develop collaborative activities (Kadigia Faccin et al., 2021). Besides, much of the research and academic activities are governed by research projects, with resources used to acquire capital or pay third parties (*eg* proofreading, data collection). In Brazil, even with the outbreak of the pandemic, few calls for project financing were launched, which probably meant that researchers had to maintain some planning (causation) to allocate resources from projects already approved to those surveyed by COVID-19.

Thus, even in a crisis situation, in which projects require effectuation, the presence of causation practices may prove necessary to meet the contextual demands and, as suggested (Sarasvathy, 2001), select opportunities that have greater potential to maximize the final return, within the possible results.

CONCLUSION

The purpose of this exploratory research was to understand the practices of open innovation in Brazil during the first phase of the COVID-19 crisis and the impact of research institutions in these practices.

Collaborative projects developed in times of crisis, such as the one caused by the coronavirus, demonstrated that the orientation for effectuation is essential. However, the execution process is governed by flexibility and the acceptance of losses. It is important to note that experimentation did not appear as a necessary condition for the researched projects. The university's presence, the university-industry collaboration, demonstrated that causation behavior is a necessary condition. This "causation" condition in university-industry collaboration projects seems to reinforce the critical holes about the barriers for collaboration between university and industry.

As a limitation of the study, we can highlight the choice of projects developed between March and May 2020. Although it allowed access to proposals for rapid response projects to the crisis that began in March 2020, it did not allow the monitoring of projects with a longer duration. The expansion of the analysis for projects that occurred throughout the year 2020, could reveal changes in practices over time, caused by learning throughout the process, for example. Besides, we highlight that the Brazilian technology import culture and the lack of U-I interaction dynamics in the national innovation system may have had a direct impact on the predominance of causality practices when cooperating with universities, as explained in topic 4.3. Thus, it cannot be said that the combination of causality practices is prevalent in times of crisis when U-I collaboration is involved, it is necessary to extend the research to different institutional contexts.

Future Research could concentrate in the replication of this study in other countries (France, Norway and Russia) by an international consortium of researchers in order to compare if the universities influence in the entrepreneurial orientation of a project in a crisis time.

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