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CAPTURING CAUSAL COMPLEXITY: A formal qualitative approach to explanatory research

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INTRODUCTION

Scientific research is a fundamental process that drives the advancement of modern society by enabling the discovery of new ideas, the formulation of theories, and the solution of complex challenges. To ensure that the results obtained are reliable and valuable, research must be conducted with rigor, ensuring its relevance and scientific impact.

Academic and scientific research can be quite complex, especially in fields such as the social sciences and management. This is because the phenomena studied in these fields are often influenced by multiple factors, which can make it difficult to identify the actual causes of a given event or behavior and lead to considerations of spurious causal relationships (HAESEBROUCK; THOMANN, 2022).

Understanding causal complexity can be achieved through the explanatory research approach, which aims to go beyond the mere description of an event and seek to understand the reasons why it occurs, even when the available information is limited. In addition to identifying the how and why of a given phenomenon, explanatory research allows for the prediction of future occurrences (CRESWELL, 2014; GIL, 2018).

Future events can be caused by the regularity of their occurrence under certain conditions. According to the theory of causation by regularity, an event B can cause an event A. However, for the cause-and-effect relationship to be reliably established, it is necessary to consider conditions other than the observed regularity in the occurrence of events, such as temporal precedence and the absence of other INUS causes. Only when these conditions are met is it possible to infer that a given condition is the cause of a specific outcome, based on regularities observed in nature (BAUMGARTNER; FALK, 2019).

Comparative configurational methods can be useful when using the theory of regularity causation to analyze events and their causes in a broader context. Such methods aim to identify complex patterns of causal relationships between variables, taking into account their interaction rather than analyzing them in isolation. In this way, the configurational approach enables a deeper and more precise understanding of causality in a given event (BAUMGARTNER; AMBÜHL, 2018).

For example, when analyzing the relationship between two events A and B, one can use comparative configurational methods to identify other factors that may be contributing to the occurrence of A. These factors may include specific conditions in which A and B occur, as well as other variables that may influence the relationship between them (causal structure and/or causal chains).

Among the comparative configurational methods, Coincidence Analysis (CNA) has stood out for its ability to deal with greater causal complexity and ambiguities in models. Through CNA, it is possible to investigate causes that tend to happen together rather than in isolation (conjunctivity); the existence of alternative paths or more than one cause (disjunctivity); and causal chains, that is, one cause leading to another (sequentiality). These characteristics allow for a more complete and accurate analysis of the causal structure (BAUMGARTNER; AMBÜHL, 2018).

CNA is an approach that allows for exploring causal relationships in a configurational manner, i.e., analyzing complex patterns of events that can lead to certain outcomes. This is particularly important when the relationships between events are not correlational but rather configurational, i.e., they depend on different combinations of factors for an effect to manifest itself (BAUMGARTNER; EPPLE, 2014).

Considering the complexity of the phenomena studied in the social sciences and administration, which are often influenced by multiple factors, the need to understand causal relationships more precisely and comprehensively arises. Therefore, the research problem is: **how can the use of comparative configurational methods, specifically Coincidence Analysis (CNA), contribute to a more in-depth analysis of causal relationships in social and management studies**?

Therefore, the overall objective of this paper is to discuss the relevance of the concept of causation and causation theory by regularity in explanatory studies, using comparative configurational methods, more specifically CNA, as a methodological tool for further analysis of causal relationships associated with social research and phenomena observed in management studies.

THEORETICAL FRAMEWORK

EXPLANATORY RESEARCH, CAUSAL RELATIONSHIPS, AND COMPLEX EVENTS IN MANAGEMENT

Unlike exploratory and descriptive research, which are limited to recording, analyzing, and interpreting data, explanatory research seeks to deepen the knowledge of reality to understand the reasons and why phenomena occur. Thus, this type of research has its main purpose to identify the causes that lead to the occurrence of certain phenomena (CRESWELL, 2014; GIL, 2018).

Social research, in particular, generally seeks to clarify the "why?" and "how?". In other words, the cause is what causes or influences something to happen. Understanding the cause of an event is critical to the advancement of knowledge, as it allows for the identification of cause-and-effect relationships that occur in the world (REITER, 2017).

Explanatory research is a way to study the causes of certain phenomena, using the scientific method to establish theoretical expectations, verify hypotheses, and test theories. This methodology seeks to answer questions such as "why?" and "how?" to understand the cause-and-effect relationships surrounding a given event (CRESWELL, 2014; GIL, 2018).

Social research, in particular, often falls into the "why?" and "how?" category. This is because society is complex and dynamic, with many factors influencing human behavior and social relationships, which naturally sparks interest in understanding the reasons and conditions that influence the occurrence of certain phenomena (CRESWELL, 2014).

In management, explanatory research is especially important since the phenomena that occur in this field are influenced by a number of interconnected and complex factors, which may be difficult to understand by observation or descriptive data collection alone. Understanding these relationships is fundamental to solving practical problems.

In this type of research, causal explanation involves the analysis of relationships between variables, establishing causality between them. Some explanatory research questions in management that involve causal complexities are shown in Frame 1:

Frame 1 Themes and questions of explanatory surveys

Topic	Research question
Business Ethics	How are managers' moral configurations related to their responses to moral boycotts?
Marketing and consumer behavior	How does the polarization of soccer team rivalry influence the non-consumption of sponsoring brand products?
Consumer behavior	How do maternal characteristics combine in profiles that explain the intention and non-intention to buy second-hand products for children?
Business strategy and politics	How does strategy influence occur in the relationship between business and the state in Brazilian cases?
Entrepreneurship and business strategy	How do strategists in an entrepreneurial context use causation and effectuation logics in prospective and retrospective rationalizations of strategies?
Business strategy	Why is a cause and effect continuous analysis of competition a crucial element in effective strategic planning?
Business management and strategy	Why is effective leadership a critical factor in successful organizational strategy implementation?

Source: Elaborated by the authors.

Explanatory research in Administration aims to understand the complex relationships that influence the phenomena in this field. To achieve this goal, it is essential to use theories that can explain the cause-and-effect relationships among the factors influencing these phenomena. The philosophy of causation is a field of study precisely dedicated to exploring the fundamental questions related to the nature and role of causation in events and processes in the world.

PHILOSOPHY OF CAUSATION

The philosophy of causation is a field of study that seeks to explain how the world works and how things relate to each other. The quest for a deeper understanding of causation dates back to philosophers in Ancient Greece, such as Aristotle, who argued that everything that exists has a cause, and that the cause explains for the existence of something (ANJUM; MUMFORD, 2018).

However, the philosophy of causation is a field that has significantly developed over time and features a wide variety of theories and approaches. Some philosophers, for example, focus on the analysis of causation in science, while others are more concerned with ontological and metaphysical questions of causation (HITCHCOCK, 2017).

One of the central issues in the philosophy of causation is the distinction between necessary and sufficient conditions. A necessary condition is one without which the event would not have occurred, while a sufficient condition is one that, by itself, is capable of producing the event (BAUMGARTNER, 2009a). For example, a storm may be a necessary condition for a tree to fall, but it is not a sufficient condition because there needs to be a strong wind for the tree to fall.

Another important issue in the philosophy of causation is the relationship between cause and effect. Some philosophers argue that the cause is what produces the effect, while others claim that the cause is simply a condition for the effect to occur. This discussion becomes even more complex when one considers that some events may have multiple causes, and a single cause may produce different effects in different contexts (HITCHCOCK, 2017).

One of the most influential theories in the philosophy of causation is David Hume's theory of causation (HUME, 2000), which argues that it is not possible to observe cause and effect directly, only their frequent association. According to Hume, causality is not an objective property of the world, but a mental construct based on past experiences. This theory was much criticized by other philosophers, who considered it a denial of the reality of causality.

Another important theory in the philosophy of causation is John Stuart Mill's theory of causality (MILL, 2009), which advocates that causality is a necessary relationship between events that can be inferred through observation and experimentation. According to Mill, causality is a cause and effect relationship that can be discovered through scientific methods and is essential to the understanding of the natural world.

In addition to these theories, the philosophy of causation is also devoted to exploring issues such as causality in complex systems, the relationship between causality and probability, and causality in social and historical events. These issues are especially relevant in fields such as sociology, economics, social sciences, and management, which deal with events that are influenced by multiple causes and occur in complex social and cultural contexts.

THEORIES OF CAUSATION APPLICABLE TO THE SOCIAL SCIENCES

Causation theories are fundamental to understanding the cause-and-effect relationships that occur in various phenomena, including those related to the social sciences. Among the main theories in this field, the counterfactual, probabilistic, interventionist, mechanistic, and regularity theories stand out (BAUMGARTNER, 2020).

The counterfactual theory defines that a causal relationship is established when, given a specific situation, a change that had occurred in the cause would have led to a change in the effect. In other words, it is when we can say that if the cause had not occurred, the effect would not occur either. The counterfactual theory seeks to establish the causal relationship by comparing different situations, one in which the cause occurred and another in which the cause did not occur (WOODWARD, 2005).

For the counterfactual theory, the most appropriate methods are based on causal interventions, such as randomized experiments and observational studies that use matching and/or regression techniques. Pairing and regression methods are used to control for confounding variables that may affect the causal relationship, allowing researchers to establish more precise relationships between the independent variable and the dependent variable (WEBER; LEURIDAN, 2008).

In turn, the probabilistic theory seeks to establish the causal relationship by calculating the probability of the effect occurring given the cause. That is, this theory considers the probability of an event occurring, given that another event occurred. Thus, it does not propose a deterministic relationship but requires the identification of the probabilities of each variable that contributes to the result (PEARL, 2009).

A common method of causal inference used in probabilistic theory is structural equation modeling. This method allows the estimation of the probability of occurrence of the effect given the cause, including conditional probabilities that describe the causal relationships between variables to estimate their effects within a system (PEARL, 2009; HAYES, 2017).

The interventionist theory, in turn, holds that causal relationships can only be established through controlled interventions in variables. The theory proposes that causes are interventions in a system, which alter the probability of an event occurring. This approach emphasizes the importance of actions, which can change the course of events and therefore influence causal relationships (BAUMGARTNER, 2020; HITCHCOCK, 2013).

One method for testing interventionist hypotheses is the controlled experiment, in which the researcher deliberately manipulates an independent variable to observe the effect on a dependent variable (SPIRTES et al., 2000). Another method is regression analysis with instrumental variables, which allows the identification of causal relationships even when the variables of interest are correlated with other factors (PEARL; MACKENZIE, 2018).

Mechanistic theory, on the other hand, seeks to understand causal relationships in terms of underlying mechanisms that explain how a cause produces an effect. It holds that causes are processes that occur in a system and produce an effect. In this approach, it is important to understand how the parts of a system interact with each other to produce an outcome to establish a precise causal relationship (BAUMGARTNER, 2020).

Simulation modeling is a common method for testing mechanistic hypotheses, where researchers can test different scenarios and observe the results (GLYMOUR; SCHEINES; SPIRTES, 2014). For example, in a study that seeks to understand how inequality affects political participation, a causal model that describes the relationships between relevant variables and simulates different scenarios to observe the effect of inequality on political participation can be developed.

Finally, the regularity theory is a classical theory of causation based on the premise that causal events occur regularly and in conjunction with other events (BAUMGARTNER, 2020). This theory posits that a cause is a necessary and sufficient condition to produce an effect and that, therefore, if a cause is not present, the effect will not occur (BAUMGARTNER; FALK, 2019).

Comparative configurational methods (CCM's) are used to verify regularities in empirical social research. These methods seek to identify specific configurations of factors that may result in certain outcomes and are useful for exploring complex causal relationships where a single explanatory variable may not be sufficient to explain the phenomenon in question (BAUMGARTNER; AMBÜHL, 2020). An overview of causation theories and methods for causal inference discussed in this section is provided (Frame 2).

Frame 2 Overview of causation theories and causal inference methods

Theory	Definition	Common methods of causal inference
Counterfactual	Establishing a causal relationship occurs when a change in the cause results in a change in the effect. It compares different situations where the cause occurred and where it did not.	Randomized experiments, observational studies with matching techniques, and regression analysis
Probabilistic	Calculating the probability of the effect occurring given the cause is a way to identify the probabilities of each variable contributing to the outcome.	Structural equation modeling, Granger causality analysis
Manipulative	Establishing a causal relationship through a controlled intervention involves focusing on manipulating variables to establish a causal connection.	Randomized controlled experiments
Interventionist	Asserting that causal relationships can only be established through controlled interventions on variables emphasizes the importance of actions that can alter the course of events.	Controlled experiments
Mechanistic	Seeking to understand causal relationships in terms of underlying mechanisms explains how a cause produces an effect.	Model simulation
Regularity	Establishing a causal relationship is based on the discovery of regularities between events.	Comparative configural methods

Source: Elaborated by the authors.

REGULARITY-BASED THEORIES OF CAUSATION

Regularity theory is one perspective for understanding causality in the fields of philosophy and science. This theory states that a cause is a condition that, when present, always results in an effect, and when that cause is absent, the effect never occurs (BAUMGARTNER; FALK, 2019). This theory advocates that causal events are characterized by repetitive and predictable patterns in nature.

Several philosophers share the view that causality is based on observed regularities in nature. They argue that the causal relationship is inferred from the observation that one event is always followed by another event under similar circumstances. Inference is a fundamental part of the scientific thinking process because it allows scientists to establish laws that describe natural regularities (BAUMGARTNER, 2009a).

David Hume, an 18th-century Scottish philosopher, argued that the idea of cause and effect is not something that can be directly observed but rather a belief that develops from habit or custom. He contended that there is no logical reason or necessity that justifies the belief that one event is the cause of another. According to the philosopher, the causal relationship between events cannot be established through empirical observation (HUME, 2000).

Hume is known for his idea that causality is a relationship between temporal contiguity and conjunctural constancy. According to him, although causality cannot be directly observed, the human mind has a natural tendency to associate events that repeatedly occur together. This propensity allows for the inference of causality, which is utilized in everyday life and science (BAUMGARTNER; FALK, 2019).

John Stuart Mill, a 19th-century British philosopher, developed the theory of causation by regularity, which argues that the causal relationship between events can be established through empirical observation. Mill posited that causal relationships can be inferred by observing regularities between events. He believed that natural laws were necessary to explain these regularities (MILL, 2009).

Mill developed the theory of conjunctural constants, where causality is seen as an objective relationship that exists in the world and is discovered through observation and experimentation. According to Mill, causal inference is possible because the human mind can identify repetitive patterns in the sequence of events (BAUMGARTNER, 2009a).

In the current philosophical discussion, Baumgartner and Falk (2019) present a new analytical approach to the theory of regularity causation called "Boolean Difference-Making" (Boolean difference-based causation). This approach is based on Boolean logic and focuses on identifying minimally necessary and sufficient conditions for one event to cause another.

This view is based on the principle of redundancy-free Boolean dependency, originally proposed by Broad in 1930 and later refined by Mackie in his INUS theory in 1974 (an acronym for "insufficient but not redundant part of an unnecessary but sufficient condition"). The principle states that only Boolean dependencies that do not contain redundancies can adequately trace the cause-and-effect relationship between events (BAUMGARTNER; FALK, 2019).

This principle was crucial in overcoming the problems encountered in classical theoretical proposals of causality, such as Hume and Mill's regularity theories. These theories struggle to address the complexity of causal relationships in the real world and often fail to adequately explain how specific events are caused by other events. The INUS theory addresses these limitations, allowing for a more sophisticated understanding of causality and the relationship between events (BAUMGARTNER; FALK, 2019).

The INUS theory was refined by Graßhoff and May (2001). While the INUS theory recognizes that several conditions can contribute to an event without being the sole cause, the (M)INUS theory introduced a hierarchy among these conditions, identifying the minimal, non-redundant, and necessary part of a condition sufficient for an effect to occur (BAUMGARTNER; AMBÜHL, 2023).

Therefore, (M)INUS theory defines causality in terms of redundancy-free Boolean dependency structures and, more importantly, does not require causes and their outcomes to be pairwise dependent. As such, it is custom-built to account for structures with conjunctivity and disjunctivity. In this way, the MINUS theory has brought greater precision to the analysis of causal relationships by more clearly identifying the conditions that contribute to the occurrence of an event (BAUMGARTNER; AMBÜHL, 2023).

In the article "Boolean Difference-Making: A Modern Regularity Theory of Causation," the authors argue that Hume and Mill's classical explanations of the causal relationship between events are problematic for a few reasons. First, Hume's explanation that causality is based on the constant conjunction of events is not sufficient to explain all cases of causality. There are situations where events do not consistently occur together, yet a causal relationship exists between them.

Second, Mill's explanation that causality is based on a universal law connecting one type of event to another type of event is also insufficient. It is often unclear which universal law should be invoked to explain a causal relationship between specific events. Additionally, there are cases where a single effect has multiple causes or where the cause is a gradual process occurring over time.

In summary, the authors argue that both classical explanations fail to consider the importance of disjunctivity and sequentiality in causality. In many cases, there are several potential causes for an effect, and causality can occur through a sequence of events rather than just a constant conjunction. For Baumgartner and Falk (2019), conjunctivity, disjunctivity, and sequentiality represent the three fundamental relationships between events that allow for the identification and explanation of causal regularities.

Conjunctivity refers to the fact that the causes of an event usually occur together. Several causes contribute to the occurrence of the event in question. These causes can be independent or interdependent, but the idea is that they do not occur in isolation. Disjunctivity, on the other hand, refers to the existence of alternative paths leading to the same event. This means that more than one cause can be responsible for a given effect, and these causes may have equal or unequal importance.

Finally, sequentiality is the idea that causes are linked in a causal chain, where one cause leads to another, which in turn leads to a third event, and so on. From this perspective, the initial cause of an event is called the primary cause, while subsequent causes are called secondary or intermediate causes. The logic of the properties of regularity of causation (Frame 3).

Frame 3 Logic of the properties of causation regularity

Concept	Boolean Logic	Example
Conjunctivity	"AND" / "NOT"	If effect X occurred only when causes Y and Z were present, we can use Boolean logic to check whether Y and Z occurred together.
Disjunctivity	"OR" / "NOT"	If effect X can be produced by both cause Y and cause Z, we can use Boolean logic to check whether Y or Z was sufficient to produce X.
Sequentiality	"AND" / "NOT"	If cause Y must occur before cause Z to produce effect X, we can use Boolean logic to check that Y occurred before Z.

Source: Elaborated by the authors.

Boolean logic plays a central role in their modern theory of causality. Baumgartner and Falk (2019) state that causality is a matter of Boolean difference, meaning that a cause makes a true/false difference in its effect. Boolean logic provides a formal way to understand and represent the relationship between cause and effect in terms of true or false propositions.

The idea is that if a cause is necessary for an effect to occur, then the presence of the cause makes a Boolean difference in the state of the world, making a proposition true that would be false in the absence of the cause. On the other hand, if a cause is sufficient for an effect, then the presence of the cause also makes a Boolean difference in the state of the world, making a proposition false that would be true in the absence of the cause.

Thus, Boolean logic is used to identify the relevant causal differences that allow a cause to be responsible for an effect. The authors' approach is an attempt to provide a causal theory based on regular and precise patterns that can be applied to different areas, including physics, biology, psychology, social sciences, management, and other fields where causality is important.

From the idea that a cause makes a Boolean difference in the occurrence of the effect, it is possible to solve many problems of traditional causal theory, such as the issue of non-identity and circular causality. Baumgartner and Falk's (2019) approach is epistemic and uses Boolean logic to establish causal relationships between events. Combining this with comparative configurational methods, they present a powerful theory and methodology of causality that can transform how one thinks about it.

COMPARATIVE CONFIGURATIONAL METHODS

Comparative Configurational Methods (CCMs) seek to understand the relationship between configurations of variables and their consequences, based on the idea that the causal relationship cannot be understood by examining each variable in isolation but in conjunction with other variables that form a specific pattern (FURNARI *et al.*, 2020).

CCMs are valuable for understanding how a combination of factors contributes to an outcome, as opposed to regression that seeks to quantify patterns of net effects and dynamics between variables and is useful in questions not solvable by traditional statistical methods (BAUMGARTNER; AMBÜHL, 2018).

CCMs examine implication hypotheses that bind specific factor values, such as "$X = \chi i$ is [not redundantly - theory (M) INUS] sufficient/necessary for $Y = \gamma i$." They use a Boolean order on sets of causes, locating their elements in distinct or similar causal paths to the outcome by examining Boolean properties as described by causal regularity theories (BAUMGARTNER; AMBÜHL, 2018).

Qualitative Comparative Analysis (QCA), developed by Charles Ragin (1981, 1987, 2008), is a commonly used CCM to identify patterns that explain a particular condition or event through a truth table. This technique is a combination of aspects of quantitative and qualitative methods, which employs set theory and Boolean analysis to conduct research that focuses on comparing cases (MARX; CAMBRÉ; RIHOUX, 2013).

QCA has been widely used in several research fields, including organizational studies (CRAGUN, 2020). Fiss (2011), for example, used this approach to create typologies of organizations, from the combination of variables, testing causal hypotheses from these typologies. For Fiss, this approach is best suited to understand the complex causal relationships in organizations, which are often not binary or exclusionary.

However, QCA has limitations in dealing with the complexity of causal relationships in data analysis. It has a top-down algorithmic structure in model creation that is susceptible to questions about its ability to find what it sets out to identify (BAUMGARTNER, 2009a). Thus, while it is a useful approach for identifying some causal relationships, it fails to deal with multiple causes and causal sequentiality. It is currently being questioned whether it tracks causality or some other non-causal relationship (HAESEBROUCK; THOMANN, 2022).

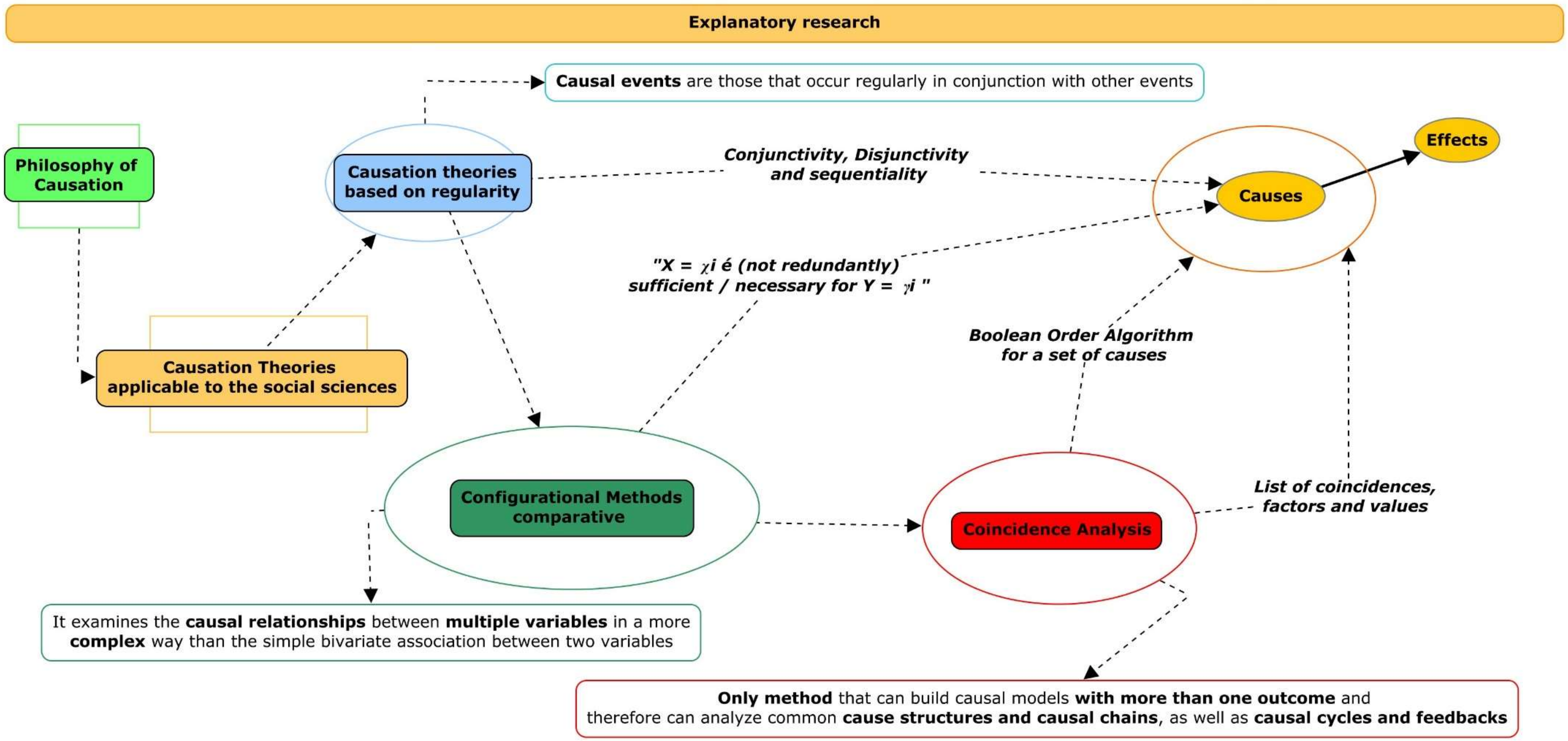
To overcome the limitations of QCA, Baumgartner (2009a) proposed a new approach in CCM called Coincidence Analysis (CNA). CNA can deal with causal complexity, allowing the analysis of multiple causes and their effects on the outcome. It uses a proprietary optimization algorithm that seeks to find minimally necessary and minimally sufficient conditions, fulfilling the requirements necessary to infer causality according to a formal theory of causation (BAUMGARTNER; EPPLE, 2014).

CNA takes a bottom-up approach, combining values of individual factors into more complex dependency structures (BAUMGARTNER; AMBÜHL, 2020). It begins by selecting an outcome to be explained to identify a set of relevant conditions to explain the outcome. Next, CNA uses Boolean logic to test all possible combinations of these conditions, aiming to identify the minimally necessary and sufficient causal configurations for the outcome in question (BAUMGARTNER, 2009a).

In this way, CNA can analyze structural and causal chains, allowing systematic cross-comparisons, while also ensuring the complexity of each case (BAUMGARTNER; EPPLE, 2014). This makes it possible to include adjusted hypotheses and model interactions between causes, putting it at a more advanced level for data analysis compared to QCA (SWIATCZAK; HAESEBROUCK, 2020).

CNA is a valuable tool for researchers and professionals who seek to understand the complexity of phenomena in different areas of knowledge. For Baumgartner and Ambühl (2021), CNA is the only existing method already tested in methodological benchmarking studies that allow the construction of causal models with more than one outcome, favoring the analysis of common cause structures and causal chains, as well as causal cycles and feedbacks. A synthesis of the explanatory research is presented for understanding causal complexity, taking into account the discussions held so far, before further delving into the CNA methodology (Figure 1).

Figure 1 Summary of the explanatory research for understanding causal complexity



Source: Elaborated by the authors.

COINCIDENCE ANALYSIS METHODOLOGY (CNA)

CNA seeks to identify patterns of causal relationships from a coincidence list. A coincidence refers to the instantiation of different factor values by the same case, where factors are categorical properties (qualitative characteristics) used to partition cases into subsets, and values are assignments that consider belonging or not belonging to a unit of observation in the identified subset (BAUMGARTNER; AMBÜHL, 2021).

The list of coincidences can have factors with bivalued or multivalued properties. Bivalued factors (defining only 2 disjoint subsets) can be classified as crisp-set attribution, characterized by a clear and definite separation between two distinct options or categories, or fuzzy-set attribution, which presents a continuous scale of pertinence, allowing an object or event to belong to a set at different degrees of intensity (BAUMGARTNER; AMBÜHL, 2018).

For crisp-set factors, only two scores are taken into consideration: "belongs" or "does not belong," represented by "1" and "0," respectively. For fuzzy-set factors, on the other hand, the assessment of pertinence can vary on a continuous scale in the closed interval of [0, 1], where "1" indicates full pertinence, "0" indicates not full pertinence, "0.5" indicates maximum ambiguity regarding pertinence in the sets in question, and values in the open intervals of (0, 0.5) and (0.5, 1) indicate varying degrees of pertinence (BAUMGARTNER; AMBÜHL, 2018).

For example, in a coincidence involving a binary factor "A" (e.g., interest or not interest) and a fuzzy-set factor "B" (e.g., interest or no interest in using mobile baking technology), if the pertinence score of "A" is "1," this means that the relationship belongs to "A" (mobile baking technology consumer). If the relevance score of "B" is "0.8," this means that the relationship belongs more to "B" (interest in using mobile banking technology) than to non-B (or "b").

In the case of multi-valued factors (where there are three or more disjointed subsets), it is possible to determine the relevance scores if a crisp-set score is used to identify the subset to which a case belongs. Thus, since the subsets are disjoint when a case belongs to a specific subset (e.g., economic stratum Class A), symbolized by "1," this implies that this case does not belong to other subsets, symbolically represented by "2," and so on (e.g., economic stratum Class B).

In fuzzy-set scoring systems with multivalued factors, it is essential to define the belonging scores for all subsets except the last one evaluated. This is because, since the subsets are disjoint and the sum of all fuzzy belonging scores for a case is equal to 1 (for example, the use of mobile banking for bill payment), it is possible to deduce the score for the last subset (THIEM, 2014). An example of a list of coincidences with bivalued and multivalued factors is shown (Frame 4).

Frame 4 Example of a list of coincidences with bivalued and multivalued properties

Prope		Consumer mobile baking technology	Interest to use mobile baking technology	Socioeconomic category	Mobile banking service of interest
Factor		A	B	C	D
Values		A: Consumer a: Non-consumer	B: Interested b: Not interested	1: A-Class 2: B-Class 3: Upper-Class C 4: Class D or E	1: Bill Payments 2: Transfers/Pix 3: Investments
		(Bivalorate)	(Bivalorate)	(Multivalorado)	(Multivalorado)
Score		*Crisp-set*	*Fuzzy-set*	*Crisp-set*	Fuzzy-set
Coincidences	C1	0 [a]	0,8 [B]	3 [Classe C]	(0,8, 0,2, 0,0) [1]
	C2	0 [a]	0,2 [b]	2 [Classe B]	(0,0, 1,0, 0,0) [2]
	C3	1 [A]	1 [B]	4 [Classe D ou E]	(0,6, 0,5, 0,5) [1]

Adapted Source: Freitas (2021).

The assignment of belonging scores is important to understand the degree of belonging of each element to a specific set or category. These scores can be used to identify patterns, trends, or relationships among the collected data, allowing for more accurate and informed analysis and decision-making (FREITAS, 2021). The assignment of fuzzy set-type belonging scores with bivalued factors can occur in two ways: (1) absolute, via direct assignment (DA), and (2) relative, via the Totally Fuzzy and Relative (TFR) approach (DUŞA, 2021).

The direct assignment method allows for the assignment of scores on a fuzzy set without the need to establish criteria, equations, or other calculations to define the limits between the pertinence categories. This technique is one of the simplest ways to obtain a calibrated condition from raw data. However, to avoid maximum ambiguity (0.5) in fuzzy scoring, experts usually opt for 4- or 6-point scales to convert raw data into fuzzy sets (DUŞA, 2021).

In turn, the Totally Fuzzy Relative (TFR) attribution method, proposed by Cheli and Lemmi (1995) and refined by Filippone, Cheli, and D'Agostino (2001) as TFRa, uses fuzzy set theory to model the uncertainty and subjectivity involved in multidimensional evaluations of certain constructs. The method consists of three steps: calibration, normalization, and attribution.

To analyze causality, the factors in a list of coincidences can be obtained through several data collection techniques, such as structured interviews in repertory grids for Honey's Content Analysis and Key Construct Categories Analysis, as shown in the study by Santos, Martins, and Freitas (2023), or the application of surveys with Likert-type scales, as used in the study by Nunes et al. (2022). Scenario-based experiments can also be used to collect data, as shown in Brescia's research (2021).

In CNA, coincidences are used to identify the minimally necessary and sufficient conditions for a given outcome, called the equifinal outcome. In other words, different combinations of conditions can achieve the same end goal through different paths and with different initial conditions. Identifying these conditions can aid in understanding complex social phenomena, particularly in comparative research (BAUMGARTNER; THIEM, 2015).

To identify causal models in a list of coincidences, CNA uses Boolean logic through a formal algorithm implemented in the free software package R®. The algorithm operates in two steps, searching for minimally sufficient and minimally necessary conditions to instantiate a specific result, testing factor values alone or combined by the operators "and" and "or," respectively (BAUMGARTNER; THIEM, 2015).

The search strategy consists of finding minimally sufficient conditions ("msc") to instantiate a specific result, starting with single values of one factor and progressing to combinations of several factors. If the initial search is not successful, the search advances to find other msc conditions through conjunctions formed by the logical "and" operator, combining two or more values of different factors (BAUMGARTNER, 2009a,b).

The second step of the search strategy involves finding the minimum conditions necessary to achieve the desired result, using the msc already identified. The search starts with individual msc, and if necessary, advances to disjunctions of two or more msc. These disjunctions are formed by the logical "or" operator and are used only if the previous msc search is unsuccessful (BAUMGARTNER, 2009a,b).

The models arising from the encountered conditions represent the "disjunctive normal form" ("disjunctive normal form," DNF), that is, minimally necessary disjunctions of minimally sufficient conditions for the instantiation of the outcome (BAUMGARTNER; AMBÜHL, 2018; BAUMGARTNER; FALK, 2019). The results obtained after completion are potentially causal models called Minimal Theories, which contain the most parsimonious causal models in explaining the analyzed outcomes.

The final solution is redundancy-free and can be an atomic solution for a single output [represented by "atomic solution formulas" (asf)] or a complex solution for multiple outputs [so-called "complex solution formulas" (csf)], according to the latest Regularity Theory (BAUMGARTNER; FALK, 2019). An example of a causal model generated by CNA is the expression "(A + B ↔ C) * (D + AB ↔ E)," which evidences the three Boolean properties already discussed: conjunctivity, disjunctivity, and sequentiality (BAUMGARTNER; AMBÜHL, 2021), where:

- A, B, C, D, and E represent the factor values;
- The asterisk symbol (*) represents the Boolean product (conjunction operation in propositional logic) and is translated as "and";
- The addition symbol (+) represents the Boolean sum (disjunction operation in propositional logic) and is translated as "or";
- The symbol ↔ represents Boolean equality (equivalence operation in proposition logic) and is translated as "if" and "only if," "necessary and sufficient for," or "sufficient and necessary for."

As an example, one of the theoretical expectations about the usage behavior of mobile banking technology by older consumers could be represented by the following expression: CMB * CRE * RAF ↔ ICF, where:

- CMB: belonging to the set of consumers with the highest frequency of mobile baking technology use;
- CRE: belonging to the set of seniors with positive beliefs regarding the use of mobile baking technology;
- RAF: belonging to the set of seniors with reasons in favor of using mobile baking technology;
- ICF: belonging to the set of seniors with the highest intention of future use of mobile baking technology.

To ensure the rigor of explanatory research with a qualitative-formal approach, CNA incorporates two properties into its methodology: consistency and coverage. Consistency is responsible for ensuring the reliability and replicability of the causal modeling results, representing the degree to which empirical evidence is consistent with the theoretical relationship of the sets. Coverage, on the other hand, seeks to consider all possible relevant causes, indicating the empirical relevance or importance of conditions (RIHOUX; RAGIN, 2009).

Robustness analysis is another inherent property of CNA. Robustness is a measure of a model's ability to withstand variations in the minimum consistency and coverage thresholds established for the construction of its models. In causal modeling, robustness refers to the ability of the model (or simpler or more complex versions of it) to be inferred even when there are variations in that parameter (PARKKINEN; BAUMGARTNER, 2023).

An example of code used in CNA is given and explained in Frame 5: ***cna(df, ordering=list("PRTH"), notcols="PRTH", strict=TRUE, con=0.75, cov=0.75, maxstep=c(3,3,9)) robust <- frscore(df,rat = c(0.95, 0.75, -0.05), allconcov=T, ordering=list("PRTH"), notcols= 'PRTH', strict=TRUE, output="asf", normalize=F, verbose=F, type="cs", inus.only=T, maxstep = c(3,3,9)) robust[order(robust$score, decreasing=T),]***

Frame 5 Example CNA and Fscore Function Parameter Description

Parameters	Description
df	Data set to be analyzed
ordering	Order in which the factors will be evaluated
notcols	Columns that will be considered in the analysis
strict	Indicates whether the analysis should be restricted or not
con	Minimum consistency score for a relationship to be considered
cov	Minimum coverage for a subset to be considered
maxstep	Maximum number of steps to identify a subset
rat	Vector of three values that defines the cut-off rate for each step of the analysis
allconcov	Indicates whether all coverages should be considered or only the largest one
output	Output format
normalize	Indicates whether scores should be normalized
verbose	Indicates whether status messages should be printed
type	Defines the cutoff type for the analysis
inus.only	Indicates whether only the results of the last step should be considered

Source: Elaborated by the authors.

RESULTS OF STUDIES APPLYING NAC

In this section, the practical applicability of the NAC methodological tool is presented for a more detailed analysis of the causal relations associated with social research and phenomena observed in Management studies. To this end, some studies conducted by researchers in Brazil and elsewhere in the world in recent years are shown.

SUPPLY CHAIN

The first study presented is by Santos, Martins, and Freitas (2023), who used CNA to identify how social capital contributes to the development of resilience in public administration supply networks. The research followed a qualitative-formal approach, using structured interviews with the repertory grid technique for data collection. The collected data were subjected to Honey's content analysis and key construct analysis before the application of the CNA.

A total of 247 constructs were identified in the research, grouped into 18 factors (attributes of social capital) that could causally explain resilience in supply networks. These factors were considered causally relevant since they appeared in at least one of the selected solutions. The factors that presented a frequency higher than 10% of the solutions found (50 models) were highlighted, i.e., those that occurred more than five times.

The study contributes to the literature by understanding social capital as a multilevel construct that influences the development of resilience in supply chains and by prioritizing the constructs that most impact resilience in the public sector, considering the perspective of inter-construct of the investigation was Rivalry organizational relationship practitioners.

The research pointed out that the development of resilience in public administration supply networks is strongly related to social capital, highlighting the attributes of sharing technical information, precision in communication, anticipation in the communication of relevant information, reciprocity, trust, transparency, and commitment.

These results have significant implications for business and public sector organizations, as they highlight the importance of building and strengthening social capital to increase the resilience of supply networks. This can lead to better coordination, collaboration, and adaptation in situations of crisis or disruption, benefiting not only the organizations involved but also society as a whole.

SPORTS MARKETING

A second study presented was developed by Nunes et al. (2022), which applies the CNA to assess how descriptive factors of rivalry combine in different ways to constitute these feelings that manifest themselves in different degrees of intensity. Using a qualitative-formal approach, a questionnaire with closed-ended questions on a 7-point Likert scale was applied in the survey at hand. The data collected from over 1000 fans were analyzed using the coincidence analysis technique.

In the study, the construct of the investigation was Rivalry (RIV), which refers to the feelings that a group of supporters harbors for the supporters, organization, sponsors, and others involved with the rival team. The aggregation of scores was used to address the constitution of the factors that made up Rivalry (Indirect competition, Outgroup sports spirit, Sense of satisfaction, Glory out of reflected failure, Schadenfreude, and Perception of reciprocal rivalry).

As from the NAC, the authors identified the most relevant factors for the constitution of rivalry among soccer fans. The innovative strategy of verifying the constitution of the constructs separately, before interpreting the second-level solution (relationship between first and second-level explanations in terms of aggregation), provided complementarity between the different explanatory levels.

According to the study, the supporter's relationship with his club sponsor is the only relevant causal factor for the consistent consumption of sponsored products. Rivalry is an important factor in product rejection, but only when combined with the supporter's identification with his club and his positive relationship with the companies that invest in his team. The study suggests that the absence of rivalry is sufficient to explain the consumption of products from rival sponsors.

The results of the study have great potential for future research in sports marketing. The asymmetric analysis perspective can be applied to other factors to better understand the relationships between them. In addition, the study indicates that rivalry can affect sponsor relationships and brand rejection, which can be useful for sponsors and sports marketing managers to understand fan behavior.

The study also found different subtypes of rivalry, ranging from less personal rivalry to more intimate opposition. This suggests that rivalry can be formed by alternative combinations, which seem to be associated with different subtypes of this feeling. The contribution of the study is relevant to the evaluation of rivalry from an individual perspective, rather than objectively analyzing a specific match.

The results showed that rivalry combined with fan identification with their club and their positive relationship with sponsoring companies influenced consistent consumption of sponsored products. These findings have implications for companies investing in sports sponsorships, as it highlights the importance of considering rivalry and fan identification when developing sports marketing strategies. Understanding how these factors interact can help companies better target their marketing efforts and strengthen relationships with fans, generating positive business impacts.

ORGANIZATIONAL CHANGES

A third study presented was conducted by Sprang, Miech, and Gusler (2023). The study uses configurational analysis to determine the necessary and sufficient conditions to produce reductions in secondary traumatic stress (STS) symptoms in workers as well as improvements in the well-being of individual professionals within organizations. The research involved a cohort of 6,033 professionals working with individuals exposed to trauma, representing 52 organizations.

The research investigated the role of organizational champions in promoting change in the STS approach in organizations. Organizational champions are individuals or teams who seek to promote change in their workplace. They are instrumental in promoting change in an organization, disseminating innovative ideas and strategies, and creating change across the enterprise. STS is a phenomenon that affects professionals indirectly exposed to trauma through the traumatic stories of their patients or clients.

Methodologically, "minimally sufficient conditions" (i.e., "msc") was applied within the R package "Cna" to examine all 52 cases and all 15 factors at once, aiming to identify specific combinations of conditions with especially strong connections to the outcome of interest. This exhaustive process considers every combination of values instantiated in the original dataset and identifies all one-, two-, and three-condition configurations that meet the specified consistency threshold.

The CNA results showed that organizational change in the STS approach and problem-solving strategies led by advocates (organizational champions) resulted in reductions in individual practitioners' STS symptoms. These results indicate the importance of organizational champions in promoting positive change in the STS approach in organizations.

Furthermore, the study also highlighted the importance of peer involvement and knowledge sharing among advocates in wellness environments. This type of approach led to improvements at the organizational level, showing that change at this level can have a direct impact on individual well-being. The study highlights the importance of raising awareness about secondary traumatic stress and addressing it in organizations.

Research suggests that organizations encourage strategies led by organizational champions and peer involvement to create a culture of wellness. Companies must provide resources to address the impact of STS on their employees and ensure a healthy work environment. Awareness and a proactive approach to STS are key.

In sum, the implications of these findings highlight the importance of recognizing and addressing secondary traumatic stress in organizations. By prioritizing strategies led by organizational champions and promoting a healthy work environment, businesses and public sector organizations can protect the well-being of their employees, promote positive change, and improve the quality of services offered.

LEAN MANAGEMENT

A fourth study presented was conducted by Charns et al. (2023). The research sought to understand what factors and organizational dynamics enable the Lean management (Lean) transformation of healthcare organizations. Primary research data was collected through two waves of interviews in 2016-2017 with 121 leaders and employees at seven veterans' medical centers participating in Lean business transformation.

In the paper, CNA was used to identify which factors and organizational dynamics enabled Lean management (Lean) transformation at seven U.S. Department of Veterans Affairs medical centers. For each center, 7 potential enablers were identified, coded, and ranked, and the outcome measure was the extent of Lean transformation, assessed by coding and ranking 11 markers of the depth and spread of transformation.

CNA was used to identify the enablers that distinguished among centers with different levels of Lean transformation, and representative quotes were identified for these enablers. As a result, it was possible to identify that leadership support and capability development were sufficient to achieve Lean transformation at three levels with 100% consistency and coverage. The study notes that high scores on both factors were related to high Lean transformation, medium scores on only one of the factors corresponded to medium transformation, and low scores on both factors corresponded to low transformation. Additionally, low scores on communication and data availability and very low scores on alignment characterized the centers with low transformation. Centers with high leadership support also showed high veteran involvement.

Overall, applying the CNA allowed the researchers to identify which factors were most important in achieving a successful transformation and which were least important. This can help healthcare organizations prioritize their transformation efforts and improve their chances of success.

GENERAL CONTRIBUTIONS OF THE STUDIES

The studies presented used Coincidence Analysis (CNA) as a comparative configurational methodology to conduct explanatory research in the field of social sciences and management. The use of CNA contributed to a deeper analysis of causal relationships in each of these studies, allowing the identification of specific configurations of variables that lead to certain outcomes.

An important methodological advance is the ability of CNA to identify emergent and configurational patterns, revealing how different combinations of factors influence a given outcome. This allows researchers to understand not only the linear relationships between isolated variables, as structural equation modeling seeks to do, but also the interactions and synergies between the elements of the system under analysis. This more integrated perspective is fundamental to advancing theoretical knowledge, providing a more complete and accurate view of the phenomena being studied.

In addition, the application of CNA also has relevant practical implications for researchers. By using this configurational approach, researchers can identify the key elements that drive a particular outcome and understand how these elements combine to create favorable or unfavorable conditions. This provides valuable insights for developing practical strategies and effective interventions in different contexts.

Researchers can use CNA results to propose more targeted and personalized recommendations for organizations, professionals, or individuals, taking into account the complexity and interconnectedness of the factors involved. This configurational approach can assist in making more informed decisions and developing more effective solutions to complex problems.

In addition, CNA can open up new research perspectives by encouraging more integrative and multidisciplinary approaches. By considering factor configurations rather than isolated variables, researchers can explore intersections between different fields of study and integrate knowledge from various disciplines. This can lead to a more comprehensive understanding of phenomena and the development of more robust theories.

CONSIDERATIONS

This theoretical paper explored how the application of comparative configurational methods, in particular Coincidence Analysis (CNA), can enrich the understanding of causal relationships in explanatory research developed in social and management studies.

Explanatory research is an important tool for understanding complex events in various areas of knowledge. Regularity Causation Theory is an approach that can be used to infer causal relationships based on observed regularities, which allows the identification of the real causes of a given event or behavior.

Furthermore, Comparative Configurational Methods are a way to identify complex patterns of causal relationships between values of variables, taking into account the interaction between them. In this sense, Coincidence Analysis (CNA) stands out as a more robust and correct methodological tool to explore common structures and causal chains in a configurational manner, allowing a deeper understanding of complex causal relationships in organizational contexts.

CNA presents properties of conjunctivity, disjunctivity, and sequentiality, which allows for a more complete analysis of the Boolean causal structure, identifying causes that tend to happen together, the existence of alternative paths or more than one cause, as well as causal chains. These features enable a more precise understanding of causality in a given event.

The CNA methodology is designed to retrieve Boolean causal links, which is particularly relevant for analyzing processes with conjunctural causality (component causation) and equifinality (alternative causation). These characteristics make CNA an essential tool for conducting rigorous explanatory research in Management and other disciplines that seek to understand the complexity of causal relationships in social and organizational phenomena.

Coincidence Analysis (CNA) has emerged as a promising approach, overcoming the limitations of Qualitative Comparative Analysis (QCA) and presenting a series of potentialities and opportunities for studies of various natures. By using CNA, researchers and professionals have access to an advanced methodology capable of dealing with the complexity of causal relationships and offering a deeper understanding of phenomena in different areas of knowledge.

One of the main advantages of CNA over QCA is its ability to deal with multiple causes and causal sequentiality. While QCA has a top-down algorithmic structure that can present difficulties in identifying complex relationships, CNA adopts a bottom-up approach, allowing the analysis of multiple causes and their effects on the outcome. This enables the modeling of interactions between causes and the inclusion of adjusted hypotheses, leading to a more accurate and comprehensive understanding of the phenomena studied.

The ability of CNA to analyze common cause structures, causal chains, causal cycles, and feedback is also crucial for a comprehensive understanding of the phenomena studied. This approach allows for a deeper analysis of the interactions between different variables, assisting in the identification of complex relationships and the formulation of more robust causal theories.

In summary, Coincidence Analysis (CNA) presents itself as a powerful analysis tool, overcoming the limitations of Qualitative Comparative Analysis (QCA). By offering a more flexible, comprehensive, and accurate approach to identifying causal relationships, CNA brings significant gains to businesses, companies, and society, providing valuable insights for strategic decision-making, the improvement of public policies, and the understanding of complex phenomena in various areas of knowledge.

Although QCA is a well-established and widely used technique in the field of Management, CNA is still largely ignored by researchers in this field. However, CNA has been gaining prominence and dominating applications of comparative configurational methods in journals from other prestigious disciplines, particularly in the areas of public health, and social and political sciences. Some of the major journals with published articles, and their JCR impact factor for 2021, are the Journal of General Internal Medicine [FI 6.473], Journal of Mixed Methods Research [FI 5.746], Sociological Methods & Research [FI 4.677], Health Services Research [FI 3.734], and Systematic Reviews [FI 3.136], among others.

CNA was first introduced by Baumgartner (2009a) and generalized by Baumgartner and Ambühl (2018). The literature on CNA methodology and its application are constantly expanding. A page on the University of Bergen's website (https://www.uib.no/en/cna/121344/cna-literature-and-software) brings together literature that provides an overview and updated material with the latest advances in the methodology. On that page, a Zotero CNA Group library provides bibliographic information, currently with 76 papers involving the CNA methodology.

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