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Qualitative comparative analysis (QCA): an application for the industry

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Abstract This article examines the management in Colombian industrial sectors using qualitative comparative analysis (QCA). This method conceptualizes cases as combinations of attributes and use Boolean algebra to derive simplified expressions of combinations that lead to a specific outcome. In this analysis, we show the value of this method for studying the management in the industrial from different approaches.

Keywords Qualitative comparative analysis · Industrial sector · Applied microeconomics

1 Introduction

Qualitative comparative analysis (QCA) was first suggested by Charles Ragin in 1987 as a method for analyzing data sets consisting of binary variables (Ragin 1987). The basic concept was to constitute such data by Boolean functions. In the meantime, Ragin (2000, 2008) has expanded the method to allow constructions of fuzzy set relations; further extensions allow dealing with variables having more than two values. As a research approach, QCA attempts to integrate qualitative and quantitative research methods (Rohwer 2010).

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This article thus concentrates on the connection between QCA and a case study. In particular, we aim at addressing two core questions that are subject to regular debates. On the one hand, does QCA relate to a specific conception of 'what is a case?' (Ragin and Becker 1992). On the other hand, in concrete terms, how evaluate the management in Colombian food industries conducting the successive stages of a QCA procedure?. These two questions will be analysed across this study showing QCA as an approach with its specific goals, assumptions, qualities and techniques to evaluate management in the industries.

The present article focuses on QCA as a data analysis technique in a case study to evaluate management in the manufacturing industries taking into account that the objective of this analysis is first of all illustrative. We will show that our methodology also has some weaknesses, and, hence, all proposed results should be interpreted with caution and in the light of our assumptions.

In the cases of emerging economies managed to achieve industrialized catch-up development especially in Latin American (Wolfe-Phillips 1979; Worsley 1979). Therefore, it is important to evaluate the management with the aim to determine what are the key factors that allow to achieve successful and sustainable management in the context of the industrial sector of emerging economies. Moreover, in these economies the development depends of suitable actions such as the modernization of the production, capital aid, and transfer of know-how, so that the developing countries can reach the stage of industrialized countries (Nuschler 2005) where these actions depend on adequate and appropriate management to strengthen the development and welling of these countries.

The reminder of this article is organized as follows. Section 2 presents our methodology. Section 3 presents the sample of the case study in the manufacturing industries using QCA. Section 4 shows results and discussion. Section 5 offers a several conclusions and main implications of the application of QCA in management case study for industry.

2 Methods and data

In this section, we explained methods and data used in this study with the aim to analysis our study case applying QCA.

2.1 Methods

QCA as method is founded on the binary logic of Boolean algebra. Each case is represented as a combination of causal and outcome conditions. The fundamental concept is that cases can be denoted by formal logical statements in which the independent variables (conditions) for each case, in combination, are seen as logically implying the score on the dependent variable (outcome) for that case. These combinations can be contrasted with each other and then logically simplified through a bottom–up process of paired comparison (Ragin 1987).

QCA's propensity to expose certain types of complex causal structures is only an asset if there are good (theoretical) reasons to believe that a phenomenon under study is driven by such a causal structure. No method is per se superior. Rather, its usefulness is determined by its fit to the research problem at hand (Wagemann and Schneider 2010).

The first stage in a QCA is to specify the significant causal conditions for the outcome variable. In this study the significant causal conditions are the institutional subsystems implied by the VoC-approach. The next step is to build a truth table with data for selected cases regarding the causal conditions and the outcome variable. Truth tables list the logically possible

combinations of conditions and the outcome associated with each combination. Moreover, a truth table elaborates and formalizes the process of examining cases.

Next, examination of a truth table by itself facilitates certain kinds of analysis. It allows for a study of diversity, showing which configurations are common and which ones do not happen or happen very seldom. If the cases are named, for example they are countries, or named organisations, then it is possible to study groupings of organisations that display the outcome bringing to bear on the analysis researcher knowledge and familiarity with particular cases.

The second step, the analysis of causal sufficiency which it calls a 'truth table solution', is a list of different combinations of causal factors that have met specified criteria of sufficiency for the outcome to occur. This involves that the membership score on the outcome is consistently higher than the membership score of the causal combination. The 'truth table' algorithm takes account both of the degree of inconsistency and of the notion that cases with strong membership of the causal condition or causal combination provide the most relevant cases.

To build the truth table, csQCA lays out all logically probably combinations of conditions which are considered, including those without empirical instances. The consistency score for a structure is a measure of the subset relationship. QCA analyses the extent to which specific causal factors or configurations are subsets of the outcome, and the consistency score measures this subset relationship. Consistency is thus a measure of the extent to which membership strength in the causal configuration is consistently equal to or less than membership in the outcome (Epstein et al. 2007: p. 10).

For each structure (row in the truth table), minimum membership scores (causal combination intersected with outcome) are added for all cases. This number is divided by the sum of all minimum membership scores in the causal combination. The formula of consistency is:

$$\text{Consistency}\,(X_i \leq Y_i) = \sum [\min\,(X_i, Y_i)] \,/\, \sum\,(X_i)\,.$$

In this formula, the min(X) is the intersection ("AND" or $\cap$) of all X. $\Sigma(X)$ is the union ("OR" or $\cup$) of all X When membership in outcome Y is less than membership in causal configuration X, the numerator will be smaller than the denominator and the consistency score will decrease. "Consistency scores range from 0 to 1, with 0 indicating no subset relationship and a score of 1 denoting a perfect subset relationship (Epstein et al. 2007: p. 10)."

In contrast, coverage applies to the proportion of the sum of the membership scores in an outcome that a particular configuration explains. In other words, it explains how many cases are covered with the sufficiency configuration for outcome Y. The high coverage score denotes that the configuration is consistent with the outcome and it has many cases with the configuration outcome "in", while low coverage scores indicate that even if the causal configuration is consistent with the outcome, it is substantively trivial. Studying coverage scores supports us in avoiding spurious configurations for the chosen outcome.

$$\text{Coverage}\,(X_i \geq Y_i) = \sum [\min\,(X_i, Y_i)] \,/\, \sum\,(Y_i)\,.$$

The results show the calculation of both raw and unique coverage of each combination. The raw and unique coverage joined to an outcome is very applicable as it not only reveals coverage of each configuration but also its relative empirical weight (Ragin 2006). This calculation is very applicable when there are many several paths to the same outcome. Raw coverage measures 'the relative importance of several combinations of causally relevant conditions' (Ragin 2006: p. 305): the proportion that a configuration covers the outcome. It is assessed

by the sum of consistent scores of the configuration divided by the sum of outcome scores. On the other hand, unique coverage assesses the weight of the configuration: the proportion that uniquely covers the outcome. Unique coverage is calculated by the coverage of a configuration of interest from the set of configurations minus the raw coverage of configurations without the particular configuration of interest. The robustness of the results of the truth table algorithm turns on getting a balance of consistency and coverage.

2.2 Data

Data for this study come from a survey applied to different Colombian industrial sectors. This survey was designed to identify several factors and variables that determine management in the Colombian industrial sectors, including questions on the rules of company, management results and conditions of the manager position.

3 Case study description from the approach QCA

The subject of this study is the management in the industrial sector of an emerging economy such as Colombia. Regarding case selection, the strategy is to select different Colombian industrial sectors with similar features.

This study seeks to analysis the management in industrial sector taking into account the role of the manager through the results and the maintenance of the control of the industry during the time period determined. Therefore, the research question that guides this analysis is the following: *Under what conditions achieve a manager to maintain this position?*

In this case, the dependent variable is the maintenance of the position of the manager (Z) during several time periods established by the rules of the company. As independent variables that explain this situation, we selected the following:

$A = 1$ if the rules of the company allow the reelection of the manager, $A = 0$ otherwise.
$B = 1$ if the manager has made a good management, $B = 0$ otherwise.
$C = 1$ if the board of directors nominates a strong candidate, $C = 0$ otherwise.

Table 1 show the analysis of variables for every case study of the industrial sector taking into account the relationship with independent variables and the research question taking into account descriptive framework.

Table 1 Relationship between dependent and independent variables

Case	Z	A	B	C
I	Reelected	Reelection allowed	Good management	No strong candidate
II	Reelected	Reelection allowed	Bad management	No strong candidate
III	No-reelected	Reelection allowed	Bad management	Strong candidate
IV	No-reelected	Reelection allowed	Good management	Strong candidate
V	No-reelected	Reelection allowed	Bad management	Strong candidate
VI	Reelected	Reelection allowed	Bad management	Strong candidate
VII	Reelected	Reelection allowed	Good management	Strong candidate

Variables: Z: Reelection; A: The rules of the company allow the reelection; B: Management evaluation; C: Strong candidate

Table 2 Truth table of the relationship between dependent and independent variables

Case	*Z*	*A*	*B*	*C*
I	1	1	1	0
II	1	1	0	0
III	0	1	0	1
IV	0	1	1	0
V	1	1	1	1
VI	0	1	0	0
VII	0	1	1	1
VIII	1	1	0	1
IX	1	1	1	1

Variables: *Z*: Reelection; *A*: The rules of the company allow the reelection; *B*: Management evaluation; *C*: Strong candidate

Table 2 show the same descriptive framework of Table 1 using the binary framework to define the behavior of variables used in this study. A value of one is assigned when the feature exists, whereas a value of zero is assigned when the feature does not exist.

In the Table 2, the majority of cases with successful reelection have two common features or conditions: (1) the rules of the company allow the reelection and (2) the absence of a strong candidate. This fact should suggest that both features could be necessaries to obtain reelection. On the other hand, it is clear that *A* (rules of the company) is not an enough condition to achieve reelection, but *C* (strong candidate) if could be. This table could generate the following conclusions: *A* and *C* are individually necessary causes and jointly enough for the reelection and *C* is an individual necessary condition and enough for the reelection, whereas *A* could be irrelevant taking into account difference method.

4 Results and discussion

In this section, we show the results obtained of the application of csQCA to analysis our case study from approach of this method.

4.1 Truth table analysis

Table 3 shows the completed truth table from csQCA. The consist column gives the measure of consistency. It means that the membership score on the outcome is consistently higher than the membership score of the causal combination, weighted by the relevance of each case. Consistency scores of less than 0.75 or even 0.8 mean that there is considerable inconsistency. Scores should be above 0.9. The top configuration has a consistency 1.0. The rest have

Table 3 The completed truth table

A	*B*	*C*	Number	Consist
1	1	0	5	1.000
1	0	0	5	1.000
1	1	1	4	0.600
1	0	1	2	0.600

Table 4 Truth table analysis

	Raw coverage	Unique coverage	Consistency
a*∼c	0.500	0.500	1.000
∼c	0.500	0.500	1.000
∼c*a	0.500	0.500	1.000
Solution coverage	0.500		
Solution consistency	1.000		

too much inconsistency. So, only the first two rows are consistent with those configurations being, for the most part, sufficient to analyse the conditions that achieve that a manager maintains this position. However, only the first two rows are consistent with those configurations being, for the most part, sufficient for the analysis of the case study. Moreover, an analysis of necessary conditions shows that the condition of reelection allowed and the condition of no strong candidate are consistent with necessity with a score of over 0.8.

Table 4 shows the solution for the case study from csQCA. The raw coverage is 50% for the instances of the outcome and consistency is one. This shows that the absence of a strong candidate it is sufficient, for that a manager achieves to maintain this position. However, the presence of the rules of the company allows the reelection appears to make little difference in the possible solutions.

These results indicate that a manager should maintain this position while the board of directors does not nominate a strong candidate implying that the results of management have not influence in the changes of a manager in a company. The results should explain by the fact that the companies analysed are small and medium enterprises with familiar management that guarantee the maintenance of the manager.

The results of both csQCA illustrated that more than one causal condition conjecturally were working together to bring about an outcome. Also, more than one set of such conjectural causes exist which could lead the maintenance of the manager position.

5 Conclusions

In this article, we have used the QCA to analysis the management in the Colombian industrial sector from approach of the manager taking into account the conditions that allow that a manager maintains this position. With this aim, the independent variables selected were the following: the rules of the company, the results of management and the nomination of a strong candidate.

QCA as method is founded on the binary logic of Boolean algebra. Each case is represented as a combination of causal and outcome conditions. The idea is that cases can be represented by formal logical statements in which the independent variables (conditions) for each case, in combination, are seen as logically implying the score on the dependent variable (outcome) for that case. These combinations can be contrasted with each other and then logically simplified through a bottom–up process of paired comparison.

The results indicate that the rules of the company is not an enough condition to achieve reelection of a manager, but the nomination of a strong candidate if could be. Therefore, the rules of the company and the nomination of a strong candidate are individually necessary causes and jointly enough for the reelection. Moreover, the results also indicate that a manager should maintain this position while the board of directors does not nominate a strong candidate implying that the results of management have not influence in the changes of a

manager in a company which could be explained by the fact that the companies analysed are small and medium enterprises with familiar management that guarantee the maintenance of the manager.

With this case study, we can demonstrate that QCA it is an important method to analyse the management with different approaches that combine causal relationships in the industrial management.

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