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Identifying single necessary conditions with NCA and fsQCA☆

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ABSTRACT

Single necessary (but not sufficient) conditions are critically important for business theory and practice. Without them, the outcomes cannot occur, and other conditions cannot compensate for this absence. Currently two analytical approaches are available for identifying single necessary conditions: Necessary Condition Analysis (NCA), which was recently developed, and fuzzy-set qualitative comparative analysis (fsQCA), which is a more established approach. FsQCA normally focuses on sufficient but not necessary configurations, but can also identify necessary but not sufficient conditions. This study uses NCA to analyze two examples of empirical datasets published in the Journal of Business Research that use fsQCA to identify single necessary conditions. A comparison of the results of NCA and fsQCA shows that NCA can identify more necessary conditions than fsQCA and can specify the level of the condition that is required for a given level of the outcome.

1. Introduction

Business researchers and practitioners acknowledge that single variables (organizational efforts, resources, etc.) cannot produce the outcome of interest (e.g., good performance). Complex combinations of single conditions are more likely to explain (i.e., are sufficient for) that outcome. For example, Wu et al. (2014, p. 1666) state that "complexity theory includes the recognition that no simple condition is the cause of an outcome of interest." Woodside (2013, p. 465) reports that "the use of expressions, "key success factors" and "critical success factors" […] is misleading […]."

Although single sufficient conditions to produce the outcome normally do not exist, single necessary conditions that allow the outcome to occur are widespread. For example, a student who wishes to enter a graduate program needs to have an adequate GRE test score, sales success is only possible if a salesman has a learning attitude, a highly cited methodological paper must have practical recommendations, and a Caesar salad must have croutons. In these examples (discussed in Dul, 2016), an adequate GRE score, a learning attitude, practical recommendations, and croutons are necessary conditions for the desired outcomes. The examples show that necessary conditions are very common and very relevant. If a single necessary condition is not in place, the outcome will not occur (hence the absence of the condition results in guaranteed failure). But if the necessary condition is in place, the outcome is not guaranteed (hence the presence of the condition does not produce guaranteed success). All single necessary conditions must be part of any configuration that produces (i.e., is sufficient for) the outcome. For example, if management commitment were an organizational ingredient that is necessary for successful organizational change, any sufficient configuration for successful change would have to include management commitment. Without this ingredient, the intended successful change would fail. However, management commitment as a single condition would not produce the outcome. Therefore, researchers should identify single necessary conditions. Other conditions cannot compensate for the absence of the single necessary condition.

Currently two methods are available for identifying single necessary conditions: Necessary Condition Analysis (NCA) and fsQCA (Vis & Dul, 2014). The operationalization of "necessary condition" is different in these methods (see Fig. 1).

FsQCA (Ragin, 2008) is a set-theoretical technique in which X and Y represent calibrated set membership scores. FsQCA recommends conducting a necessity analysis before performing the core analysis, which identifies sufficient configurations using a truth table (e.g., Schneider & Wagemann, 2010). In fsQCA, a condition is necessary if $Y \leq X$ for all X and Y values. In other words, for condition X to be necessary, all cases must be on or below the diagonal, which is fsQCA's reference line (Fig. 1, left). FsQCA formulates a qualitative *in kind* necessary condition: condition X is necessary for outcome Y. This formulation assumes that necessity applies to the entire range of X and Y values. FsQCA does not express degrees of membership when formulating the necessary condition. Besides identifying single necessary conditions, fsQCA also identifies necessary combinations of conditions and distinguishes between necessary AND-combinations (e.g., X_1 AND X_2 are

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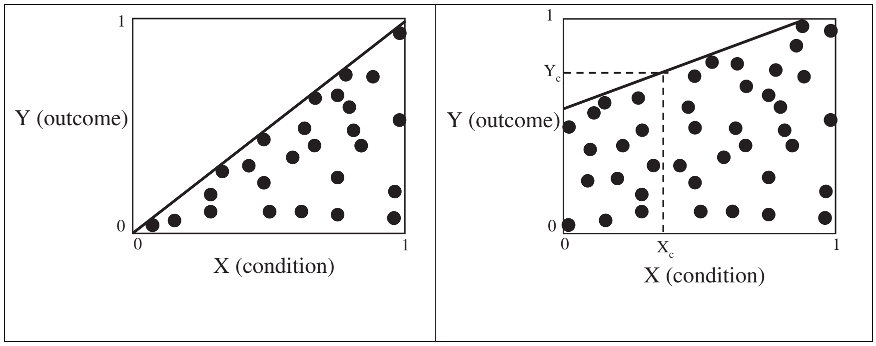

Fig. 1. Necessary relationship between X and Y. Left: fsQCA: all cases are below the diagonal reference line. Right: NCA: all cases are below the ceiling line.

necessary for Y) and necessary OR-combinations (e.g., X_1 OR X_2 are necessary for Y). Each single condition in a necessary AND-combination is a single necessary condition. Each single condition in a necessary OR-combination is a substitute of an underlying higher order single necessary condition (e.g., green apples OR red apples are necessary for an apple pie, where apple is the underlying necessary condition; Vis & Dul, 2014). This study focuses on identifying single necessary conditions only.

In contrast to fsQCA, NCA (Dul, 2016) formulates a quantitative *in degree* necessary condition and expresses which level of condition X is necessary for which level of condition Y. NCA's reference line is not the diagonal, but the ceiling line drawn on top of all cases (see the two examples in Fig. 1). This reference line represents all possible combinations of values of X and Y where X is necessary for Y and allows the formulation of many *in degree* statements of necessity, depending on the levels of X and Y. NCA formulates a quantitative *in degree* necessary condition: level $X \geq X_C$ of condition X is necessary for level Y_c of outcome Y. A necessary condition statement *in degree* is more detailed than a necessary condition statement *in kind*: the *in degree* statement explains which level of X is necessary for which level of Y. For example, when the ceiling line corresponds to the diagonal (Fig. 1, left), the following three necessary conditions could be formulated: $X \geq 0.4$ (the condition is at least “more out than in”) is necessary for $Y = 0.4$ (the outcome is “more out than in”), or $X \geq 0.6$ (the condition is at least “more in than out”), is necessary for $Y = 0.6$ (the outcome is “more in than out”), or $X \geq 0.8$ (the condition is at least “almost fully in”) is necessary for $Y = 0.8$ (the outcome is “almost fully in”). FsQCA does not usually formulate such *in degree* statements.

Another important difference between NCA and fsQCA is that NCA does not require the ceiling line to be diagonal. Whereas fsQCA's necessity uses $Y \leq X$ to formulate the qualitative *in kind* necessity statement, NCA's necessity requires $Y \leq f(X)$, where $f(X)$ can be any function. Hence, fsQCA's reference line (the diagonal) is a special case of NCA's ceiling line. Fig. 1 (right) shows an example of a linear increasing ceiling line $Y = aX + b$. NCA then formulates the necessary condition as $Y \leq aX + b$. As a result, the *in degree* statement of necessity could be, for example, that $X \geq X_c = 0.4$ (the condition is at least “more out than in the X set”) is necessary for $Y_c = 0.8$ (the outcome is “almost fully in the Y set”). This formulation of the necessary condition is impossible with fsQCA, although a small X membership score below 0.5 could be necessary for a high outcome score. Furthermore, whereas fsQCA presumes that X is necessary for Y for all ranges of X and Y, NCA's non-diagonal ceiling line shows that in certain ranges of X, the condition does not constrain the outcome, and in certain ranges of Y, the outcome is not constrained by the condition. Hence, in these ranges of the condition and the outcome, X is <u>not</u> necessary for Y (“necessity inefficiency”, Dul, 2016), whereas X <u>is</u> necessary for Y in other ranges.

A final difference between fsQCA and NCA is that fsQCA is a set-theoretic approach requiring that X and Y are calibrated set membership scores. NCA requires that X and Y are meaningful scores of the condition and the outcome. These scores can be calibrated set membership scores, as in the above examples, but also valid and reliable variable measurement scores. Consequently, researchers can apply NCA directly to meaningful, valid, and reliable original scores. Having meaningful data is a requirement for any data analysis approach.

Many XY plots of meaningful data show an empty zone in the upper left hand corner, indicating the possibility of the presence of a necessary condition. However, the perfect “triangular” scatterplot (Fig. 1, left) is relatively seldom. Usually scatterplots are “pentagonal” (Fig. 1, right). Consequently, NCA's ceiling line is positioned above rather than on fsQCA's diagonal. NCA identifies that X is necessary for Y for a specific range of X and Y values, whereas fsQCA considers the entire range of X and Y values to state that X is necessary for Y or not. Consequently, if the ceiling line is above the diagonal, NCA identifies a necessary condition, whereas fsQCA may not. FsQCA finds a necessary condition when the majority of the cases is below the diagonal reference line ($X \leq Y$). If too many cases are above the reference line (determined by the necessity consistency quantity), fsQCA does not identify a necessary condition, whereas NCA does. For example, NCA can find that the condition being at least “more out than in” of the set (X-membership score ≥ 0.4) is necessary for the outcome being “fully in the set” (Y-membership score $= 1.0$).

This article compares NCA with fsQCA (as used in the Journal of Business Research (JBR), which is currently the major outlet of QCA papers in business) to identify single necessary conditions in datasets. The article explains how NCA and fsQCA identify these conditions in further detail and then compares the methodologies using two examples published in JBR. The two examples use fsQCA differently to identify necessary conditions. The first example (Tóth, Thiesbrummel, Henneberg, & Naudé, 2015) uses fsQCA's necessity consistency (with recommended necessity consistency threshold of 0.9) to identify necessary conditions. The second example (Skarmeas, Leonidou, & Saridakis, 2014) identifies a single necessary condition by observing the single condition that is present in all selected sufficient configurations (with usual sufficiency threshold of 0.8). Using the papers' datasets, this article compares the results of these two fsQCA approaches with the results of an NCA analysis.

2. Identifying necessary conditions with NCA

NCA (Dul, 2016) draws a ceiling above the cases in the space of cases. NCA puts a “blanket” on the data in the three-dimensional space, and a line in the two-dimensional space. The ceiling $Y = f(X)$ separates the area with cases and the area without cases. The ceiling approach is in contrast with traditional regression where a line (2D) or surface (3D) is drawn through the middle of the data. The necessary condition X for Y is represented by inequality $Y \leq f(X)$: all cases are on or below the ceiling. In practice, exceptions (outliers, errors, etc.) may be present such that the “empty zone” above the ceiling is not entirely empty. Dul, Hak, Goertz, and Voss (2010) suggest allowing 5% exceptions. Several