Using Crisp Sets in QCA: An Introduction

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Agenda

- Introduce Crisp-set QCA and its mechanics (e.g. Ragin, 1987, 2000, Ragin etal. 2006, Greckhamer etal. 2008)
- Illustrate logic of set-theoretic analysis

Set-theoretic Logic: Basic Assumptions

- Causality is complex
- Cases are viewed as configurations, defined through their multiple set memberships
  - Theoretical understanding of diversity of cases
- Compare set memberships to reveal patterns of similarities/differences of cases sharing outcome
  - Identify configurations and their relationships to outcomes

Steps of Crisp Set Analysis

1. Select cases & theoretically relevant attributes
   a) Select cases based on substantive interest
   b) Select attributes and construct sets—Crisp sets distinguish ‘in’ (1, full membership), and ‘out’ (0, full non-membership)
2. Construct truth-tables—all logically possible configurations of included attributes
3. Analyze complex relationships between attributes and outcome of interest (necessity and sufficiency)
4. Evaluate and interpret results

I illustrate these with simple hypothetical example

Illustration: Hypothetical example of small-N setting

- RQ: What causes superior financial performance in bicycle manufacturing?
  - In this illustration I do not consider causes of absence of superior performance
- Hypothetical small-N dataset of 20 bicycle manufacturing firms, 5 attributes
  - Experience: years producing bicycles
  - R&Dintensity: R&D spending
  - NewMRP: New MRP system implemented?
  - Size: Size of the firm:
  - VertInt: Firm vertically integrated into distribution?

Step 1: Define and Establish Crisp Sets

- Define sets, including outcome:
  - "Set of large firms" (alt. "small firms"), "Set of experienced firms", "Set of vertically integrated firms", etc.
- Decide membership: In crisp-sets only full membership versus full non-membership (1/0)
  - Use theory and empirical knowledge to set breakpoints
- Common points of critique
  - Information loss through dichotomization
  - Potential arbitrariness of threshold
- Some responses:
  - Maintain complexity while simplifying it
  - When dichotomization is not straightforward, experiment
  - Consider fuzzy-sets to enable degrees of membership (later)

Illustration: Partial Crisp data set

Case	Experience	R&Dintense	NewMRP	FirmSize	VertIntegrated	HP
Firm1	1	0	1	1	0	0
Firm2	0	0	0	0	1	0
Firm3	1	1	1	1	1	1
Firm4	1	0	1	0	1	1
Firm5	0	0	1	0	0	0
…						

Step 2: Constructing Truth Table

- Construct Truth Table: Each row logically possible combination of crisp-sets (2^n logically possible) / Boolean expression
- Sort cases into configurations and record outcomes & consistency
  - In this example: 5 attributes = 2^n = 32 logically possible combinations
- Code outcome value

Boolean Operators: Expressing Combinatorial Logic

- QCA uses Boolean algebra to express combinatorial logic and perform comparisons
- Logical *and* (•) represents intersection of sets (→ for logical implication).
  - E.g.: size • r&dintense → superior performance
- Logical or (+) represents union of sets
  - E.g.: size • r&dintense + age • r&dintense → superior performance
  - r&dintense • (size + age) → superior performance
- Logical negation (~)
  - ~ size (0 or non-membership in set of large firms)

Simplifying Truth Table

- Boolean algebra is used to reduce truth table to expression covering combinations with same outcome (superior performance)

Simple example:

size • r&dintense + size • ~r&dintense → superior performance

size • (r&dintense + ~ r&dintense) → superior performance =

size → superior performance

Necessary and Sufficient conditions

- **Necessary condition:** must be present for an outcome to occur => when condition is necessary, all cases with outcome will exhibit causal condition
  - (e.g. all firms with superior performance are large)
- **Sufficient condition:** condition can by itself produce an outcome => all occurrences of condition are followed by the outcome
  - (e.g. all large firms have superior performance)

“Complex solution”

vertint•size•newmrp•experience +

(raw/unique coverage=0.625/0.5, consistency=1)

vertint•newmrp•~r&dintense•experience

(raw/unique coverage=0.37/0.25, consistency=1)

→ Superior Performance

(solution coverage/consistency = .875/1)

Simplified to:

vertint• experience•newmrp•(size+~r&dintense)

→ Superior Performance

“Parsimonious solution”

- **vertint•experience → Superior Performance**
  (Raw/unique/solution coverage=.875, consistency=1)

"Intermediate solution"

- **vertint• experience (size+~r&dintense)**

→ Superior Performance

(Raw/unique/solution coverage=.875, consistency=1)

Interpretation of Results

1. No component is necessary for superior performance
2. **Vertical integration into distribution, experience,** implementation of new MRP system, and either experience or not R&D intensive operations associated with superior performance (**core conditions bold)**
   - *Note: N too small to draw statistical inferences and conclude a combination is sufficient for high performance (Sufficiency shows only association)*

How NOT to Interpret Results

- Do not interpret "independent effects" separate from combinations
  - Firms lacking vertical integration are less likely to show superior performance (1 case with superior performance) than firms with vertical integration (7 successful cases)
  - Increased experience will incrementally increase likelihood of high financial performance of non-R&Dintensive firms
  - Size is positively associated with high financial performance in case of experienced firm

Crisp Sets: Conclusion

- Crisp sets contain basic logic of set-theoretic methods
  - Limited to 1/0 membership
  - Fuzzy set-theory is more sophisticated, relies on same principles
- Systematic comparison for small N
- Value of alternative model of causality