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An Introduction to fsQCA (Fuzzy-set Analysis)

Vilmos Misangyi
 Pennsylvania State University

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Agenda

- **Calibration**
 - Differences and Similarities to Crisp-sets
- **Analyses**
 - Diversity of membership across cases
 - Membership in configurations using Boolean logic (“and”)
 - Systematic examination of “consistent connections”
- **Empirical Example:**
 - Misangyi & Gregan-Paxton (U. of Delaware)
 - Decoupling among adopters of an institutional form: environmental management systems (EMS).
 - Sample: 29 US corporate facilities adopting EMS
 - National Database on EMS; Real-time, in-depth surveys


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Empirical Example

- **Research question: How do we make sense of organizational decoupling in institutional context surrounding business' impact on natural environment:**
 - Decoupling = program adoption (i.e., intentions) with non-implementation of expected practices (i.e., actions)
 - uncertainty and ambiguity in means-ends linkages and competing logics of action
 - Institutional logics = logic of action + practices
- **EMS: "process standards" (i.e., ISO14001) thought to help to improve corporate environmental performance.**
 - "most acceptable badge of achievement on environmental management" (Hillary, 2000: 16)
 - Concern that EMS adoptions are simply "part of a green ceremonial façade" (Forbes & Jermier, 2002: 206)

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Calibration of Fuzzy-Sets

- Crisp-sets capture *differences in kind* (i.e., 1/0) whereas fuzzy-sets capture both *differences in kind and degree*
- Multiple calibrations (3-, 4-, 5-, 6- value, continuous)
 - Three-value fuzzy set:
 - (1.0 = fully in; 0.5 = neither in nor out; 0.0 = fully out)
 - “Continuous” fuzzy set:
 - (1.0 = fully in; $0.5 < X < 1.0$ = more in than out; 0.5 = neither in nor out; $0.0 < X < 0.5$ = more out than in; 0.0 = fully out)
- Capture rich qualitative data and/or quantitative data (ordinal, ratio, or interval)
 - fsQCA software aids in conversion of latter

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Sets are “*Purposefully Calibrated*”

(italics in original; Ragin, 2008: 30)

- Calibration is based upon theoretical and substantive knowledge.
 - Translation based upon three qualitative anchors: full membership, full non-membership, cross-over point.
 - “External standards”: body of social and scientific knowledge and empirical evidence.
- Fundamentally different from variables and ordinal scales
 - NOT ranking of cases relative to each other as in ordinal scales
 - NOT inductively derived from sample-specific mean as are variables.


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Example: Cases' Set Memberships in EMS Practices

EMS
=
Plan
Do
Check
Act

Core: EMS Responsibility
Margin: Management Rewards
Employee Rewards





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Example: Cases' Set Memberships in EMS Practices

EMS
=
Plan
Do
Check
Act


Assess using 5-point Fuzzy Scale:
1 = "fully in"
.75 = "more in than out"
.50 = "neither in nor out"
.25 = "more out than in"
0 = "fully out"






Example: Calibrating Management Rewards


- NDEMS Survey:
 - “Is the facility’s environmental performance...incorporated into the incentive structure of *managers* (italics in original)?”
 - Possible response: yes or no. If yes, “please explain how”.






Example: Calibrating Management Rewards

- Fuzzy-set calibration:
 - 0: Environmental performance was not incorporated into the incentive structure of managers
 - .25: Environmental performance minimally incorporated (e.g., “very slightly and not directly”)
 - .75: Environmental performance partially incorporated (e.g., “environmental performance is part of performance reviews of managers”)
 - 1: Environmental performance fully incorporated (e.g., “environmental performance is viewed equally with other business performance factors”)




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Fuzzy-set Analysis

- Diversity of set memberships across cases
 - Chi-square tests (Greckhammer et al., 2008)
- Membership in configurations of practices
 - Boolean algebra and logics (i.e., *and* •)
- Systematic exam of “explicit connections” (Ragin, 2006; 2008)
 - “best understood as uniformities or near uniformities in social phenomena” and uniformities may reflect “causal connections” as well as “other types of integral connections (e.g., constitutive relationships)” (Ragin, 2006: 19).
 - Truth table algorithm
 - Subset analysis: Sufficiency of theoretical attributes (“causal conditions”) for condition of interest (“outcome”)

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ID	"Plan" Practices			"Do" Practices							
	Core	Margin	Intersection	Core	Margin	Intersection	Core	Margin	Intersection		
	Set EMS Objective (setobj)	External Stakeholder (estklv)	setobj*estklv	EMS Responsibility (emresp)	Manager Rewards (mgrreward)	Nonmanager Rewards (nmgreward)	emresp*mgreward*ereward	Training Program (train)	Aware Training (awtrain)	Job Training (jtrain)	train*awtrain*jtrain
1652	1	.25	.25	0	0	0	0	1	1	1	1
2230	1	0	0	1	0	0	0	1	.75	0	0
2843	1	0	0	1	.75	.75	.75	1	.25	.50	.25
2924	1	0	0	1	.75	.75	.75	1	.75	.75	.75
3378	1	1	1	1	.75	.75	.75	1	.75	.50	.5
3384	1	0	0	0	0	0	0	1	1	0	0
3789	1	1	1	1	.75	.75	.75	1	1	.75	.75
4754	1	1	1	1	0	0	0	1	.25	0	0
4857	1	1	1	1	0	0	0	0	0	0	0
5120	1	0	0	0	0	0	0	0	0	0	0
5557	1	1	1	1	.25	.25	.25	1	.50	.75	.5
5840	1	0	0	0	0	0	0	1	.50	0	0
5863	1	0	0	1	1	.25	.25	1	.50	.50	.5
6275	1	.25	.25	0	.25	0	0	1	.50	0	0
6543	1	0	0	1	.75	.25	.25	1	.75	.75	.75
6545	1	1	1	1	0	0	0	1	.75	0	0
6989	1	0	0	0	.25	.25	.25	1	1	1	1
7102	1	0	0	1	.75	0	0	1	1	0	0
7768	1	.25	.25	1	.75	.25	.25	1	1	.50	.5
8048	1	0	0	1	0	.25	0	1	.50	.75	.5
8256	1	0	0	1	.75	0	0	1	.50	1	.5
8525	1	.25	.25	1	0	0	0	1	.50	0	0
8610	1	0	0	0	.75	.50	0	1	1	0	0
9149	1	0	0	1	0	0	0	1	1	1	1
9402	1	0	0	1	0	0	0	0	0	0	0
9525	1	0	0	1	1	0	0	1	1	0	0
9534	1	.75	.75	1	0	0	0	0	0	0	0
9773	1	0	0	1	.75	.75	.75	1	1	1	1
9793	1	1	1	1	.75	1	.75	1	1	1	1

Total Counts by Fuzzy Value and Chi-square Test for Non-Random Diversity of Practice Implementations											
1	29	7	7	22	2	1	0	25	11	6	5
.75	0	1	1	0	11	5	6	0	5	4	3
.5	0	0	0	0	0	1	0	0	7	4	6
.25	0	4	4	0	3	6	5	0	2	0	1
0	0	17	17	7	13	16	18	4	4	14	14
χ^2 stat.	29.00***	32.21***	32.21***	7.76**	23.24***	26.00***	37.38***	15.21***	8.07*	18.07**	17.03**



Fuzzy-set Analysis

- Diversity of set memberships across cases
 - Chi-square tests (Greckhammer et al., 2008)
- Membership in configurations of practices
 - Boolean algebra and logics (i.e., and ●)
- Systematic exam of "explicit connections" (Ragin, 2006; 2008)
 - "best understood as uniformities or near uniformities in social phenomena" and uniformities may reflect "causal connections" as well as "other types of integral connections (e.g., constitutive relationships)" (Ragin, 2006: 19).
 - Truth table algorithm
 - Subset analysis: Sufficiency of theoretical attributes ("causal conditions") for condition of interest ("outcome")




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1652	1	.25	.25	0	0	0	0	1	1	1	1
2230	1	0	0	1	0	0	0	1	.75	0	0
2843	1	0	0	1	.75	.75	.75	1	.25	.50	.25
2924	1	0	0	1	.75	.75	.75	1	.75	.75	.75
3378	1	1	1	1	.75	.75	.75	1	.75	.50	.5
3384	1	0	0	0	0	0	0	1	1	0	0
3789	1	1	1	1	.75	.75	.75	1	1	.75	.75
4754	1	1	1	1	0	0	0	1	.25	0	0
4857	1	1	1	1	0	0	0	0	0	0	0
5120	1	0	0	0	0	0	0	0	0	0	0
5557	1	1	1	1	.25	.25	.25	1	.50	.75	.5
5840	1	0	0	0	0	0	0	1	.50	0	0
5863	1	0	0	1	1	.25	.25	1	.50	.50	.5
6275	1	.25	.25	0	.25	0	0	1	.50	0	0
6543	1	0	0	1	.75	.25	.25	1	.75	.75	.75
6545	1	1	1	1	0	0	0	1	.75	0	0
6989	1	0	0	0	.25	.25	.25	1	1	1	1
7102	1	0	0	1	.75	0	0	1	1	0	0
7768	1	.25	.25	1	.75	.25	.25	1	1	.50	.5
8048	1	0	0	1	0	.25	0	1	.50	.75	.5
8256	1	0	0	1	.75	0	0	1	.50	1	.5
8525	1	.25	.25	1	0	0	0	1	.50	0	0
8610	1	0	0	0	.75	.50	0	1	1	0	0
9149	1	0	0	1	0	0	0	1	1	1	1
9402	1	0	0	1	0	0	0	0	0	0	0
9525	1	0	0	1	0	0	0	1	1	0	0
9534	1	.75	.75	1	0	0	0	0	0	0	0
9773	1	0	0	1	.75	.75	.75	1	1	1	1
9793	1	1	1	1	.75	1	.75	1	1	1	1

Total Counts by Fuzzy Value and Chi-square Test for Non-Random Diversity of Practice Implementations											
1	29	7	7	22	2	1	0	25	11	6	5
.75	0	1	1	0	11	5	6	0	5	5	3
.5	0	0	0	0	0	1	0	0	7	4	6
.25	0	4	4	0	3	0	0	0	1	2	0
0	0	17	17	7	13	16	18	4	4	14	14
χ^2 stat.	29.00***	32.21***	32.21***	7.76**	23.24***	26.00***	37.38***	15.21***	8.07*	18.07**	17.03**

ID	"Check" Practices			"Act" Practices			"Plan"-"Do"-"Check"-"Act"		
	Core	Margin	Intersection	Core	Margin	Intersection	Intersection of Core Practices	Intersection of Margin Practices	Intersection of All Practices
	Audit Program (audft)	Audit Frequency (audfreq)	audit*audfreq	TMT Review (review)	Review Integrated (reviewintg)	review*reviewintg			
1652	1	.75	.75	1	1	1	0	0	0
2230	0	0	0	1	.75	.75	0	0	0
2843	1	1	1	1	0	0	1	0	0
2924	1	.75	.75	1	1	1	1	0	0
3378	1	.25	.25	1	0	0	1	0	0
3384	1	.75	.75	1	.75	.75	0	0	0
3789	1	.75	.75	1	.75	.75	1	.75	.75
4754	1	4	4	1	3	0	1	0	0
4857	1	.75	.75	1	0	0	0	0	0
5120	0	0	0	0	0	0	0	0	0
5557	1	.75	.75	1	0	0	1	0	0
5840	0	0	0	1	0	0	0	0	0
5863	1	.75	.75	1	0	0	1	0	0
6275	0	0	0	0	0	0	0	0	0
6543	1	.75	.75	1	.75	.75	1	0	0
6545	1	.75	.75	1	.75	.75	1	0	0
6989	1	.75	.75	1	0	0	0	0	0
7102	1	.75	.75	1	0	0	1	0	0
7768	1	1	1	1	1	1	1	.25	.25
8048	1	.75	.75	1	.75	.75	1	0	0
8256	1	1	1	1	.75	.75	1	0	0
8525	1	1	1	1	.75	.75	1	0	0
8610	1	.75	.75	1	1	1	1	0	0
9149	1	1	1	1	0	0	1	0	0
9402	1	1	1	1	0	0	1	0	0
9525	1	.25	.25	1	.75	.75	1	0	0
9534	0	0	0	No Data	No Data	No Data	0	0	0
9773	1	.75	.75	1	0	0	1	0	0
9793	1	.75	.75	1	0	0	1	0	0


Total Counts by Fuzzy Value and Chi-square Test for Non-Random Diversity of Practice Implementations									
1	24	6	6	26	4	4	18	0	0
.75	0	15	15	0	9	9	0	1	1
.5	0	0	0	0	0	0	0	0	0
.25	0	3	3	0	0	0	0	1	1
0	5	5	5	2	15	15	11	27	27
χ^2 stat.	12.45***	21.86***	21.86***	19.90***	29.50***	29.50***	1.69	106.34***	106.34***

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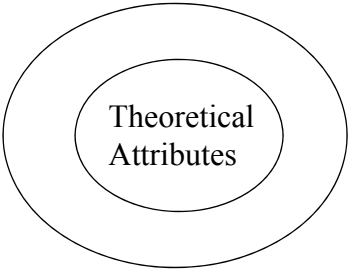
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Sufficiency



Condition of Interest

Sufficiency =
 All cases exhibiting the theoretical (“causal”) attribute(s) display the condition of interest (“outcome”).

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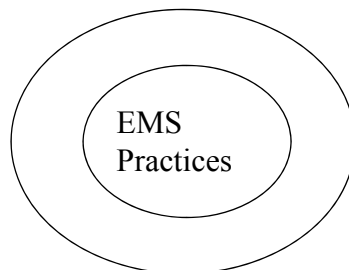
Example: Rationales for EMS Adoptions



- NDEMS Survey: “Rationale for adopting EMS”
- Six rationales emerged (PCA):
 - Public Relations / Competitive Advantage
 - Environmental Principles
 - Competitive Pressure
 - Government Assistance
 - Proactive Compliance

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Sufficiency of EMS Practices for Observing Particular Rationales



Particular EMS Rationales

Sufficiency =
All cases exhibiting the theoretical (“causal”) attribute(s) display the condition of interest (“outcome”).

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Rationale:	Public Relations/ Competitive Advantage		Environmental Principles/ Environmental Performance				Competitive Pressure	
	1	2	1	2	3	4	1	2
<i>Practice Configurations:</i>								
External Stakeholders (estkinv)	○	●	○		●		○	○
Manager Rewards (mgreward)	○					●	○	○
Employee Rewards (eereward)	○						●	○
Awareness Training (awrtrain)			●			●		●
Competence Training (jobtrain)	○	●			●			○
Audit Frequency (auditfreq)	●		●	●		●		○
Review Integration (reviewintg)		●			○		●	
Raw Coverage	.22	.07	.30	.33	.25	.32	.14	.20
Unique Coverage	.06	.01	.10	.06	.05	.03	.07	.06
Consistency	.88	1.00	1.00	1.00	.93	1.00	1.00	.85
Rationale:	Government Assistance			Proactive Compliance				
	1	2	3	1	2	3	4	5
<i>Practice Configurations:</i>								
External Stakeholders (estkinv)	●				●	○	○	
Manager Rewards (mgreward)		○			○			○
Employee Rewards (eereward)		○	●		○			○
Awareness Training (awrtrain)	●	●						●
Competence Training (jobtrain)		○		●				
Audit Frequency (auditfreq)		○				○		
Review Integration (reviewintg)			●				●	
Raw Coverage	.30	.30	.19	.45	.24	.29	.34	.44
Unique Coverage	.15	.06	.04	.12	.09	.06	.05	.01
Consistency	.76	.89	.91		.83	.88	.86	.86

Note:
 Primary conditions (i.e., part of parsimonious and intermediate solutions) are represented by ● (present) and ○ (absent);
 Contributing conditions (i.e., intermediate solution) are represented by • (present) and ◦ (absent)

In Closing....



- Fuzzy-sets afford researchers a means by which they can capture both *differences in kind and degree* of the phenomena under study
 - They are simultaneously qualitative and quantitative: they allow for qualitative assessments and afford systematic analyses using Boolean algebra and logic.
- The set-theoretic method is a qualitative approach to research which offers “researchers an interpretive algebra” (Ragin, 2000: 4) that contributes “to theory building by providing a rigorous way to combine verbal statements with logical relationships” (Fiss, 2007: 1181).