Qualitative Comparative Analysis for Medical Research

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Overview

- Review of QCA publications and software
- QCA as an investigation of invariance
- Three analytic components of QCA
  - Data set calibration
  - Necessity analysis
    - Consistency and coverage measures for necessity
    - Testing for necessary conditions
  - Sufficiency analysis
    - Consistency and coverage measures for sufficiency
    - Constructing and reducing truth tables
- Interrogating the solutions

Primary Readings on QCA

- Ragin and Rubinson (2009) “The Distinctiveness of Comparative Research”
- Ragin and Rubinson (2011) “Comparative Methods”
- Ragin (2008) *Redesigning Social Inquiry*
- Ragin (1987) *The Comparative Method*

Secondary Sources

- Compasss web site (http://www.compasss.org)
- Goertz (2006) *Social Science Concepts*
- Ragin (2000) *Fuzzy-Set Social Science*
- Rihoux and Ragin (2009) *Configurational Comparative Methods*

Software

Ragin's fs/QCA (http://www.fsqca.com):

- always produces correct results, intermediate solutions, relatively user-friendly, described in *RSI,* cutting edge
- but: Windows-only, buggy, out of date documentation, the dreaded prime implicant chart, no tools for interrogating the analysis, cutting edge

Rubinson's acq & Kirq (http://www.grundrisse.org/qca/):

- always produces correct results, sophisticated necessity analysis, supports contradictions and impossible conditions, user-friendly, cross-platform, tools for interrogating the analysis, mailing list, no prime implicant chart
- but: no intermediate solutions, solution complexity

Other Software

Cronqvist's TOSMANA:

- visualizations; cross-platform (via Mono)
- but: doesn't support fuzzy-set QCA; inspired by QCA 3.0

Dusa's QCA for R (also Huang's QCA3 for R):

- cross-platform
- but: doesn't support fuzzy-set QCA; inspired by TOSMANA/QCA 3.0
- Note: Rubinson's fsQCA package for R is obsolete

Longest and Vaisey's fuzzy module for Stata:

- ???

Varieties of QCA: Crisp Sets, Fuzzy Sets, & Multi-Valued Sets

- *The Comparative Method* (1987) describes "crisp-set QCA"
- *Fuzzy-Set Social Science* (2000) describes "fuzzy-set analysis"
- *Redesigning Social Inquiry* (2008) unifies "crisp-set QCA" and "fuzzy-set QCA"
  - crisp-set QCA is a special form of fuzzy-set QCA
  - fs/QCA, acq, and Kirq are all based on the *RSI* algorithms
- What about multi-valued QCA?

What is QCA?

- Originated as a formalization of small-N, comparative-historical research.
- QCA is a technique for identifying and analyzing invariant (consistent) relationships.
- Characterized by the search for necessary and sufficient conditions.
- Is QCA necessarily small-N?
- Is QCA necessarily case-oriented?

Invariant Relationships

- Definition: Certain aspects of cases tend to co-occur.
  - Tenured faculty tend to have many publications
  - Religious fundamentalists tend to be politically conservative
  - Patients with a cold have usually been exposed to a rhinovirus

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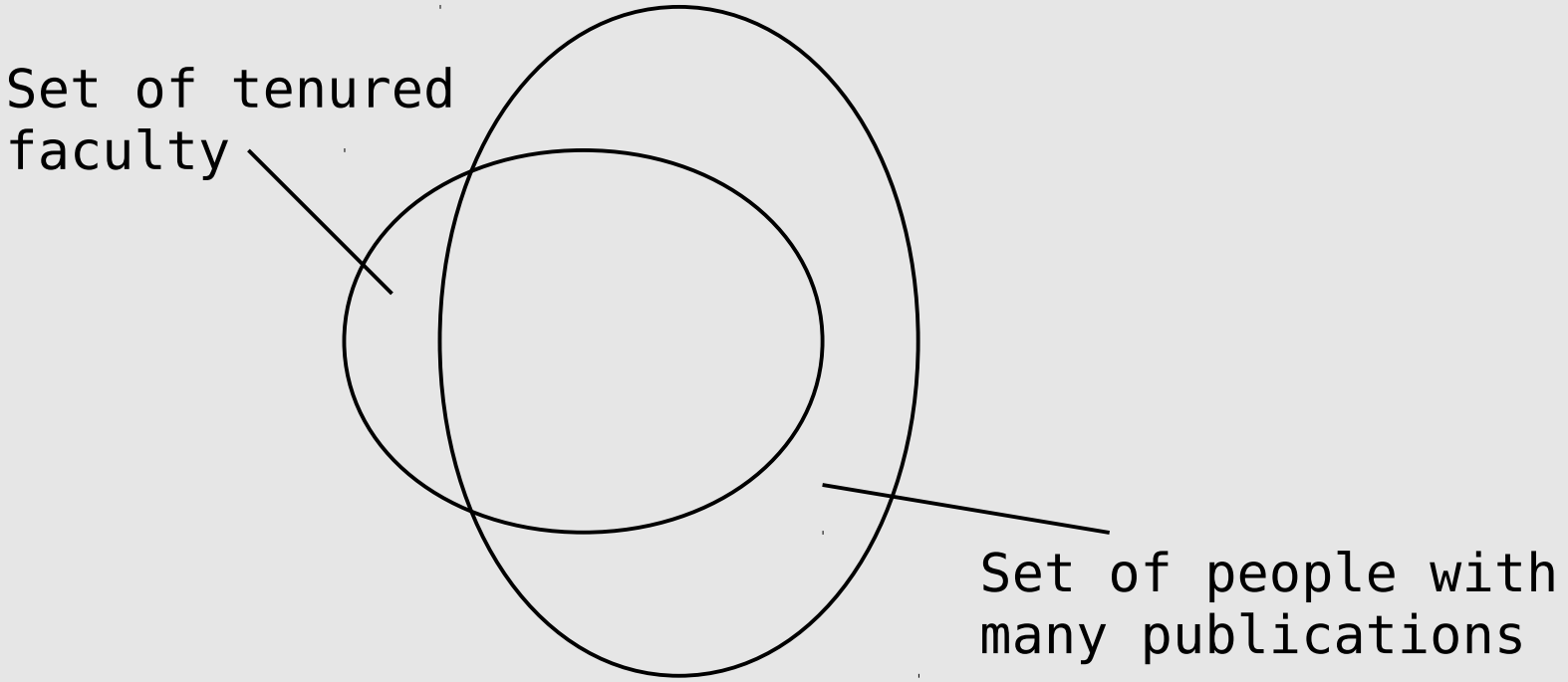

Invariant Relationships

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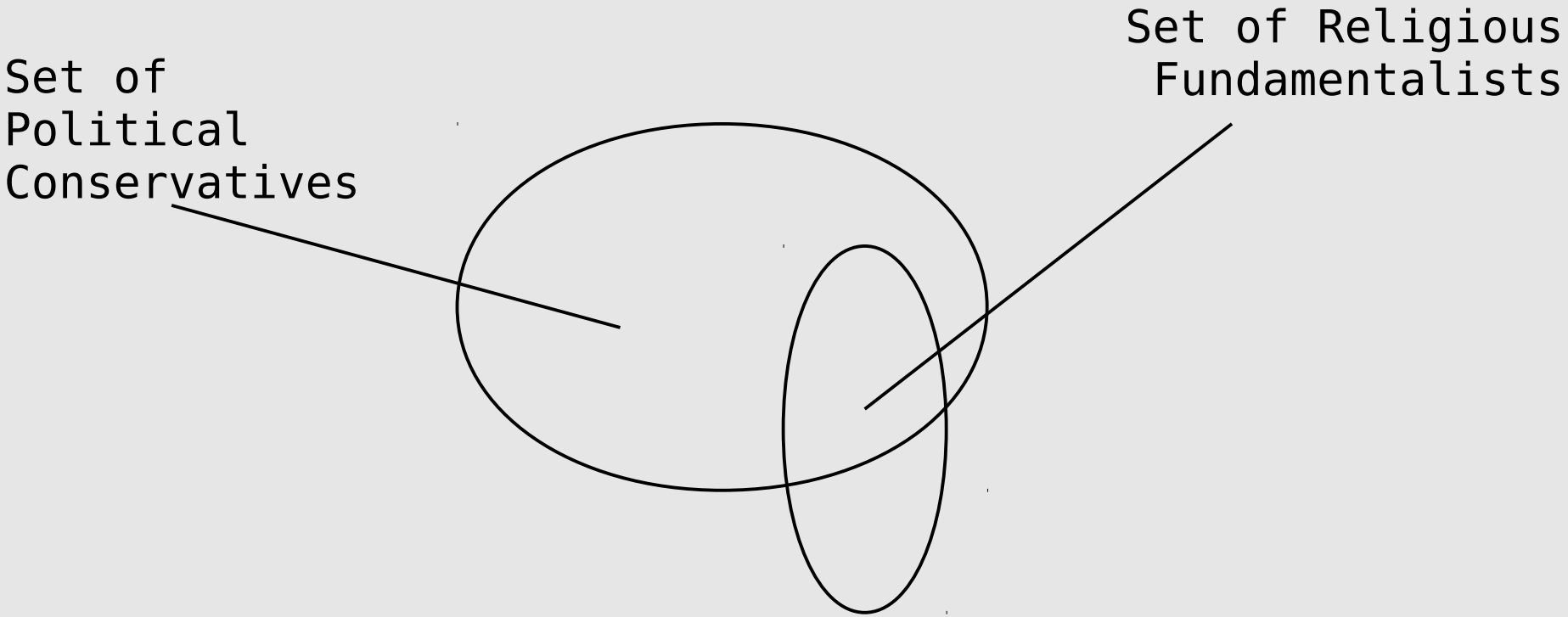

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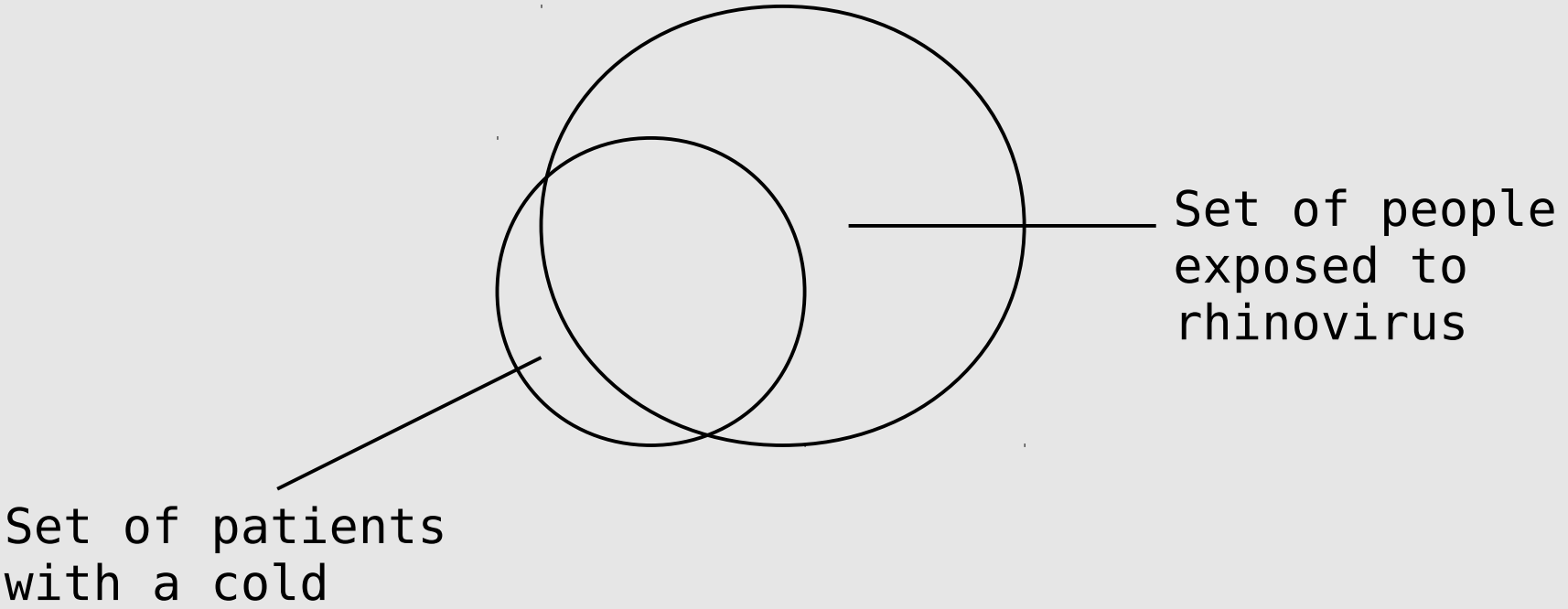
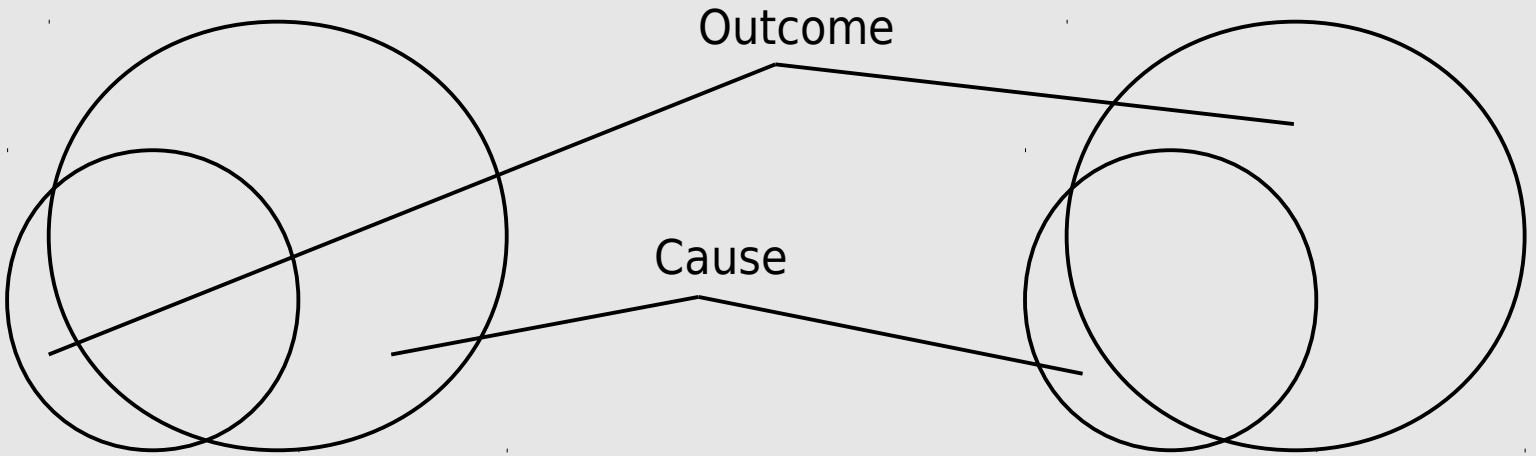
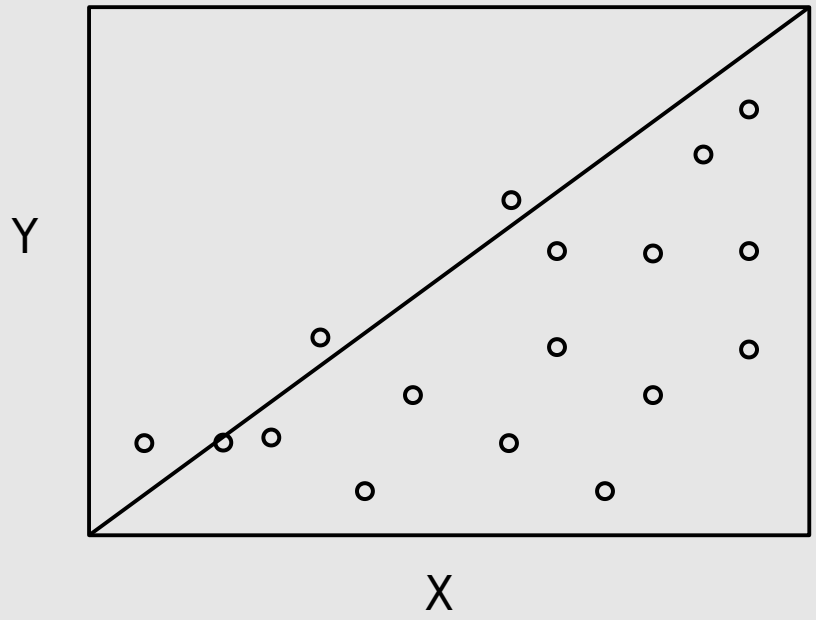
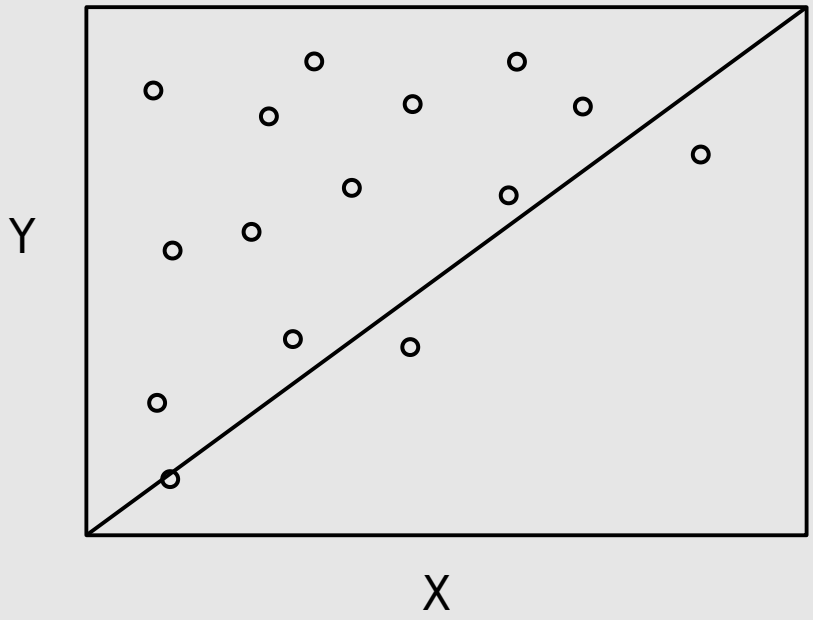


Invariant Relationships





Subset relationship consistent with necessity (X≥Y)

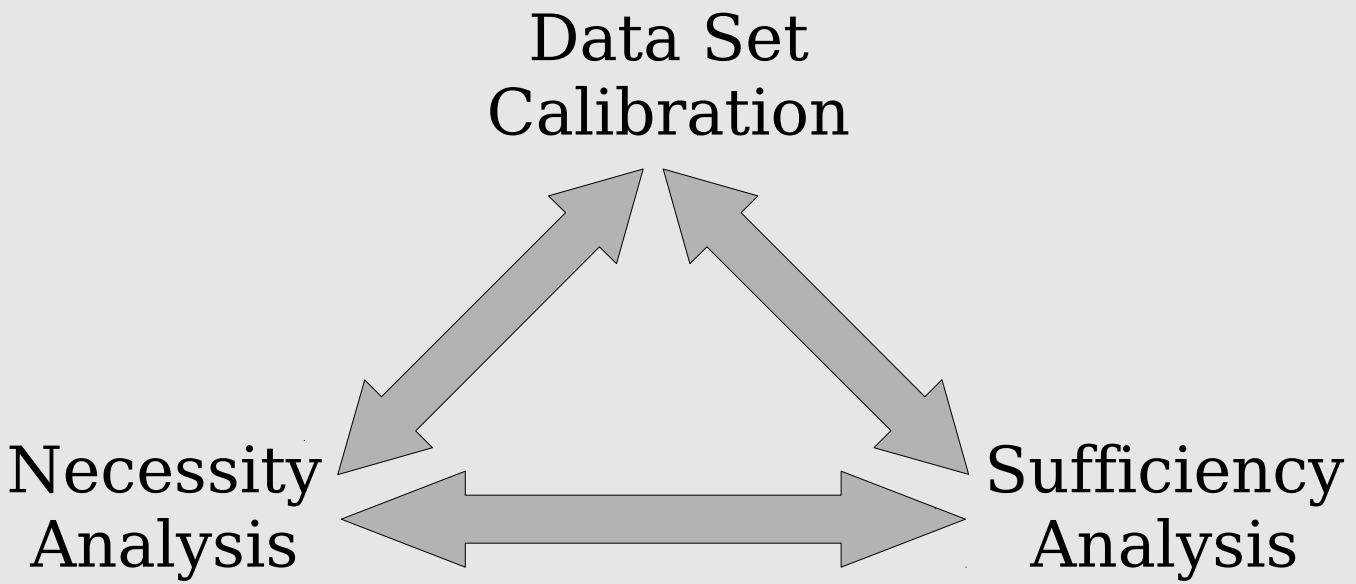


Subset relationship consistent with sufficiency (Y≥X)

Invariant Relationships

- Definition: Certain aspects of cases tend to co-occur.
  - Does not imply determinism (or stochasticism)
  - Is not vulnerable to a single disconfirming case
  - Is fundamentally set theoretic
  - Parallels how we think about causation in the “real world”:
    - To avoid getting sick, wash your hands
    - If Ralphie gets a *Red Ryder BB Gun* for Christmas, he'll shoot his eye out

Three Analytic Components of QCA



Retroductive Nature of QCA
Example: Brown and Boswell (1995)

Truth Table with Contradiction (from Table 4 of Brown and Boswell 1995)

Recent Black Migrants	Weak Union	Black Strikebreaking	Observations
T	T	T	East Chicago, Pittsburgh, Youngstown
T	F	Con	Buffalo, Chicago, Gary, Johnstown, [Cleveland]
F	T	F	Bethlehem, Joliet, McKeesport, Milwaukee, New Castle, Reading
F	F	F	Decatur, Wheeling

Retroductive Nature of QCA
Example: Brown and Boswell (1995)

Revised Truth Table without Contradiction (from Table 5 of Brown and Boswell 1995)

Recent Black Migrants	Weak Union	Local Govt Repression	Black Strikebreaking	Observations
T	T	T	T	East Chicago, Pittsburgh, Youngstown
T	T	F	—	
T	F	T	T	Buffalo, Chicago, Gary, Johnstown
T	F	F	F	Cleveland
F	T	T	F	Bethlehem, Joliet, McKeesport, New Castle, Reading
F	T	F	F	Milwaukee
F	F	T	F	Decatur
F	F	F	F	Wheeling

Boolean Algebra

- UPPERCASE for the presence of a condition
- lowercase for the absence of a condition
- Negation

  ~A = 1 – A

  a = 1 – A

- Logical and (Boolean multiplication)

  A•b = Ab = min(A,b)

- Logical or (Boolean addition)

  A+b = max(A,b)

Calibrating Data Sets

Data Set Calibration

- The process of constructing fuzzy-sets
- May be crisp or fuzzy
- Is about defining set memberships
  - degree of membership in the set of developed countries (vs GDP/capita)
  - degree of membership in the set of sick people (vs white blood cell count)
- Importance of negation and asymmetry
  - degree of membership in the set of *not* developed countries
  - degree of membership in the set of *not* sick people

Data Set Calibration

- Instrument calibration is routine in the natural sciences; largely absent in the social sciences.
- Conventional statistics emphasize relative effects: Paul is poorer than Peter; the United States' infant mortality rate is greater than that of Japan.
- Calibration allows us to state that an individual is poor or that a country's infant mortality rate is high.
- Calibration requires application of theoretical and substantive knowledge: A T cell count of below 200 µL of blood is sufficient to diagnose AIDS

Calibrating Fuzzy Sets

Crisp set	Three-value fuzzy set	Four-value fuzzy set	Six-value fuzzy set	Continuous fuzzy set
1 = fully in	1 = fully in	1 = fully in	1 = fully in	1 = fully in
	0.67 = more in than out	0.67 = more in than out	0.8 = mostly but not fully in 0.6 = more or less in	Degree of membership is more “in” than “out” 0.5 < X < 1
---------- 0.5 = Crossover Point ----------				
		0.33 = more out than in	0.4 = more or less out 0.2 = mostly but not fully out	Degree of membership is more “out” than “in” 0.0 < X < 0.5
0 = fully out	0 = fully out	0 = fully out	0 = fully out	0 = fully out

Calibrating Fuzzy Sets

- Fuzzy sets are asymmetrical
- Fuzzy sets vs crisp sets
- Fuzzy sets vs multi-valued sets vs dummy variables

Analyzing Necessary Conditions

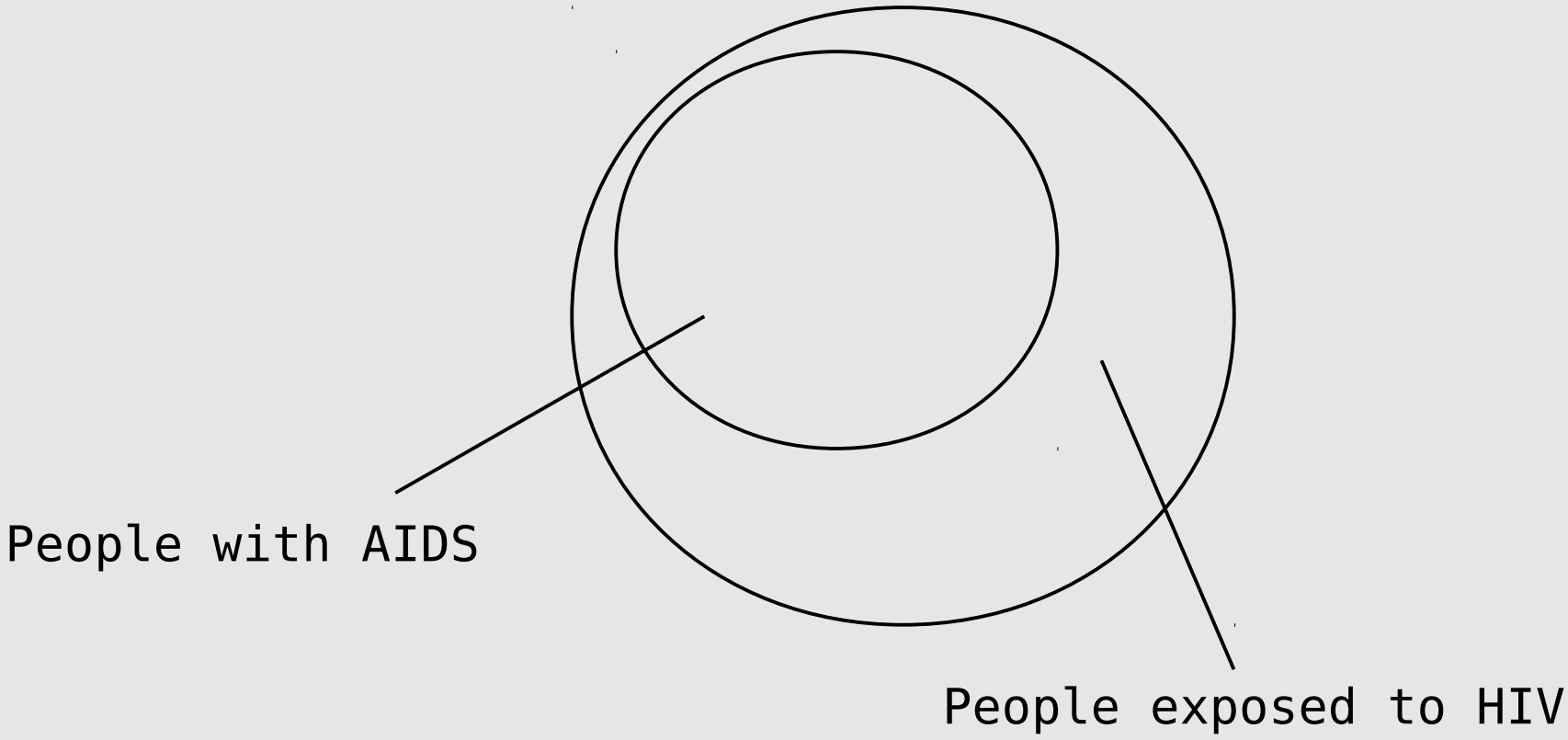
Necessity Analysis

- Underdeveloped in the literature; QCA development has focused on sufficiency analysis
- Kirq and acq have sophisticated necessity testing

Necessary Conditions

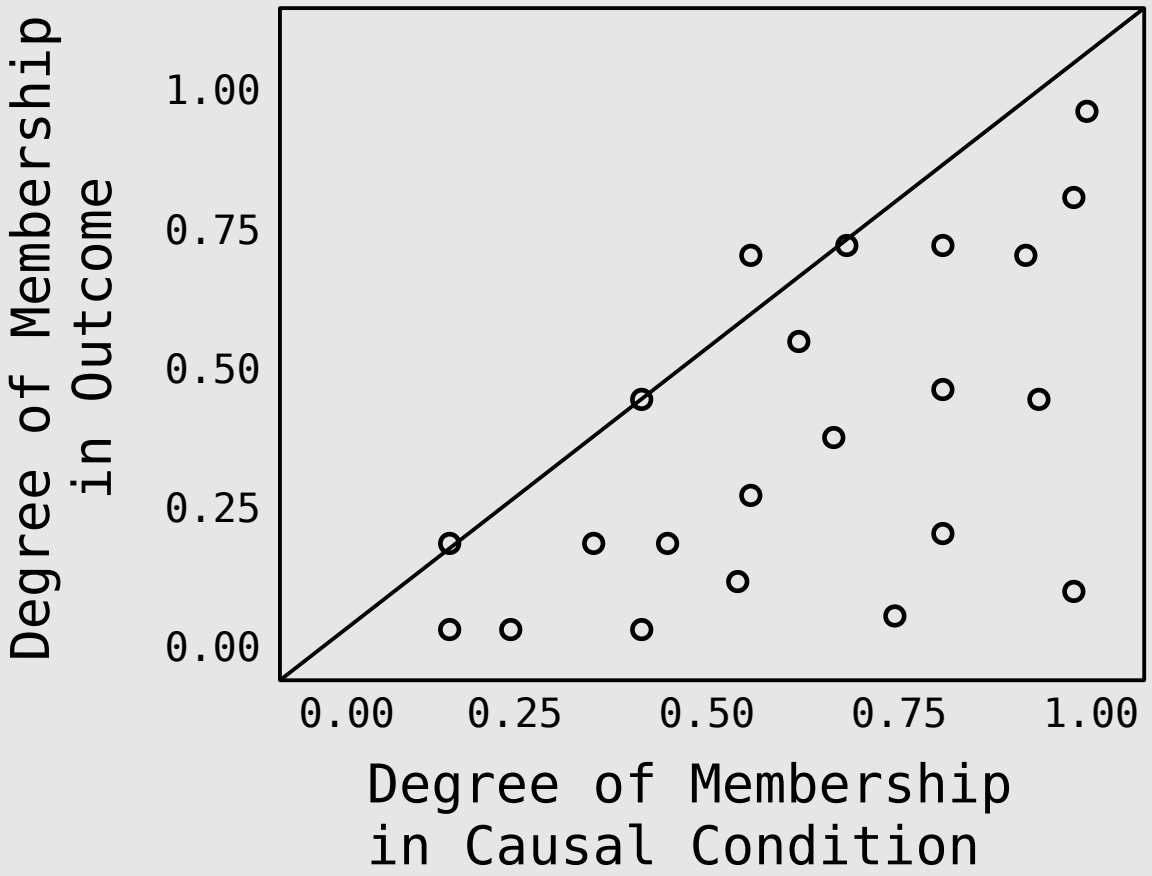
Causal condition must (almost always) be present for outcome to occur.

Outcome is a subset of Cause



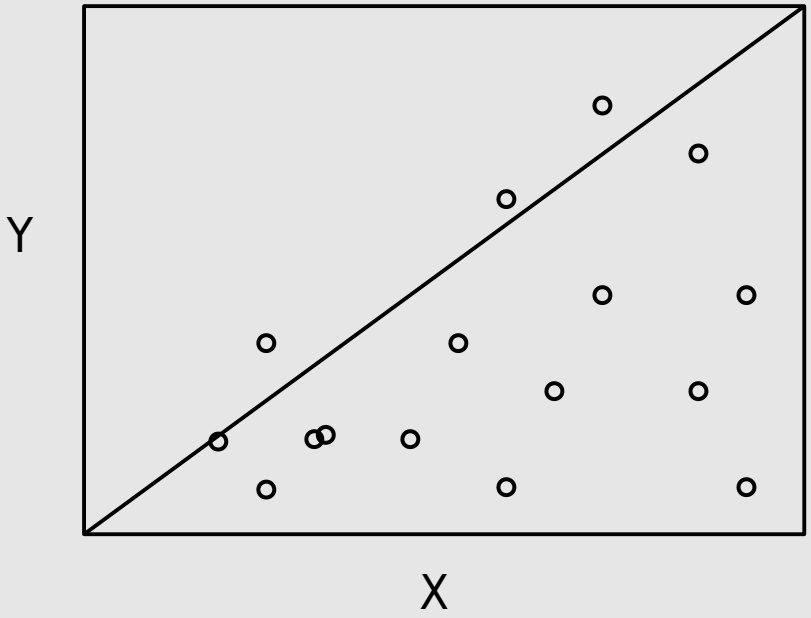
Fuzzy Subset Relationship Consistent with Necessity

Outcome is a subset of Cause ($X \geq Y$)

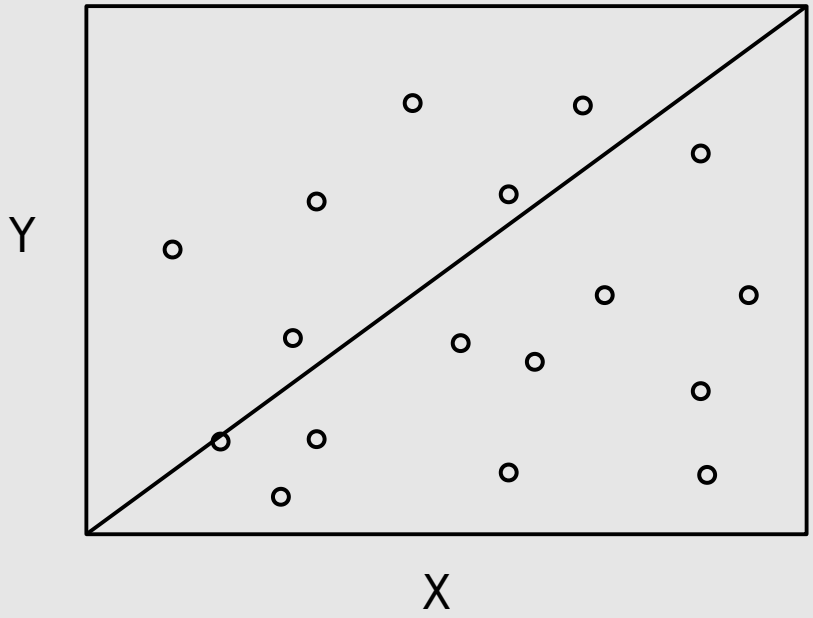


Assessing Necessary Conditions

- *Consistency* measures degree to which subset relationship is “consistent” with necessity



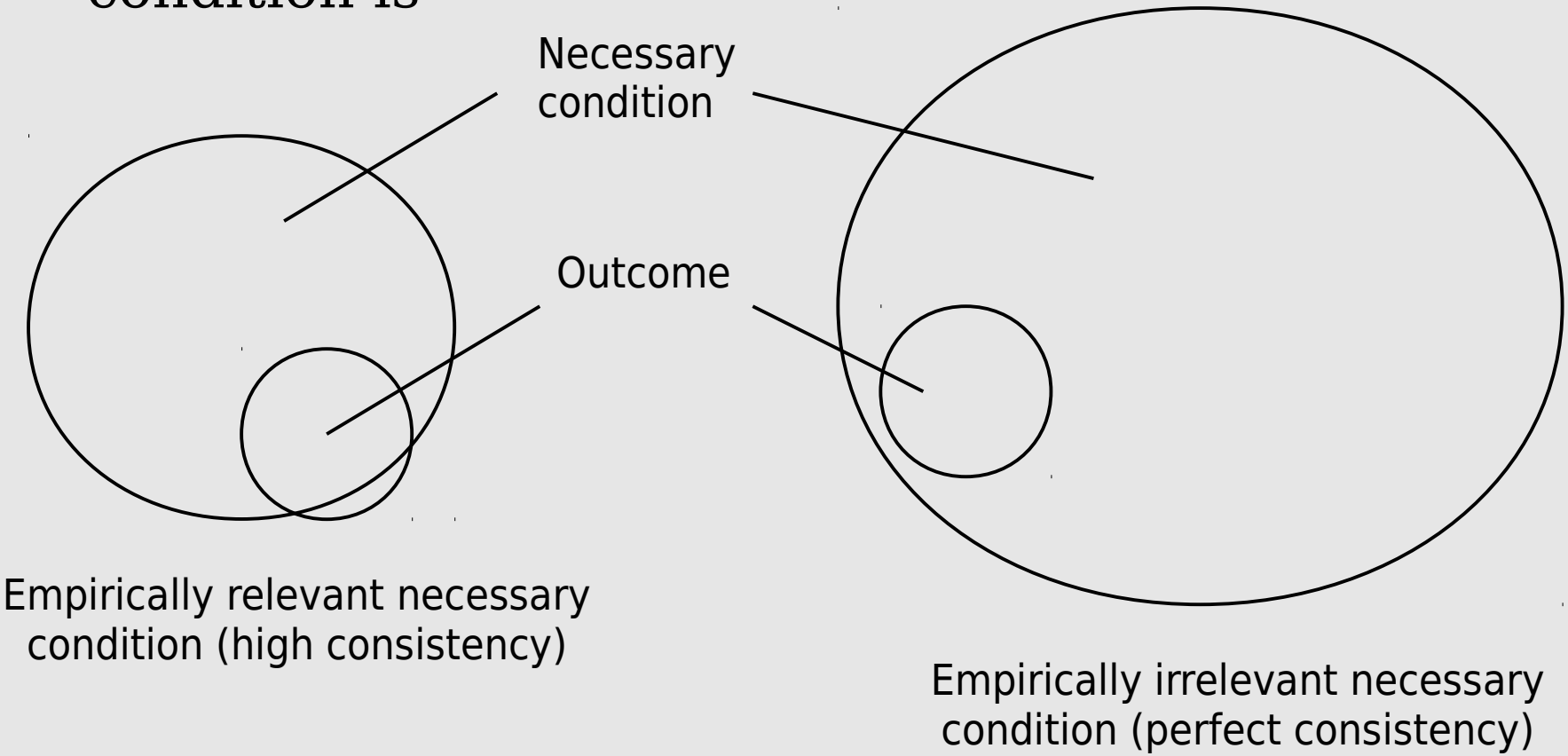
Subset relationship consistent with necessity



Subset relationship with substantial inconsistency

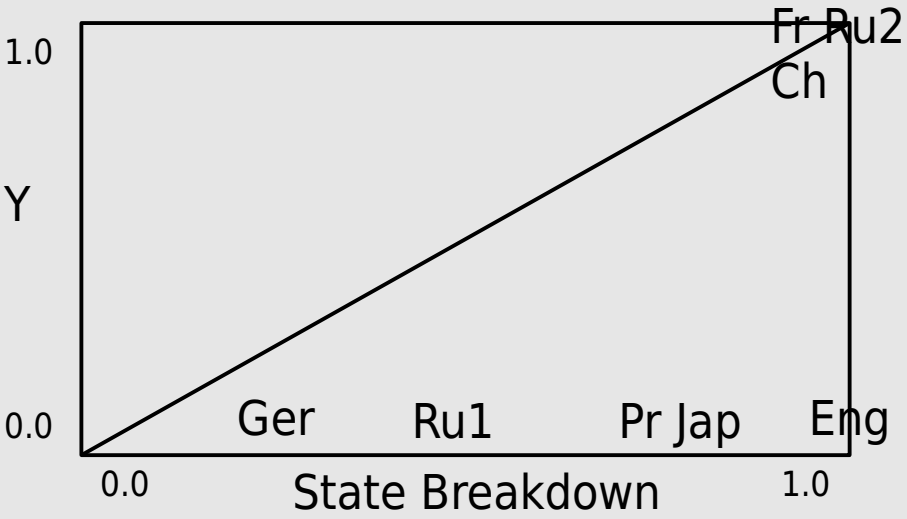
Assessing Necessary Conditions

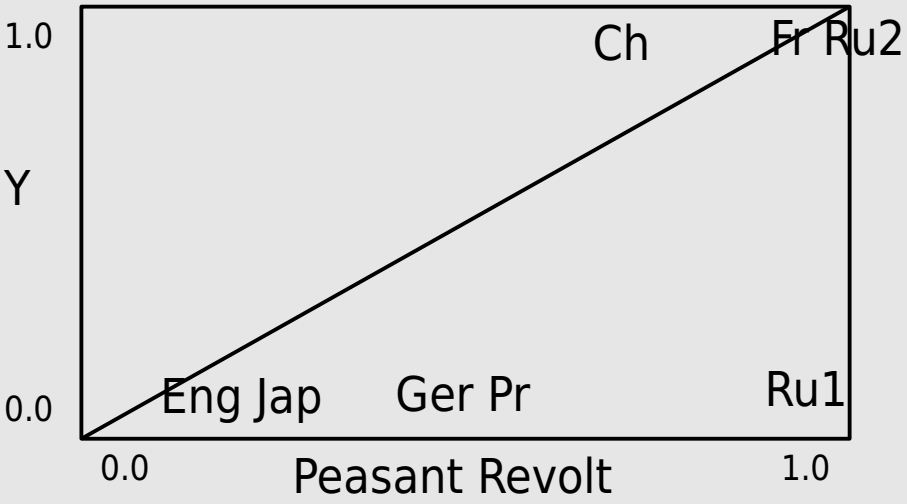
- *Coverage* measures how “relevant” a necessary condition is



Testing for Necessary Conditions

Revolution	Brk	Rev	Success?
France 1789	1.00	1.00	1.0
Russia 1917	1.00	1.00	1.0
China 1911	1.00	0.75	1.0
England 1688	1.00	0.00	0.0
Russia 1905	0.49	1.00	0.0
Germany 1848	0.25	0.49	0.0
Prussia 1807	0.75	0.49	0.0
Japan 1868	0.75	0.00	0.0





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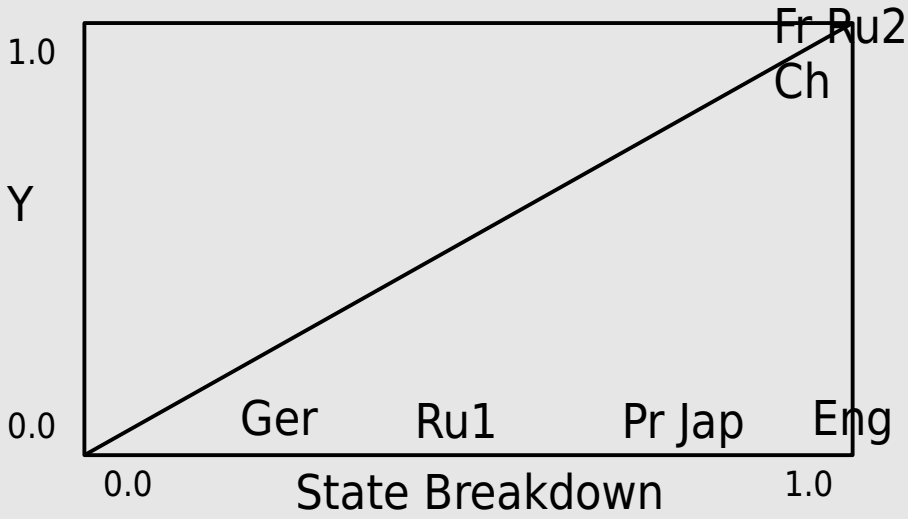
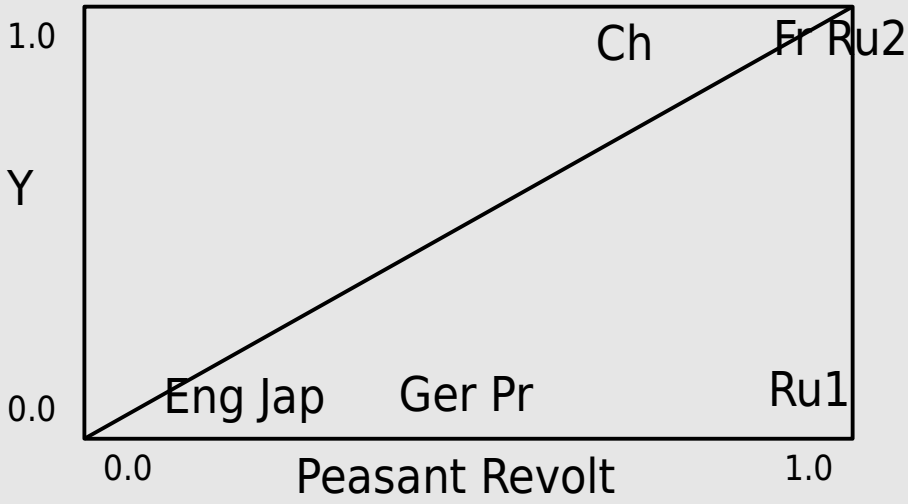
Russia 1905	0.49	1.00	0.0
Germany 1848	0.25	0.49	0.0
Prussia 1807	0.75	0.49	0.0
Japan 1868	0.75	0.00	0.0

Term	Consis	Cov
BREAKDOWN *	1.00	0.48
REVOLT	0.92	0.58
Solution	0.92	0.69





Testing for Necessary Conditions

- Assess consistency before coverage
- Join terms with logical or (e.g., A+B+C)
- Many solutions are possible
- Use of theory is crucial

Analyzing Sufficient Conditions

Sufficiency Analysis

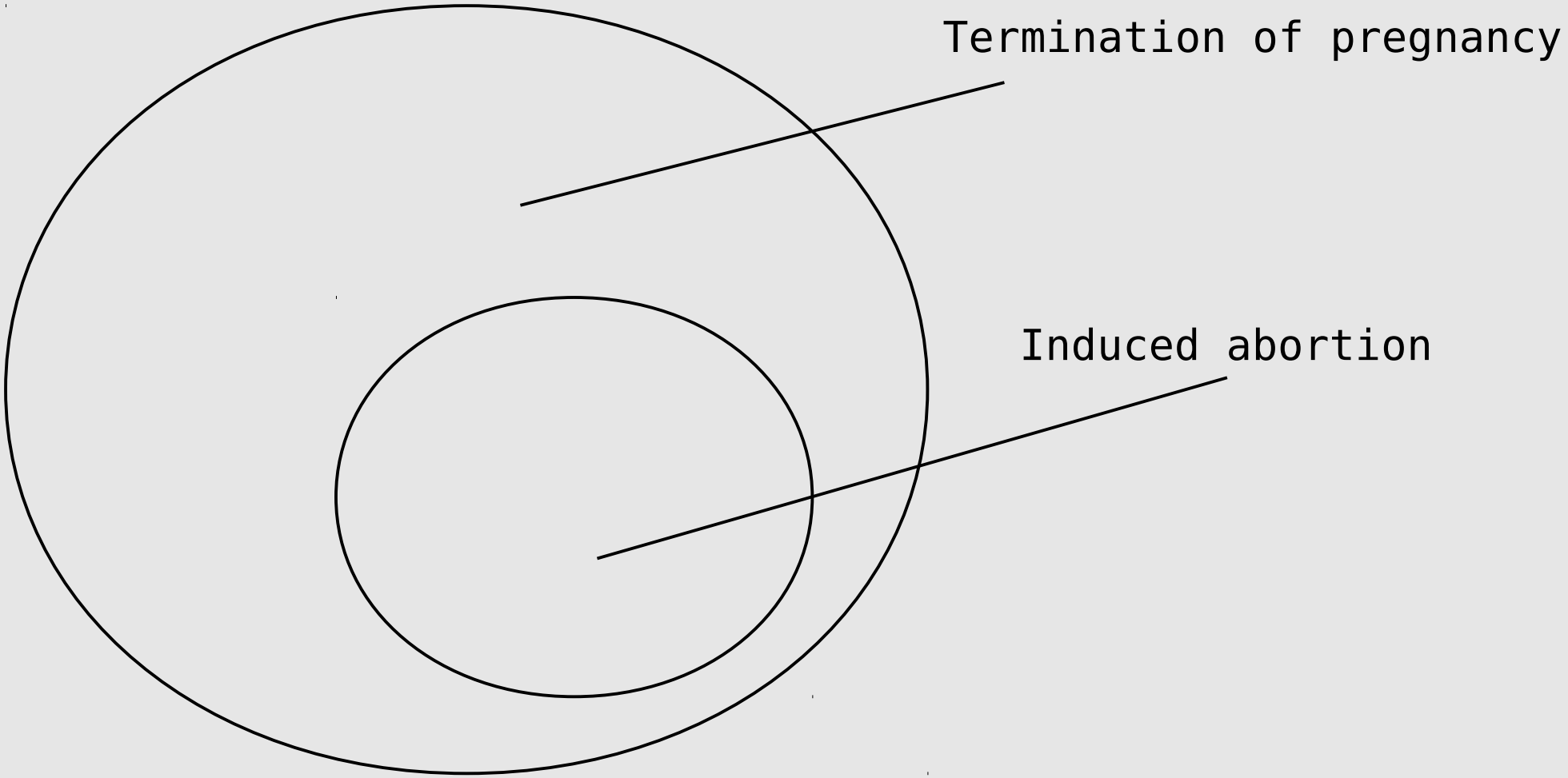
- More mature than necessity analysis; QCA development—and applications—have focused on sufficiency analysis
- Emphasis on causal complexity (a.k.a., multiple conjunctural causation, “recipes,” equifinality, or INUS conditions)

Feature	fs/QCA	Kirq & acq
Based on RSI Algorithms	√	√
Complex Solutions	√	√
Intermediate Solutions	√	
Parsimonious Solutions	√	√
Impossible Conditions		√
Contradictions		√

Sufficient Conditions

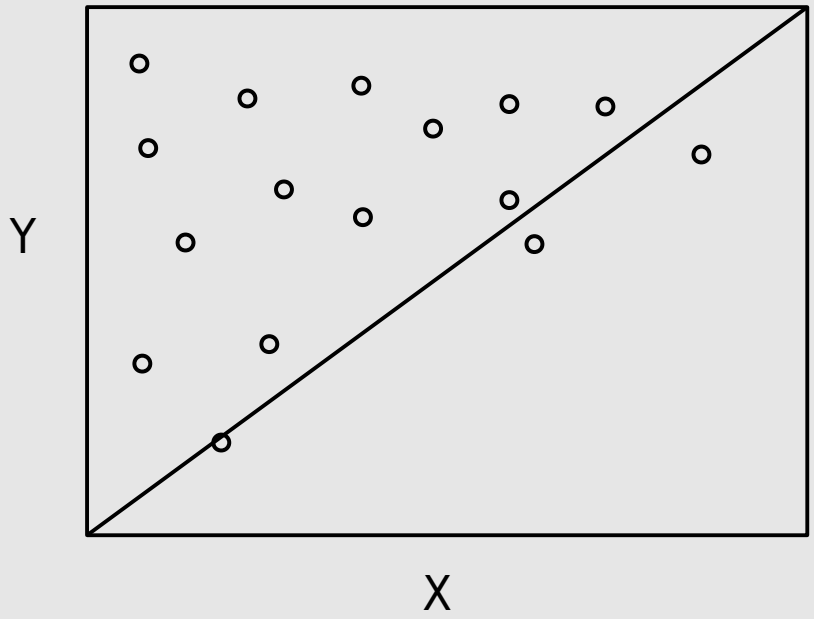
Outcome (almost) always occurs when causal condition is present.

Cause is a subset of Outcome

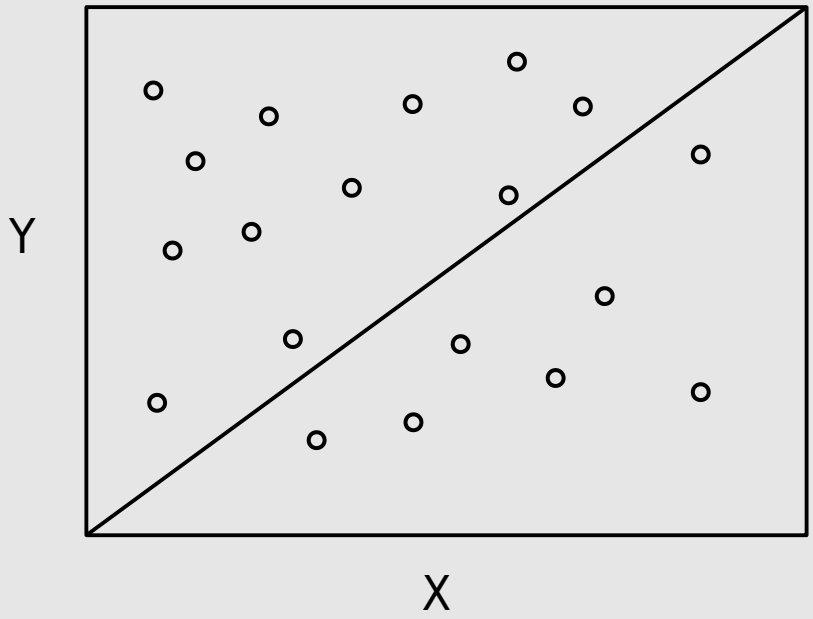


Assessing Sufficient Conditions

- *Consistency* measures degree to which subset relationship is “consistent” with sufficiency



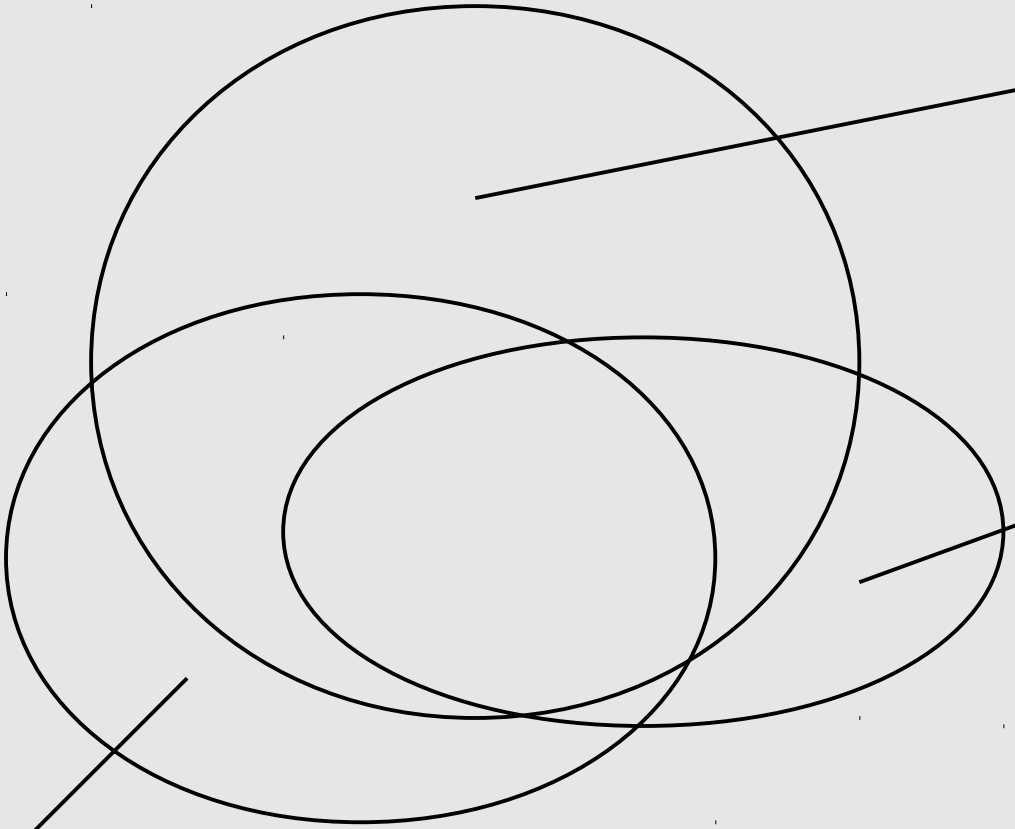
Subset relationship consistent with sufficiency



Subset relationship with substantial inconsistency

Assessing Sufficient Conditions

- *Coverage* measures the relative "importance" of each solution



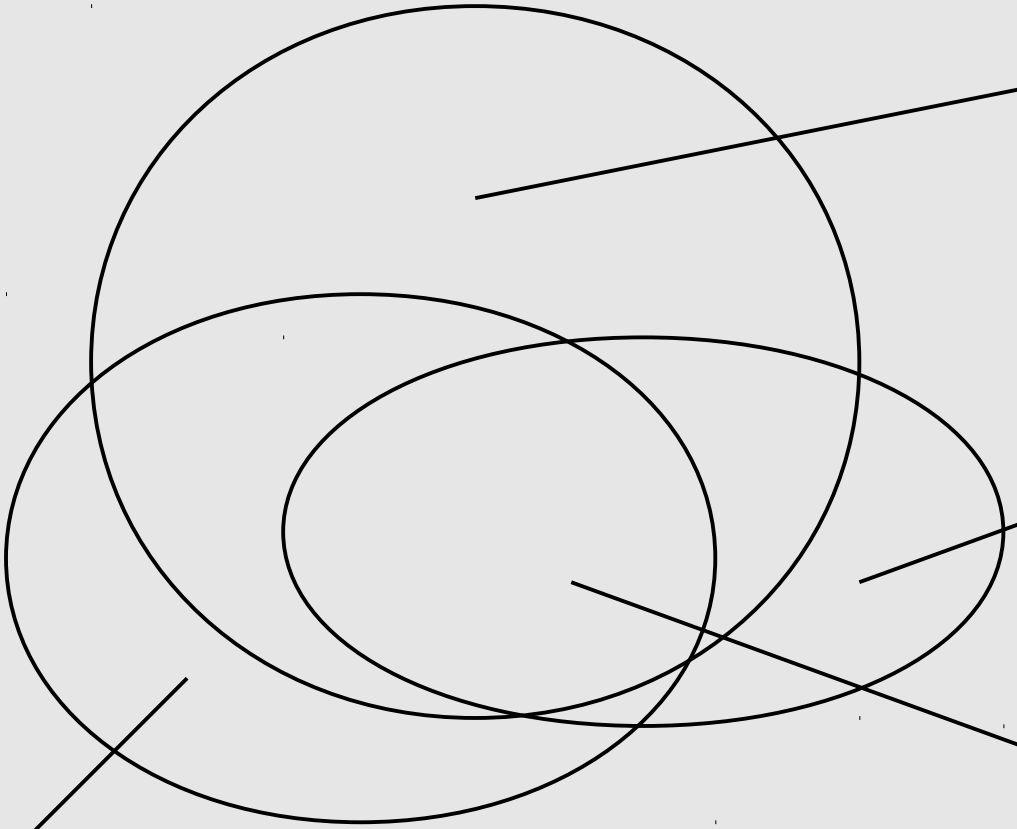
Recently deported women who do not plan to cross again (Outcome)

High SES women who haven't lived in the U.S. and aren't traveling with family (X_1)

High SES women who haven't lived in the U.S., have only attempted cross a few times and felt that their last crossing experience was very dangerous (X_2)

Assessing Sufficient Conditions

- *Coverage* measures the relative "importance" of each solution



Recently deported women who do not plan to cross again (Outcome)

High SES women who haven't lived in the U.S. and aren't traveling with family (X_1)

Women belonging to sets X_1 and X_2

High SES women who haven't lived in the U.S., have only attempted cross a few times and felt that their last crossing experience was very dangerous (X_2)

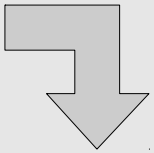
Testing for Sufficient Conditions

Term	Consis	Raw Cov	Uniq Cov
HISES*liveus*travfam +	0.90	0.32	0.13
HISES*liveus*numcross*DANGER	0.82	0.48	0.26
Solution	0.86	0.58	

Truth Table Construction

Truth table algorithm sorts observations into types

Obs	Dev	Urb	Lit	Brk
AT	.81	.12	.99	.95
BE	.99	.89	.98	.05
CZ	.58	.98	.98	.11
EE	.16	.07	.98	.88
FI	.58	.03	.99	.23
FR	.98	.03	.99	.05
DE	.89	.79	.99	.95
GR	.04	.09	.13	.94
HU	.07	.16	.88	.58
IE	.72	.05	.98	.08
IT	.34	.10	.41	.95
NL	.98	1.00	.99	.05
PL	.02	.17	.59	.88
PT	.01	.02	.01	.95



	Dev	Urb	Lit	Consis	Y	Consis Obs	Inconsis Obs
1	T	T	T	0.41	F	DE	BE, CZ, NL
2	T	T	F	—	—		
3	T	F	T	0.51	F	AT	FI, FR, IE
4	T	F	F	—	—		
5	F	T	T	—	—		
6	F	T	F	—	—		
7	F	F	T	0.83	T	EE, PL	HU
8	F	F	F	0.99	T	GR, IT, PT	

Reading Truth Tables

Truth table assesses consistency between types and outcome

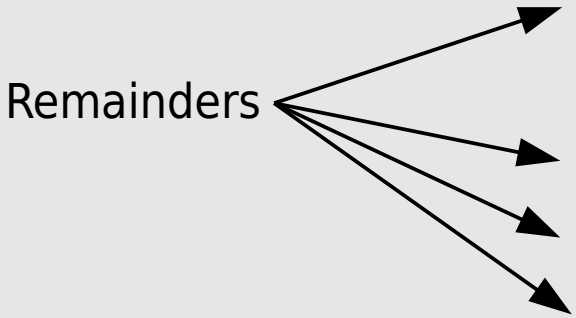
Democracy usually did not break down in countries that were (a) developed, urbanized, and literate (row 1) or (b) developed, not urbanized, and literate (row 3).

Democracy usually did break down in countries that were (c) not developed, not urbanized, and literate (row 7) or (d) not developed, not urbanized, and not literate (row 8)

	Dev	Urb	Lit	Consis	Y	Consis Obs	Inconsis Obs
1	T	T	T	0.41	F	DE	BE, CZ, NL
2	T	T	F	—	—		
3	T	F	T	0.51	F	AT	FI, FR, IE
4	T	F	F	—	—		
5	F	T	T	—	—		
6	F	T	F	—	—		
7	F	F	T	0.83	T	EE, PL	HU
8	F	F	F	0.99	T	GR, IT, PT	

Reading Truth Tables

Remainders are logically possible conditions lacking empirical instances



	Dev	Urb	Lit	Consis	Y	Consis Obs	Inconsis Obs
1	T	T	T	0.41	F	DE	BE, CZ, NL
2	T	T	F	—	—		
3	T	F	T	0.51	F	AT	FI, FR, IE
4	T	F	F	—	—		
5	F	T	T	—	—		
6	F	T	F	—	—		
7	F	F	T	0.83	T	EE, PL	HU
8	F	F	F	0.99	T	GR, IT, PT	

Invariance in Truth Tables

	Dev	Urb	Consis	Y	Consis Obs	Inconsis Obs
1	T	T	0.41	F	DE	BE, CZ, NL
2	T	F	0.51	F	AT	FI, FR, IE
3	F	T	—	—		
4	F	F	0.89	T	EE, GR, IT, PL, PT	HU

	Dev	Urb	Lit	Consis	Y	Consis Obs	Inconsis Obs
1	T	T	T	0.41	F	DE	BE, CZ, NL
2	T	T	F	—	—		
3	T	F	T	0.51	F	AT	FI, FR, IE
4	T	F	F	—	—		
5	F	T	T	—	—		
6	F	T	F	—	—		
7	F	F	T	0.83	T	EE, PL	HU
8	F	F	F	0.99	T	GR, IT, PT	

Reducing Truth Tables to Boolean Equations

To Primitive Expressions:

Term	Consis	Raw Cov	Uniq Cov	Observations
dev*urb*LIT +	0.83	0.42	0.27	EE, PL, [HU]
dev*urb*lit	0.99	0.40	0.24	GR, IT, PT
Solution	0.88	0.66		

Reducing Truth Tables to Boolean Equations

To Primitive Expressions:

Term	Consis	Raw Cov	Uniq Cov	Observations
dev*urb*LIT +	0.83	0.42	0.27	EE, PL, [HU]
dev*urb*lit	0.99	0.40	0.24	GR, IT, PT
Solution	0.88	0.66		

To Prime Implicants:

Term	Consis	Raw Cov	Uniq Cov	Observations
dev*urb	0.89	0.71	0.71	EE, PL, GR, IT, PT, [HU]
Solution	0.89	0.71		

Reducing Truth Tables to Boolean Equations

Reduce Prime Implicants (Complex Solution):

Term	Consis	Raw Cov	Uniq Cov	Observations
dev*urb	0.89	0.71	0.71	EE, PL, GR, IT, PT, [HU]
Solution	0.89	0.71		

Reducing Truth Tables to Boolean Equations

Reduce Prime Implicants (Complex Solution):

Term	Consis	Raw Cov	Uniq Cov	Observations
dev*urb	0.89	0.71	0.71	EE, PL, GR, IT, PT, [HU]
Solution	0.89	0.71		

Reduce Prime Implicants Using Remainders (Parsimonious Solution):

Term	Consis	Raw Cov	Uniq Cov	Observations
dev	0.82	0.73	0.73	EE, PL, GR, IT, PT, [HU]
Solution	0.82	0.73		

Constructing Intermediate Solutions

Complex Solution

Acsir +
ACSir +
ASIR

Parsimonious Solution

i +
SR

Intermediate Solution #1

Ai +
ACSi +
ASR

Ai +
ASR

Intermediate Solution #2

Air +
ASIR

Factoring Results

Initial Solution:

ELECTIONS * POLICE +
urban * POLICE +
CONFLICT * ELECTIONS * URBAN +
CONFLICT * elections * urban +
conflict * ELECTIONS * urban

Factored Solution:

POLICE (ELECTIONS + urban) +
URBAN (CONFLICT * ELECTIONS) +
urban ((CONFLICT * elections) + (conflict * ELECTIONS)