Qualitative Comparative Analysis

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Overview

- Retroductive nature of QCA
- Data set calibration
- Analyzing Necessary Conditions
  - Consistency and coverage measures for necessity
  - Testing for necessary conditions
- Analyzing Sufficient Conditions
  - Consistency and coverage measures for sufficiency
  - Constructing truth tables
  - Reducing truth tables
  - Interrogating the solutions

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/negation 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

- Instrument calibration is routine in the natural sciences; largely absent in the social sciences.

- Social sciences emphasize relative effects: Paul is poorer than Peter; the United States is more democratic than North Korea.

- Calibration allows us to state that an individual is poor or that a country is democratic.

- Calibration requires application of theoretical and substantive knowledge.

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

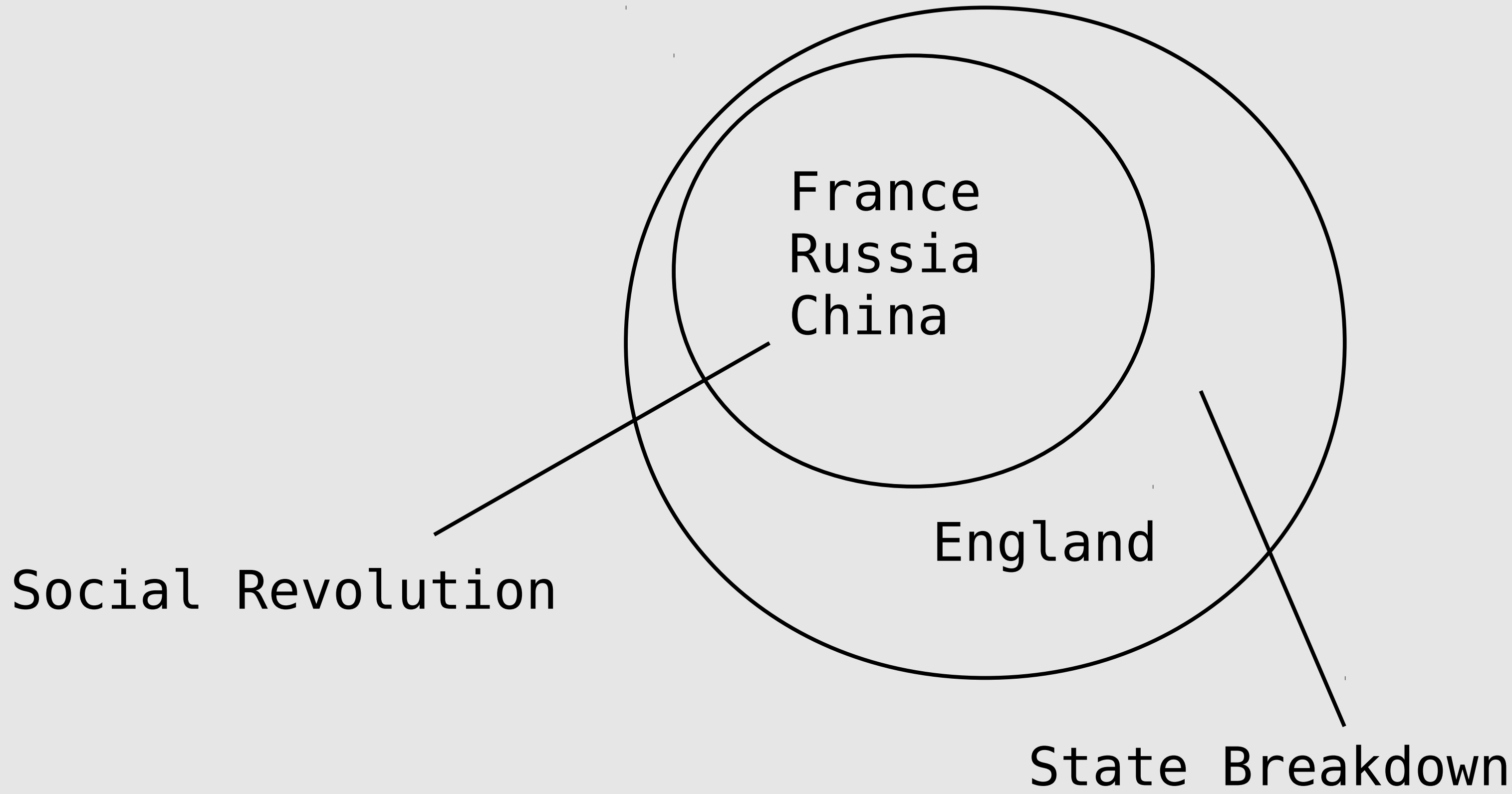
Necessity Analysis

- Underdeveloped in the literature; QCA development has focused on sufficiency analysis
- libfsqca-based software has sophisticated necessity testing

Necessary Conditions

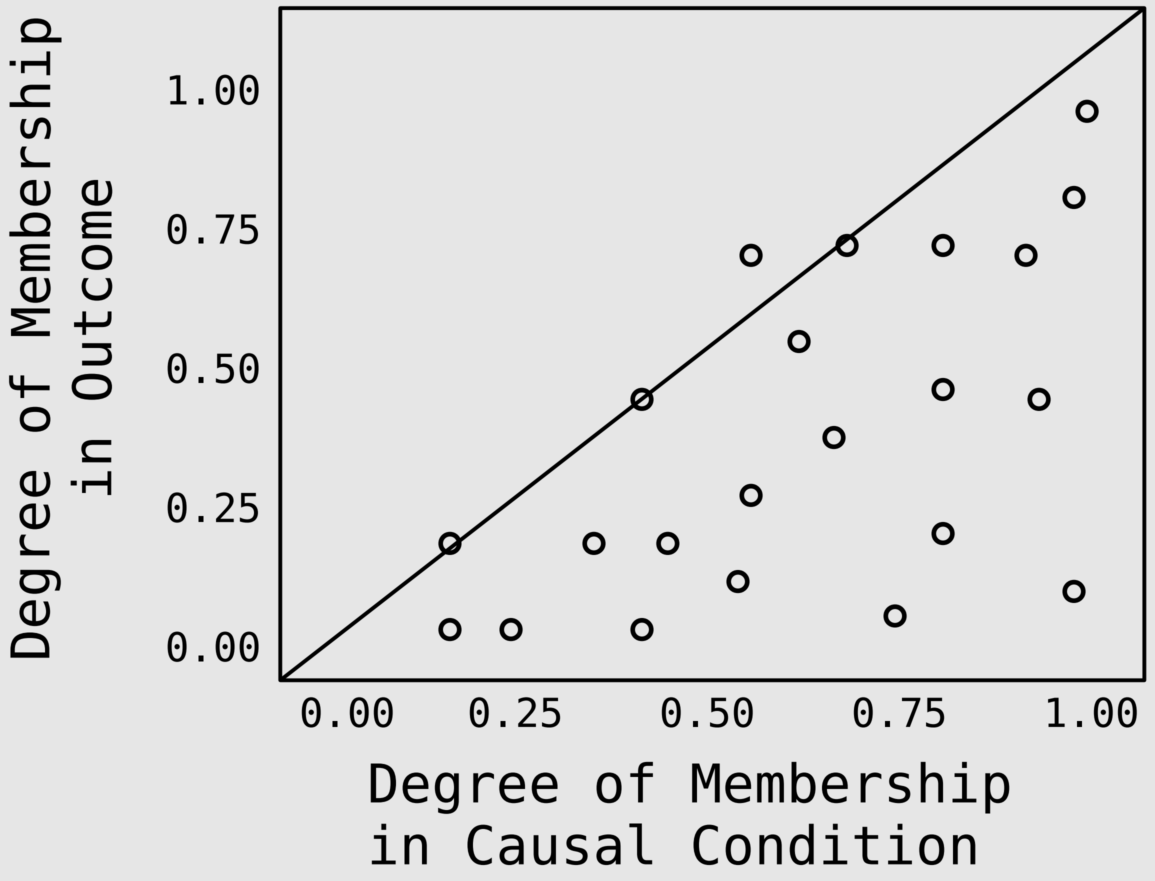
Causal condition must (almost always) be present for outcome to occur.

Outcome is a subset of Cause



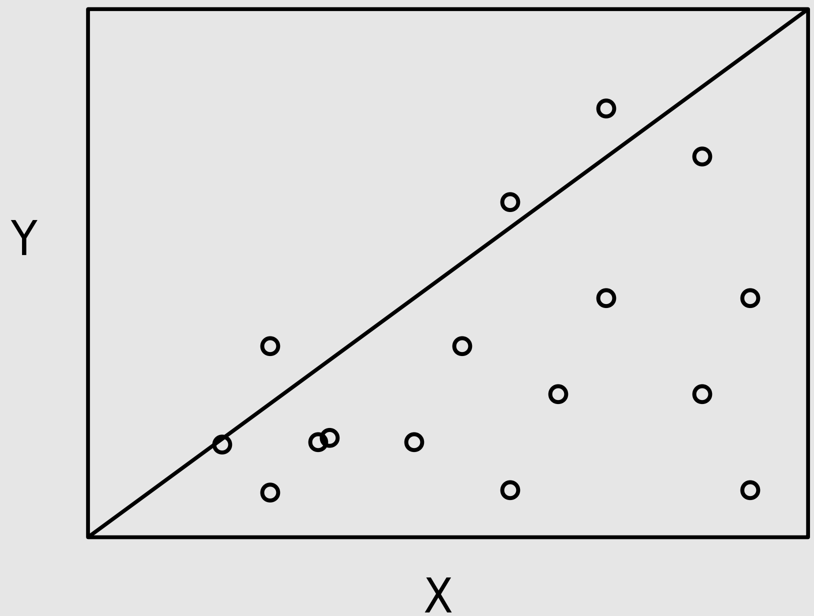
Fuzzy Subset Relationship Consistent with Necessity

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

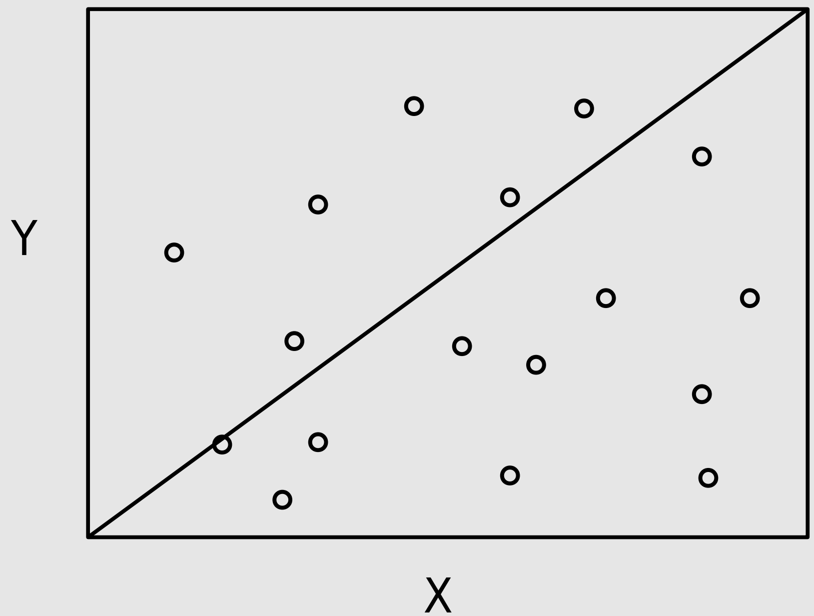


Assessing Necessary Conditions

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



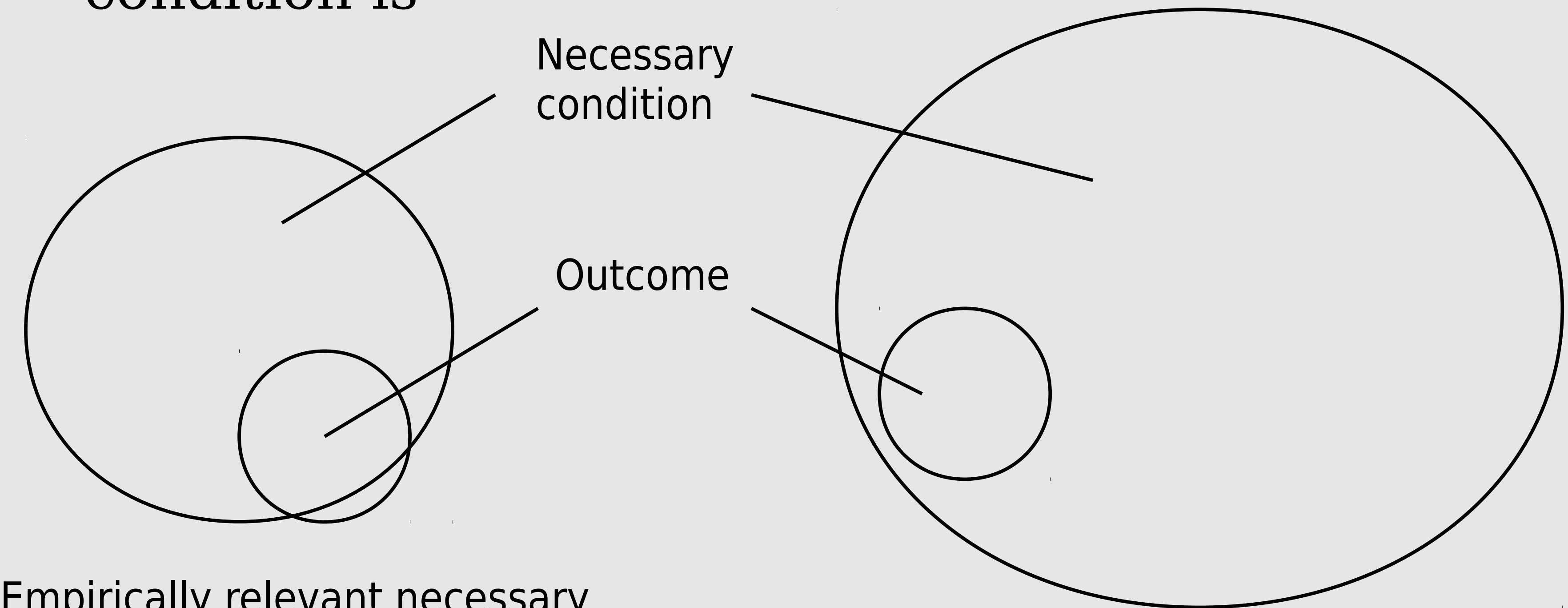
Subset relationship consistent with necessity



Subset relationship with substantial inconsistency

Assessing Necessary Conditions

- *Coverage* measures how "relevant" a necessary condition is

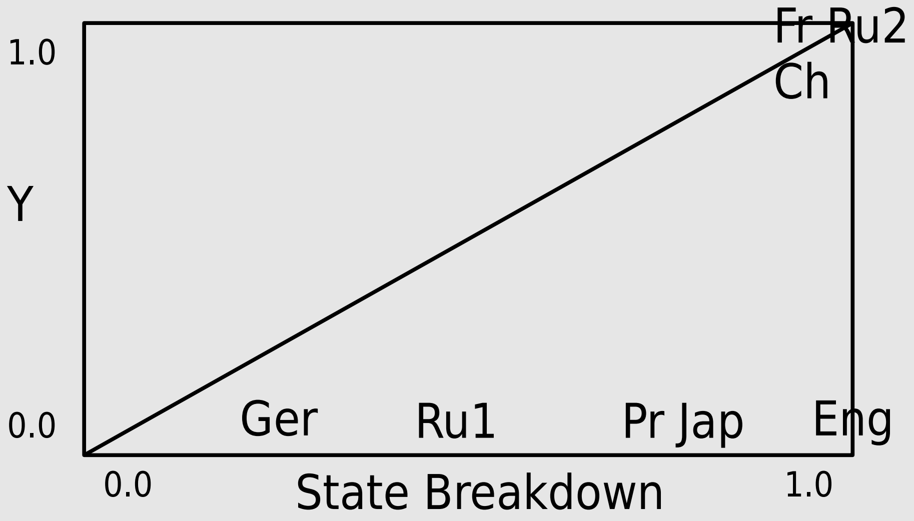


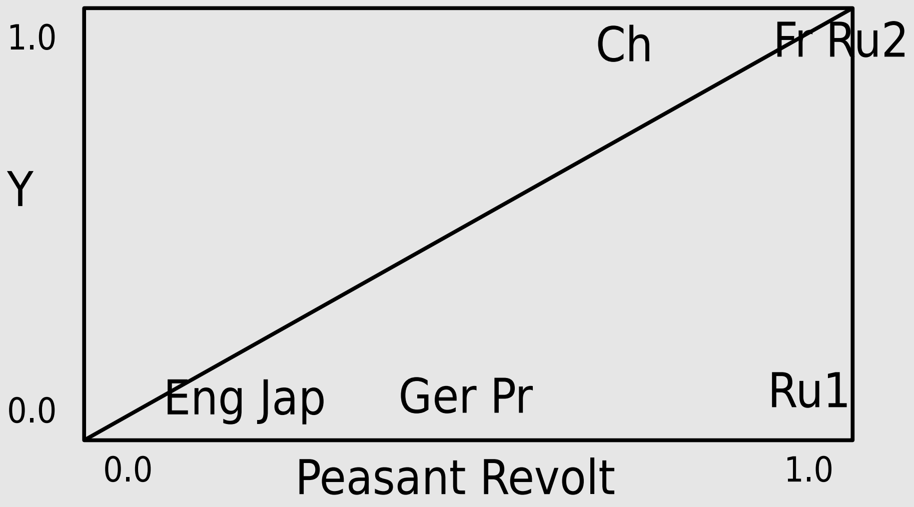
Empirically relevant necessary condition (high consistency)

Empirically irrelevant necessary condition (perfect consistency)

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





Testing for Necessary Conditions

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Russia 1917	1.00	1.00	1.0
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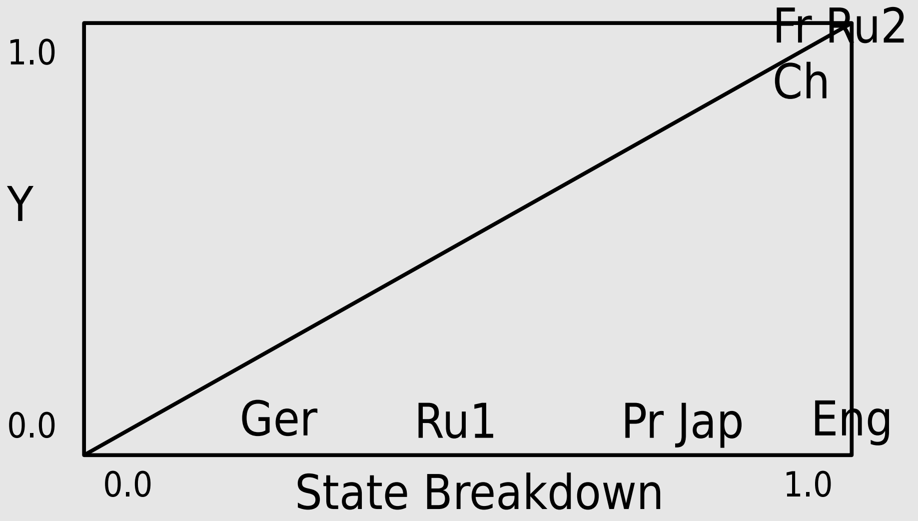
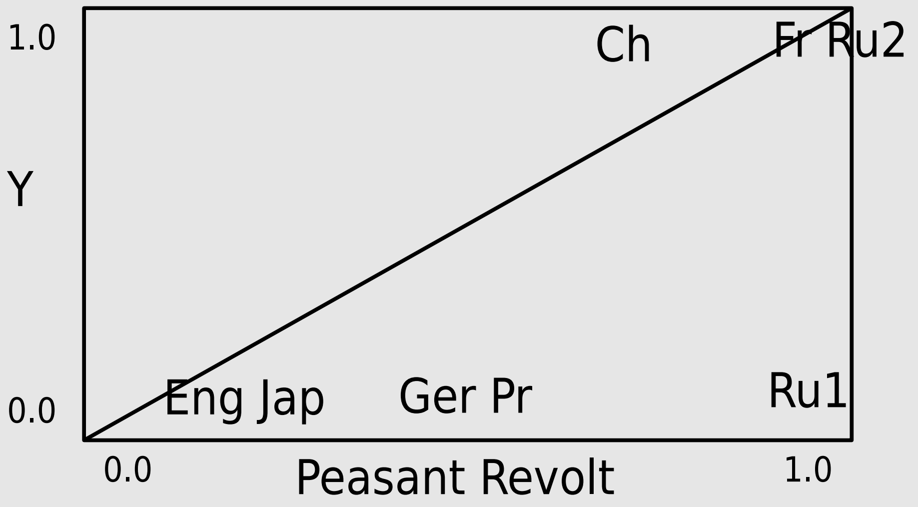
Russia 1905	0.49	1.00	0.0
Germany 1848	0.25	0.49	0.0
Prussia 1807	0.75	0.49	0.0
Japan 1868	0.75	0.00	0.0

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

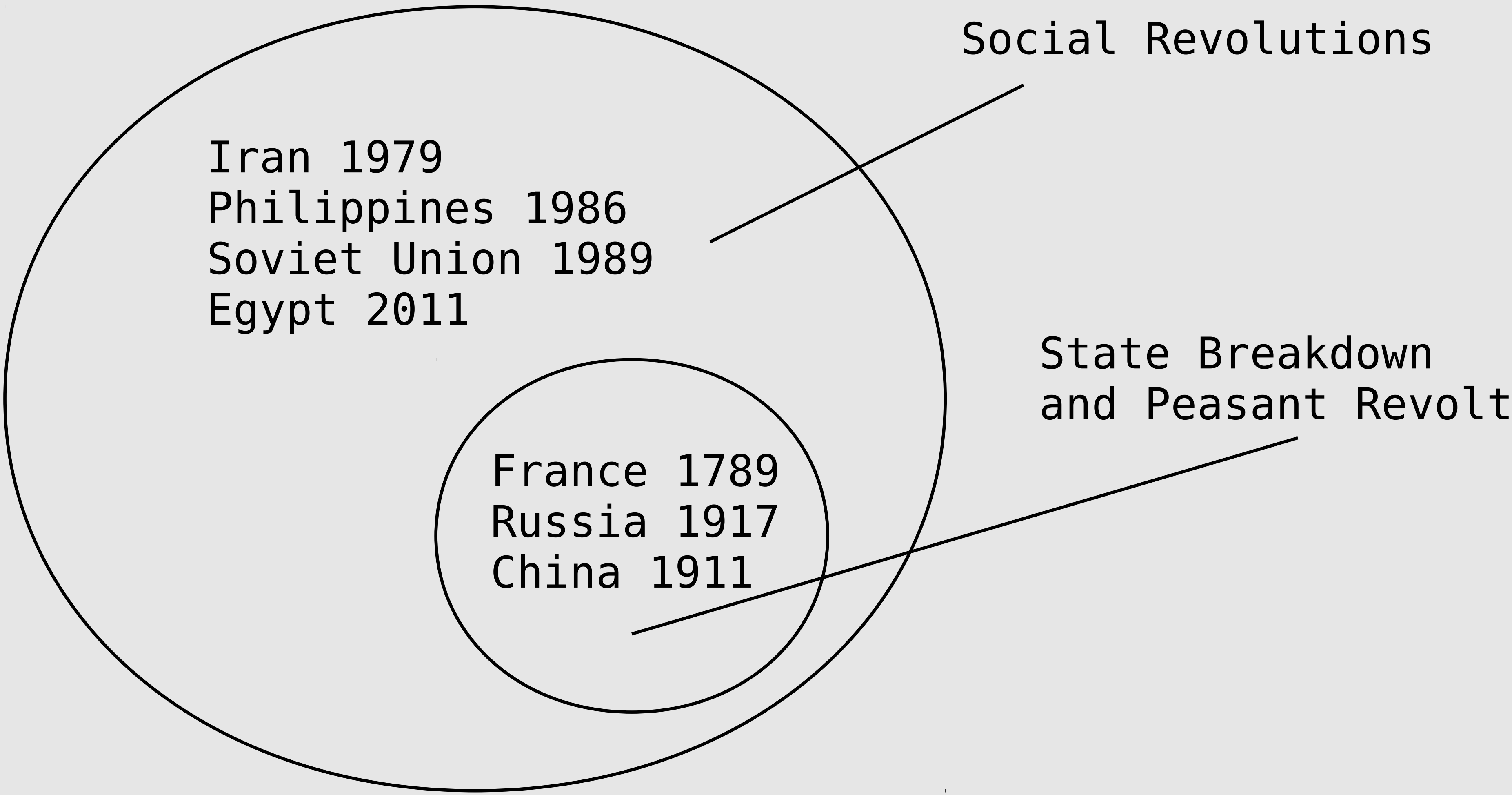
- More mature than necessity analysis; QCA development—and applications—have focused on sufficiency analysis
- Emphasis on causal complexity (a.k.a., multiple conjunctural causation, “recipes,” equifinality, or INUS conditions)

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

Sufficient Conditions

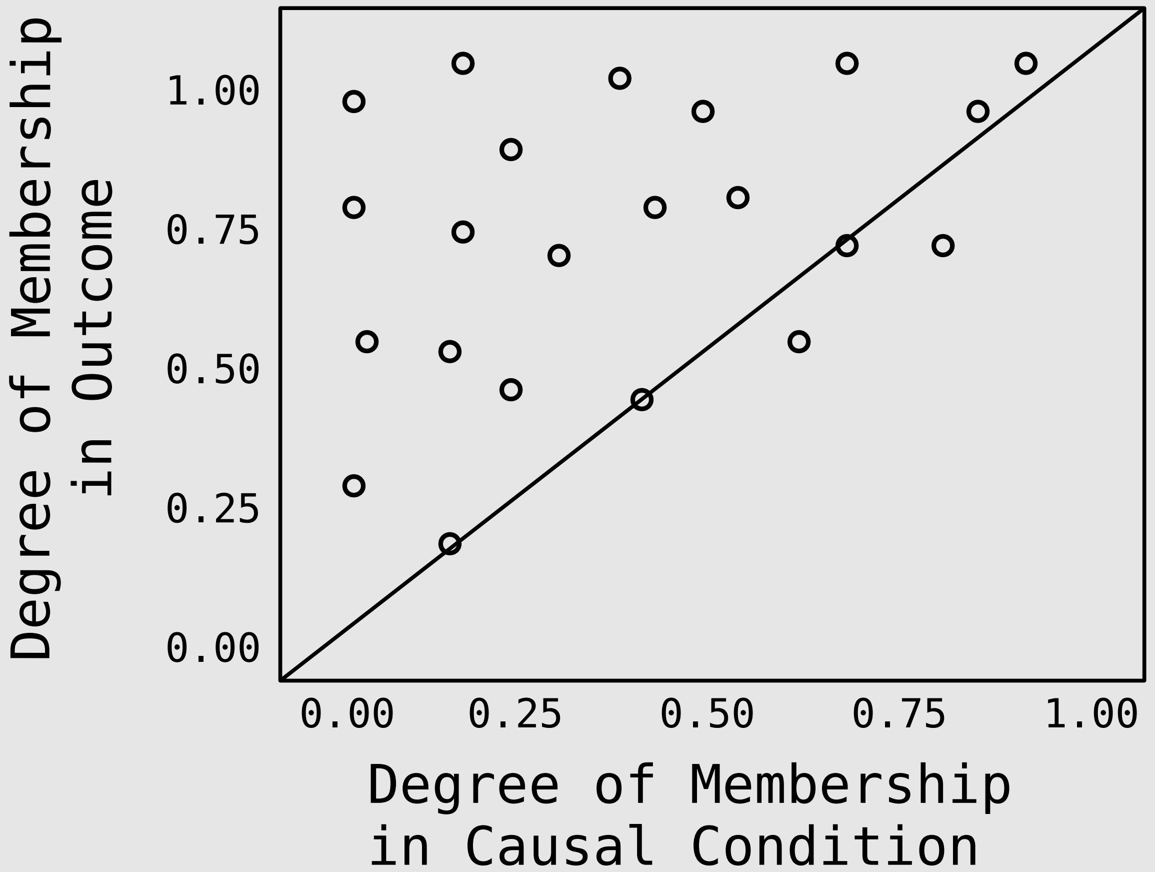
Outcome (almost) always occurs when causal condition is present.

Cause is a subset of Outcome



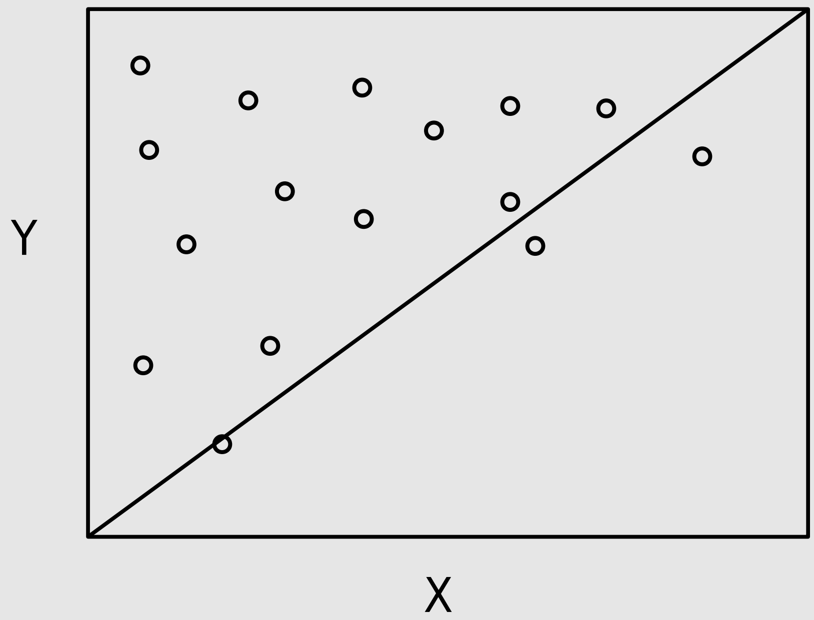
Fuzzy Subset Relationship Consistent with Sufficiency

Cause is a subset of Outcome (Y ≥ X)

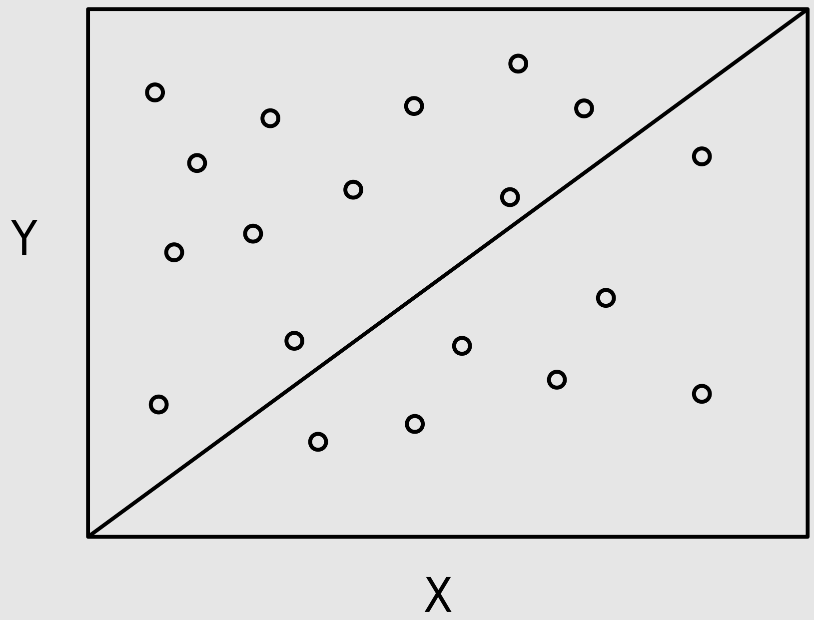


Assessing Sufficient Conditions

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



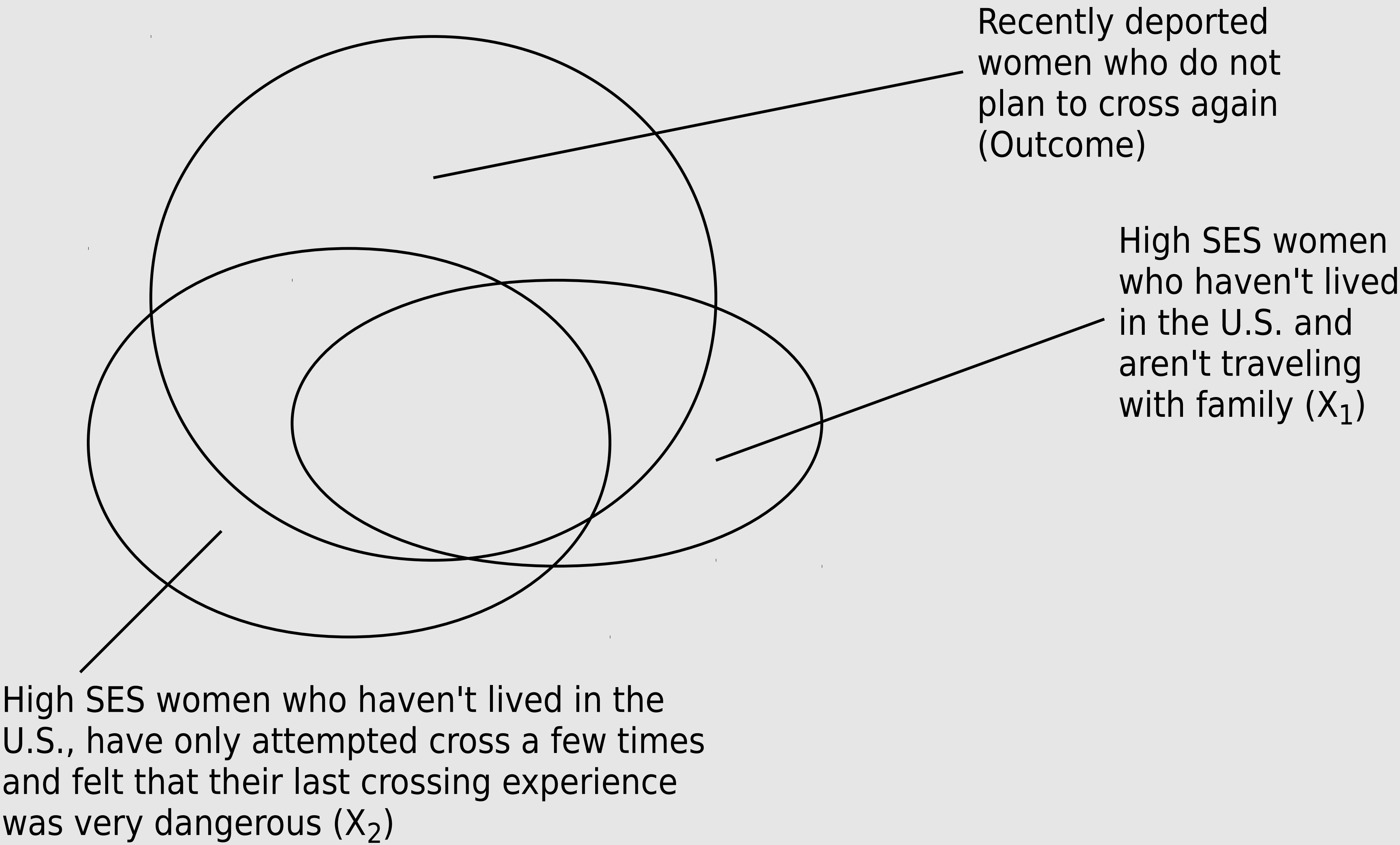
Subset relationship consistent with sufficiency



Subset relationship with substantial inconsistency

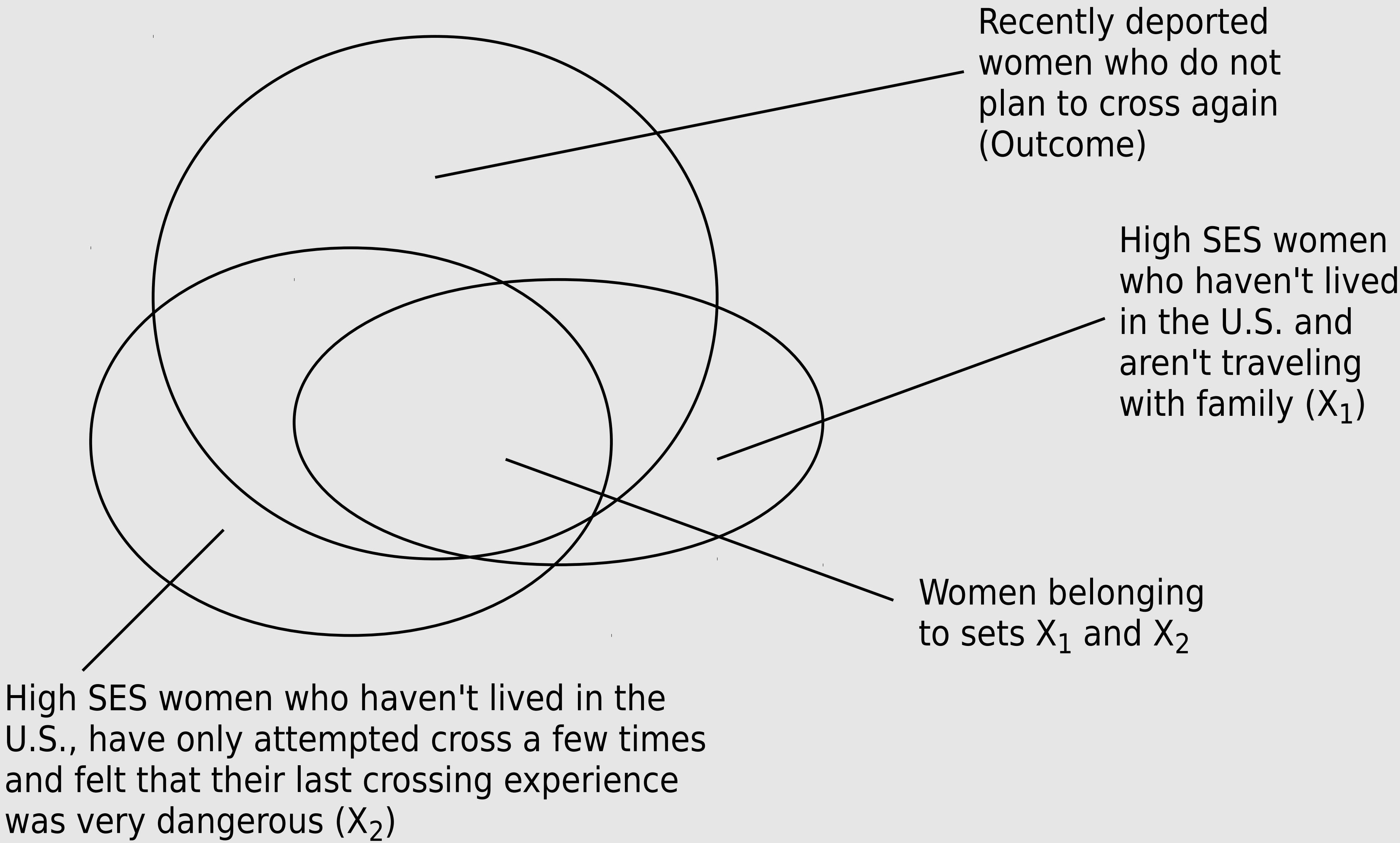
Assessing Sufficient Conditions

- *Coverage* measures the relative “importance” of each solution



Assessing Sufficient Conditions

- *Coverage* measures the relative “importance” of each solution



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	

Truth Table Construction

Truth table algorithm sorts observations into types

Obs	Dev	Urb	Lit	Brk	DUL	DUl	DuL	Dul	dUL	dUl	duL	dul
AT	.81	.12	.99	.95	.12	.01	**.81**	.12	.12	.01	.19	.01
BE	.99	.89	.98	.05	**.89**	.02	.11	.01	.01	.01	.01	.01
CZ	.58	.98	.98	.11	**.58**	.02	.02	.02	.42	.02	.02	.02
EE	.16	.07	.98	.88	.07	.02	.16	.07	.07	.02	**.84**	.02
FI	.58	.03	.99	.23	.03	.01	**.58**	.03	.03	.01	.42	.01
FR	.98	.03	.99	.05	.03	.01	**.97**	.02	.02	.01	.02	.01
DE	.89	.79	.99	.95	**.79**	.01	.21	.11	.11	.01	.11	.01
GR	.04	.09	.13	.94	.04	.04	.04	.09	.09	.09	.13	**.87**
HU	.07	.16	.88	.58	.07	.07	.07	.16	.16	.12	**.84**	.12
IE	.72	.05	.98	.08	.05	.02	**.72**	.05	.05	.02	.28	.02
IT	.34	.10	.41	.95	.10	.10	.34	.10	.10	.10	.41	**.59**
NL	.98	1.00	.99	.05	**.98**	.01	.00	.00	.02	.01	.00	.00
PL	.02	.17	.59	.88	.02	.02	.02	.17	.17	.17	**.59**	.41
PT	.01	.02	.01	.95	.01	.01	.01	.02	.01	.02	.01	**.98**

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

Remainders

	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 + $\longrightarrow$ Ai +
ACSi + ASR
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)