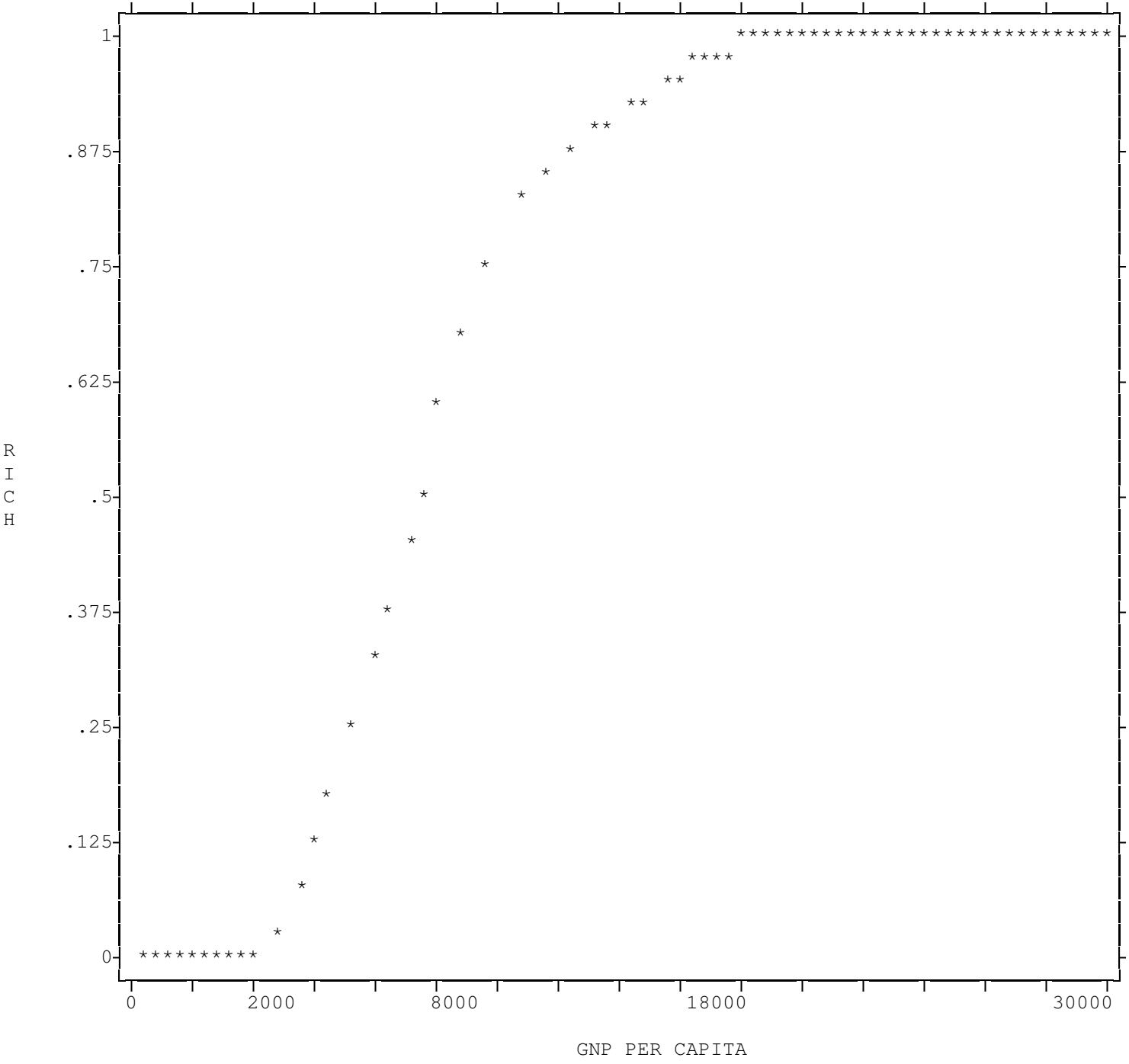
CRISP VERSUS FUZZY SETS

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
			.9 = mostly but not fully in	Degree of membership is more "in" than "out": $.5 < x_i < 1$
		.75 = more in than out	.7 = more or less in	
	.5 = neither fully in nor fully out			.5 = cross-over: neither in nor out
		.25 = more out than in	.3 = more or less out	Degree of membership is more "out" than "in": $0 < x_i < .5$
			.1 = mostly but not fully out	
0 = fully out	0 = fully out	0 = fully out	0 = fully out	0 = fully out

FUZZY MEMBERSHIP IN THE SET OF "RICH COUNTRIES"

GNP/capita:	Membership (M):	Verbal Labels:
100 ----> 1,999	M = 0	clearly not-rich
2,000 ----> 7,999	0 < M < .5	more or less not-rich
8,000	M = .5	in between
8,001 ----> 17,999	.5 < M < 1.0	more or less rich
18,000 ----> 30,000	M = 1.0	clearly rich

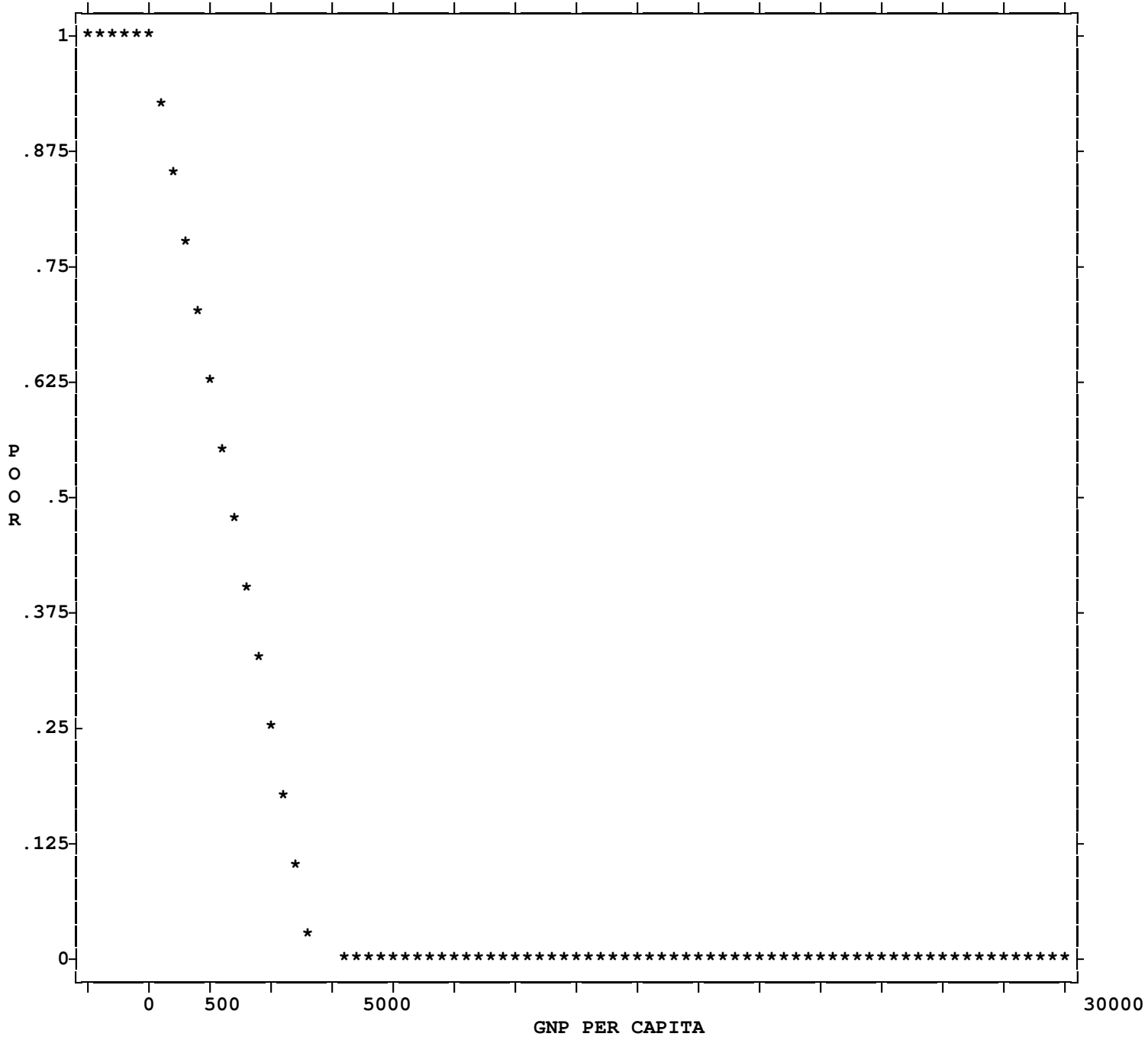
PLOT OF FUZZY MEMBERSHIP SCORES FOR THE SET OF "RICH COUNTRIES"



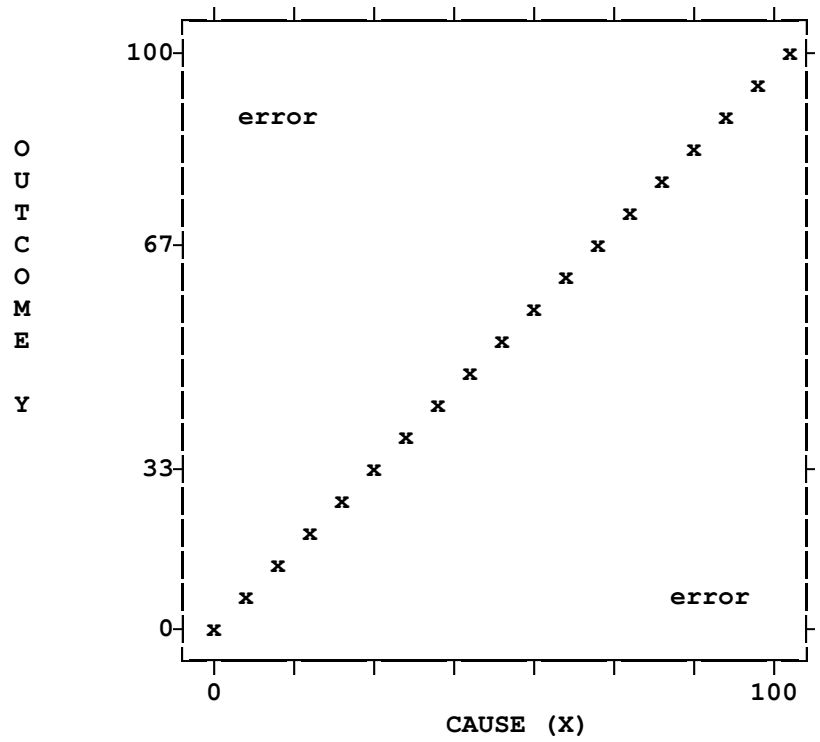
FUZZY MEMBERSHIP IN THE SET OF "POOR COUNTRIES"

GNP/capita (US$):	Membership (M):	Verbal Labels:
100 ----> 499	M = 1.0	clearly poor
500 ----> 999	.5 < M < .1	more or less poor
1,000	M = .5	in between
1,001 ----> 4,999	0 < M < .5	more or less not-poor
5,000 ----> 30,000	M = 0	clearly not-poor

PLOT OF FUZZY MEMBERSHI P SCORES I N THE SET OF "POOR COUNTRI ES"



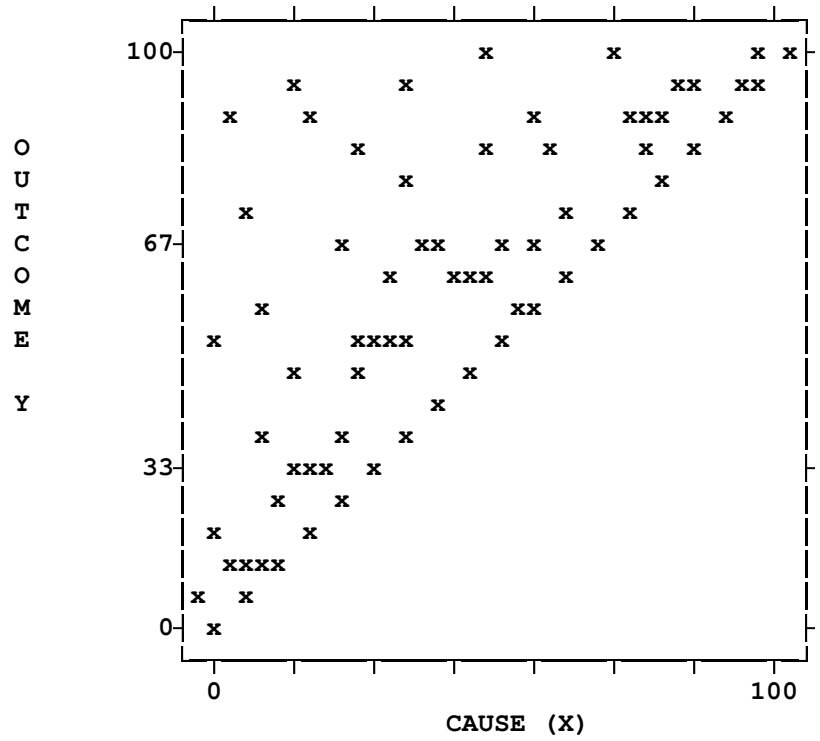
DECONSTRUCTING THE CONVENTIONAL SCATTERPLOT



- In conventional quantitative analysis, points in the lower-right corner and the upper-left corner of this plot are "errors," just as cases in cells 1 and 4 of the 2X2 crisp-set table are errors.

- With fuzzy sets, cases in these regions of the plot have different interpretations: Cases in the lower-right corner violate the argument that the cause is a subset of the outcome; cases in the upper-left corner violate the argument that the outcome is a subset of the cause.

THE CAUSE (X) IS A SUBSET OF THE OUTCOME (Y)

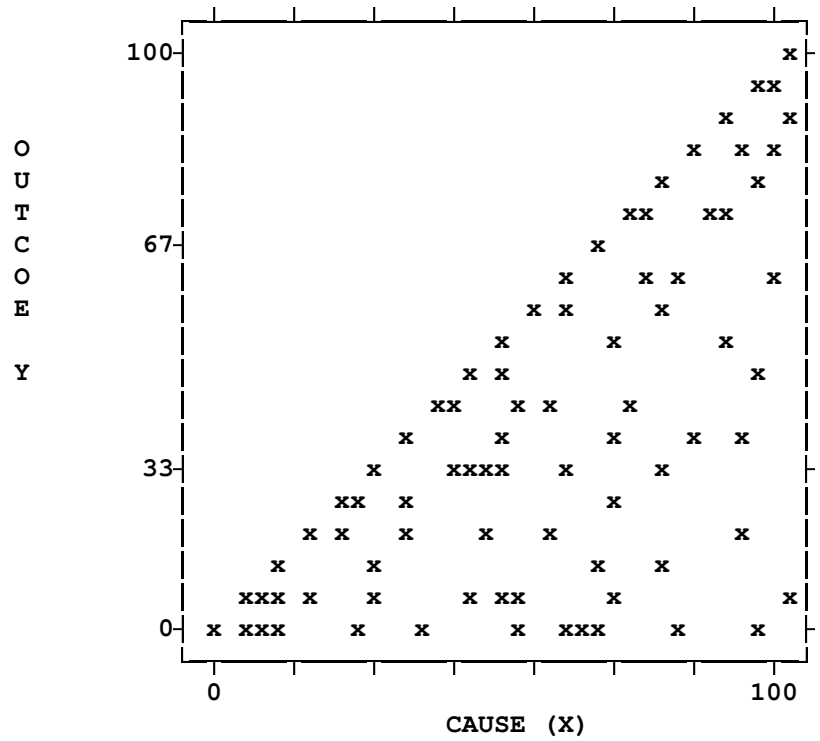


- This plot illustrates the characteristic upper-triangular plot indicating the fuzzy subset relation: $X \leq Y$ (cause is a subset of the outcome). This also can be viewed as a plot supporting the contention that X is sufficient for Y.

- Cases in the upper-left region are not errors, as they would be in a conventional quantitative analysis. Rather, these are cases with high membership in the outcome due to the operation of other causes. After all, the argument here is that X is a subset of Y (i.e., X is one of perhaps several ways to generate or achieve Y). Therefore, cases of Y without X (i.e., high membership in Y coupled with low membership in X) are to be expected.

- In this plot, cases in the lower-right region would be serious errors because these would be instances of high membership in the cause coupled with low membership in the outcome. Such cases would undermine the argument that there is an explicit connection between X and Y such that X is a subset of Y.

THE OUTCOME (Y) IS A SUBSET OF THE CAUSE (x)



- This plot illustrates the characteristic lower-triangular plot indicating the fuzzy superset relation: X ≥ Y (outcome is a subset of the cause). This also can be viewed as a plot supporting the contention that X is necessary for Y.

- Cases in the lower-right region are not errors, as they would be in a conventional quantitative analysis. Rather, these are cases with low membership in the outcome, despite having high membership in the cause. This pattern indicates that Y is a subset of X: condition X must be present for Y to occur, but X is not capable of generating Y by itself. Other conditions may be required as well. Therefore, cases of X without Y (i.e., high membership in X coupled with low membership in Y) are to be expected.

- Cases in the upper-left region would be serious errors because these would be instances of low membership in the cause coupled with high membership in the outcome. In this plot, such cases would undermine the argument that there is an explicit connection between X and Y such that Y is a subset of X.

REFINING THE FUZZY SUBSET RELATION: 1. CAUSE IS A SUBSET OF THE OUTCOME

- When elaborating the subset relation X ≤ Y with fuzzy sets, the goal is to move cases to the left side of the main diagonal of the scatterplot (i.e., above it).

- When the argument is that the cause (X) is a subset of the outcome (Y), cases below the diagonal are "errors" because these X scores exceed the corresponding outcome (Y) scores.

- As with crisp set analysis, logical *and* can be used to move scores to the correct side of the diagonal. With logical *and*, conditions are compounded, which in turn involves taking the minimum membership score of the compounded sets as the membership of a case in the combinations. Mathematically, A*B must be less than or equal to A.

- Thus, the elaboration of a subset relation through additional compounded conditions lowers the X values and thus may move cases toward the left side of the diagonal.

FUZZY-SET DATA ON CLASS VOTING IN THE ADVANCED INDUSTRIAL SOCIETIES

Country	Weak Class voting (W)	Affluent (A)	Income Inequality (I)	Manufacturing (M)	Strong Unions (U)
Australia	0.6	0.8	0.6	0.4	0.6
Belgium	0.6	0.6	0.2	0.2	0.8
Denmark	0.2	0.6	0.4	0.2	0.8
France	0.8	0.6	0.8	0.2	0.2
Germany	0.6	0.6	0.8	0.4	0.4
Ireland	0.8	0.2	0.6	0.8	0.6
Italy	0.6	0.4	0.8	0.2	0.6
Netherlands	0.8	0.6	0.4	0.2	0.4
Norway	0.2	0.6	0.4	0.6	0.8
Sweden	0.0	0.8	0.4	0.8	1.0
United Kingdom	0.4	0.6	0.6	0.8	0.6
United States	1.0	1.0	0.8	0.4	0.2

ILLUSTRATION OF LOGICAL *AND*

Country	Affluent (A)		Income Inequality (I)		Manufacturing (M)		Strong Unions (U)		Affluent* Income Inequality	Affluent* Income Inequality* Weak Unions
	A	**a**	**I**	**i**	**M**	**m**	**U**	**u**	**A*I**	**A*I*u**
Australia	0.8	0.2	0.6	0.4	0.4	0.6	0.6	0.4	0.6	0.4
Belgium	0.6	0.4	0.2	0.8	0.2	0.8	0.8	0.2	0.2	0.2
Denmark	0.6	0.4	0.4	0.6	0.2	0.8	0.8	0.2	0.4	0.2
France	0.6	0.4	0.8	0.2	0.2	0.8	0.2	0.8	0.6	0.6
Germany	0.6	0.4	0.8	0.2	0.4	0.6	0.4	0.6	0.6	0.6
Ireland	0.2	0.8	0.6	0.4	0.8	0.2	0.6	0.4	0.2	0.2
Italy	0.4	0.6	0.8	0.2	0.2	0.8	0.6	0.4	0.4	0.4
Netherlands	0.6	0.4	0.4	0.6	0.2	0.8	0.4	0.6	0.4	0.4
Norway	0.6	0.4	0.4	0.6	0.6	0.4	0.8	0.2	0.4	0.2
Sweden	0.8	0.2	0.4	0.6	0.8	0.2	1.0	0.0	0.4	0.0
Ukingdom	0.6	0.4	0.6	0.4	0.8	0.2	0.6	0.4	0.6	0.4
Ustates	1.0	0.0	0.8	0.2	0.4	0.6	0.2	0.8	0.8	0.8

REFINING THE FUZZY SUBSET RELATION: 2. OUTCOME IS A SUBSET OF THE CAUSE

- When elaborating the subset relation $Y \leq X$ with fuzzy sets, the goal is to move cases toward the right side of the main diagonal of the scatterplot (i.e., below it).

- When the argument is that the outcome (Y) is a subset of the cause (X), cases above the diagonal are "errors" because these X scores are less than the corresponding outcome (Y) scores.

- As with crisp set analysis, logical *or* can be used to move scores to the correct side of the diagonal. With logical *or* conditions are substitutable, which in turn involves taking the maximum membership score of the substitutable sets. It follows mathematically that $A + B \geq A$.

- Thus, the elaboration of a superset relation through additional substitutable conditions raises the X values and thus moves cases toward the right side of the diagonal.

ILLUSTRATION OF LOGICAL *OR*

Country	Affluent (A)		Income Inequality (I)		Manufacturing (M)		Strong Unions (U)		Manufacturing + Strong Unions	Low Inequality * (Manufacturing + Strong Unions)
	A	**a**	**I**	**i**	**M**	**m**	**U**	**u**	**M+U**	**i*(M+U)**
Australia	0.8	0.2	0.6	0.4	0.4	0.6	0.6	0.4	0.6	0.4
Belgium	0.6	0.4	0.2	0.8	0.2	0.8	0.8	0.2	0.8	0.8
Denmark	0.6	0.4	0.4	0.6	0.2	0.8	0.8	0.2	0.8	0.6
France	0.6	0.4	0.8	0.2	0.2	0.8	0.2	0.8	0.2	0.2
Germany	0.6	0.4	0.8	0.2	0.4	0.6	0.4	0.6	0.4	0.2
Ireland	0.2	0.8	0.6	0.4	0.8	0.2	0.6	0.4	0.8	0.4
Italy	0.4	0.6	0.8	0.2	0.2	0.8	0.6	0.4	0.6	0.2
Netherlands	0.6	0.4	0.4	0.6	0.2	0.8	0.4	0.6	0.4	0.4
Norway	0.6	0.4	0.4	0.6	0.6	0.4	0.8	0.2	0.8	0.6
Sweden	0.8	0.2	0.4	0.6	0.8	0.2	1.0	0.0	1.0	0.6
UKingdom	0.6	0.4	0.6	0.4	0.8	0.2	0.6	0.4	0.8	0.4
UStates	1.0	0.0	0.8	0.2	0.4	0.6	0.2	0.8	0.4	0.2

FUZZY SETS AND CONFIGURATIONS

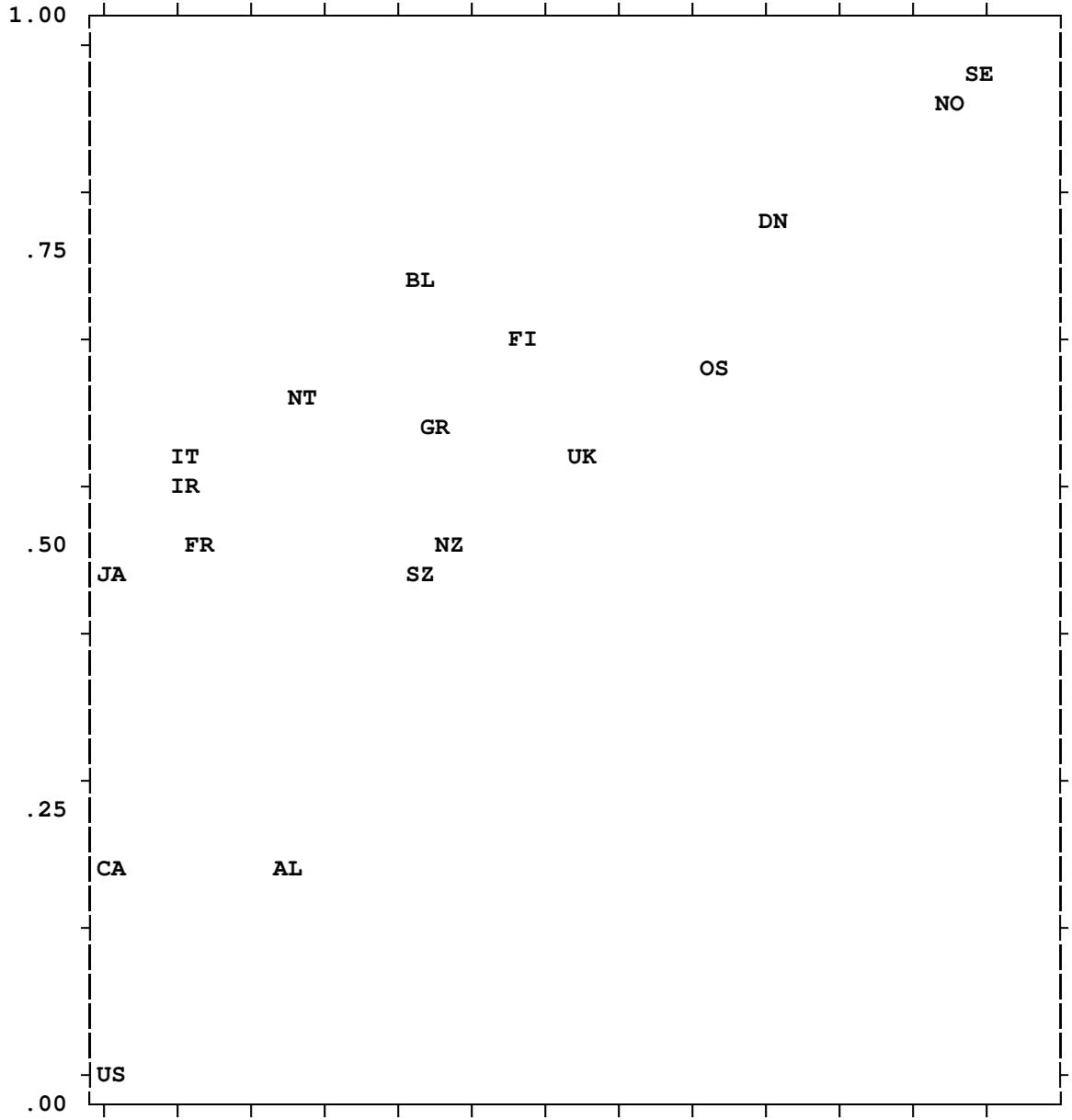
Country	Income Inequality		Manufacturing		Strong Unions									
	I	**i**	**M**	**m**	**U**	**u**	**i*m*u**	**i*m*U**	**i*M*u**	**i*M*U**	**I*m*u**	**I*m*U**	**I*M*u**	**I*M*U**
Australia	0.6	0.4	0.4	0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.6	0.4	0.4
Belgium	0.2	0.8	0.2	0.8	0.8	0.2	0.2	0.8	0.2	0.2	0.2	0.2	0.2	0.2
Denmark	0.4	0.6	0.2	0.8	0.8	0.2	0.2	0.6	0.2	0.2	0.2	0.4	0.2	0.2
France	0.8	0.2	0.2	0.8	0.2	0.8	0.2	0.2	0.2	0.2	0.8	0.2	0.2	0.2
Germany	0.8	0.2	0.4	0.6	0.4	0.6	0.2	0.2	0.2	0.2	0.6	0.4	0.4	0.4
Ireland	0.6	0.4	0.8	0.2	0.6	0.4	0.2	0.2	0.4	0.4	0.2	0.2	0.4	0.6
Italy	0.8	0.2	0.2	0.8	0.6	0.4	0.2	0.2	0.2	0.2	0.4	0.6	0.2	0.2
Netherlands	0.4	0.6	0.2	0.8	0.4	0.6	0.6	0.4	0.2	0.2	0.4	0.4	0.2	0.2
Norway	0.4	0.6	0.6	0.4	0.8	0.2	0.2	0.4	0.2	0.6	0.2	0.4	0.2	0.4
Sweden	0.4	0.6	0.8	0.2	1.0	0.0	0.0	0.2	0.0	0.6	0.0	0.2	0.0	0.4
UKingdom	0.6	0.4	0.8	0.2	0.6	0.4	0.2	0.2	0.4	0.4	0.2	0.2	0.4	0.6
UStates	0.8	0.2	0.4	0.6	0.2	0.8	0.2	0.2	0.2	0.2	0.6	0.2	0.4	0.2

With three fuzzy sets, the vector space has eight corners. It is possible to calculate the membership of each case in each corner.

The corners can be viewed as ideal typic cases; the membership of a case is a corner is the degree to which it conforms to the ideal type represented by the corner.

In crisp-set analysis, by contrast, membership in a corner is either 1 or 0 and a case can have nonzero membership in only one corner.

HYPOTHETICAL PLOT OF CONFIGURATION MEMBERSHIP VS. OUTCOME



Plot of weak class voting against membership in a combination of causes (X axis).

The Fuzzy-Set Procedure

1. The researcher calibrates fuzzy membership scores for all relevant causal conditions and the outcome. It is OK to mix crisp and fuzzy causal conditions.

2. fsQCA calculates the membership of each case in all the logically possible combinations of membership. In each calculation the minimum membership score is used.

3. fsQCA calculates the degree to which membership in each combination of conditions is a consistent subset of membership in the outcome.

4. The results of these 2^k analyses are recorded in a truth table. In effect, each row of the (crisp) truth table represents a corner of the multidimensional space defined by the causal conditions.

5. fsQCA also calculates the number of cases with greater than .5 membership in each combination of conditions. This information is used to assess patterns of limited diversity.

6. The researcher uses the information in the truth table (from #4 and #5) to code the outcome in the truth table. This involves decisions about frequency and consistency thresholds.

7. fsQCA analyzes the truth table. Usually, two solutions are derived, one with remainders set to false (0), the other with remainders set to don't care (-). These two solutions establish the range of plausible solutions (the complexity/parsimony continuum).

NSF Tends to Fund Research That:

- tests existing theory;

- focuses on general patterns, evidenced by correlations between variables and discernible across "large" *N*s;

- uses research assistants to collect and analyze data;

- has a research design that is specified at the outset of the research, usually in the proposal itself; and

- culminates in the creation of a public good--a large-*N* data set that is, in effect, purchased by the NSF for the social scientific community.

In this funding template, principal investigators (PIs) are funded primarily to supervise data collection efforts and subsequent analyses of these data by research assistants. It is often assumed that little in the way of release time for PIs is required for this supervision.

Most Qualitative Research, In Sharp Contrast:

- builds new theory or challenges existing theory;
- focuses on small *N*s, studied intensively;
- relies on the PI as the key data collection instrument;
- develops the research design in the course of the research, as the investigator learns more about his/her cases; and
- culminates in a data archive that is useful mostly to researchers who have substantial knowledge of the cases studied or of similar cases, not a broad community of researchers.

In short, the typical qualitative research project completely contradicts the NSF funding template.

What All "Good" Principle Investigators Should Do:

- *Write clearly and engagingly* for a broad audience of social scientists. For example, define and explain disciplinary or project specific jargon.

- *Situate the research in relation to existing theory* whether the research goal is to challenge conventional views of some phenomenon or to develop new theory or chart new terrain.

- *Locate the research in the literature* citing existing studies of related phenomena, specifying comparable cases, building on findings of other researchers, and bringing this research into dialogue with the work of others.

- *Articulate the theoretical contribution* the research promises to make by indicating what gaps in theory this project will fill, what argument motivates the research, what findings might be expected.

- *Outline clearly the research procedures* including details about where, when, who, what, and how the research will be conducted.

- *Provide evidence of the project's feasibility* including documentation of permission to access research sites and resources and human subjects approval.

- *Provide a catalog of the data to be collected* including examples of the kinds of evidence to be gathered, the different modes of data collection that will be used, the places data will be obtained.

- *Discuss a plan for data analysis* including a discussion of different strategies for managing the various types of data to be gathered, how data will be stored and accessed, and the procedures for making sense of the information obtained.

- *Describe a strategy to refine the concepts and construct theory* as more is learned about the case(s) under investigation.

- *Include plans to look for and interpret disconfirming evidence*, alternative explanations, unexpected findings, and new interpretations—try to be wrong as well as right.

- *Provide an assessment of the possible impact of the researcher's presence and biography* on the research from the point of problem selection through data collection and analysis; this is especially important where the researcher is present during data collection and thus can have a direct impact on and potentially bias the results.

- *Provide information about replicability*, in particular try to consider and suggest ways in which this research might be reproduced by others.

- *Describe the data archive* that will be left behind for others to use and the plan for maintaining confidentiality.