A synthetic strategy should also allow consideration of alternative explanations. One weakness of case-oriented studies is the fact that they are very private products; they contradict the communal norms of scientific investigation (Merton 1973). A case-oriented investigator labors in isolation to produce a study which, in the end, bears his or her mark. Typically, a case-oriented study elaborates the ideas and theories of the investigator with data that are not generally known or accessible to other investigators, and often only perfunctory consideration of alternative explanations and arguments is offered. In essence, case-oriented analyses usually stack the deck in favor of the preferred theory. The variable-oriented strategy, by contrast, is conservative by design. Favored theories are pitted against alternatives and forced to compete in the struggle to explain variation. While the variable-oriented strategy is more consistent with the norms of scientific investigation, especially those borrowed from the natural sciences, its conservative bias discourages interpretive analysis. Theories win or lose; only rarely are they used to understand events. A synthetic strategy should provide a way to test alternative arguments and at the same time encourage the use of theory as a basis for interpretation. After all, the goals of social science are to test theories—to reject unsupportable ideas—but also to advance the collective understanding of common origins and possible common destinies.

In short, the ideal synthetic strategy should integrate the best features of the case-oriented approach with the best features of the variable-oriented approach. This integration would allow investigators to address questions relevant to many cases in a way that does not contradict either the complexity of social causation or the variety of empirical social phenomena. The key to a proper synthetic strategy is the idea of qualitative comparative analysis—the notion of comparing wholes as configurations of parts. This is the *via media* between complexity and generality, between the radically analytic variable-oriented strategy and the highly personalized case-oriented strategy.

Qualitative comparison of cases is not easily accomplished with traditional statistical methods based on linear algebra. In the next chapter I present an alternative algebraic basis for comparative analysis. Specifically, I show how Boolean algebra can be used as a basis for analyzing multiple conjunctural causation.

6

A Boolean Approach to Qualitative Comparison: Basic Concepts

An explicit algebraic basis for qualitative comparison exists in Boolean algebra. Also known as the algebra of logic and as the algebra of sets, Boolean algebra was developed in the mid-nineteenth century by George Boole. It is not necessary to understand Boolean algebra in its entirety in order to comprehend its uses in comparative social science. The Boolean principles used in qualitative comparative analysis are quite simple. They are easy to grasp because they are consistent with simple logical principles common to many types of social scientific investigation. To a slightly lesser extent they are also consistent with everyday experience.

This chapter outlines basic features of Boolean algebra relevant to qualitative comparison. Although it is not an introduction to Boolean algebra, which is beyond the scope of this book, all relevant features of Boolean algebra are presented. This chapter also describes the Boolean algorithms that are used to compare cases holistically and presents simple, hypothetical examples. These algorithms are based on the work of electrical engineers who developed them in the 1950s to simplify switching circuits. As I hope to show, these are not mechanical procedures—despite their origins. There is an important element of investigator input, what electrical engineers would call engineering art, at virtually every stage of Boolean-based qualitative comparison. Chapter 7 presents advanced principles of Boolean algebra, and Chapter 8 presents examples of the application of these procedures to several data sets.

It is important to point out that the qualitative comparative method presented in this and subsequent chapters uses Boolean algebra, but it is not limited to this algebraic system. It is possible to mimic many of the basic algorithmic principles discussed with more conventional techniques, and it is possible to apply some of these alternative techniques to interval-scale variables. Thus, the ideas presented in these chapters are not limited to dichotomous social data (such as presence/absence of structures or events) or to a narrowly Boolean (that is, logical) formulation. A strictly Boolean approach is presented because the principles of qualitative comparison are much easier to grasp and to apply when formulated in this manner.

BASIC FEATURES OF BOOLEAN ALGEBRA

There are ten aspects of Boolean algebra that are essential to its use in social science. These are presented in rough sequence here, with more difficult concepts following simpler concepts. Whenever possible, applications to hypothetical social data are supplied.

USE OF BINARY DATA. There are two conditions or states in Boolean algebra: true (or present) and false (or absent). These two states are represented in base 2: 1 indicates presence; 0 indicates absence. The typical Boolean-based comparative analysis addresses the presence/absence conditions under which a certain outcome is obtained (that is, is true). Thus, in a Boolean analysis of social data all variables, independent and dependent, must be nominal-scale measures. Interval-scale measures are transformed into multicategory nominal-scale measures. Nominal-scale measures with more than two categories are represented with several binary variables.

While these procedures entail some loss of information, the loss typically is not great. In many comparative studies this restriction does not pose a major obstacle because many phenomena of interest to comparativists, both causes and outcomes, are already nominal-scale measures. They are qualitative phenomena, such as the presence or absence of events, processes, and structures, that are difficult to measure on interval scales. In Barrington Moore's (1966) study, for example, the main "variables" were qualitative distinctions such as the presence or absence of communal peasant villages in certain countries or regions. While interval-scale measures of some of the phenomena of interest to comparativists are sometimes available, meaningful

transformation of such measures into multicategory nominal-scale variables can be achieved by incorporating substantive and theoretical criteria.

USE OF TRUTH TABLE TO REPRESENT DATA. In order to use Boolean algebra as a technique of qualitative comparison, it is necessary to reconstruct a raw data matrix as a truth table. The idea behind a truth table is simple. Once the data have been recoded into nominal-scale variables and represented in binary form (as 1's and 0's), it is necessary only to sort the data into their different combinations of values on the independent variables. Each logical combination of values on the independent variables is represented as one row of the truth table. Once this part of the truth table is constructed, each row is assigned an output value (a score of 1 or 0 on the dependent variable) based on the scores of the cases which share that combination of input values (that combination of scores on the independent variables). Thus, both the different combinations of input values (independent variables) and their associated output values (the dependent variable) are summarized in a truth table.

Truth tables have as many rows as there are logically possible combinations of values on the causal variables. If there are four binary independent variables, for example, the truth table will contain $2^4 = 16$ rows, one for each logically possible combination of four presence/absence independent variables. The truth table for a moderate-sized data set with four binary independent variables and one binary dependent variable (with 1 = present and 0 = absent) is shown in Table 3. (In all, this truth table would have sixteen rows.) Technically, there is no reason to include the frequency of each combination as part of the truth table. These values are included in the examples to remind the reader that each row is not a single case but a summary of all the cases with a certain combination of input values. In this respect, a row of a truth table is like a cell from a multiway cross-classification of several categorical independent variables.

Note that the outcome variable must be either 1 or 0, not an average or a probability. This requirement may present problems to the extent that clear tendencies are not evident in the data. In the first row of the hypothetical truth table (cases scoring 0 on all four causes, X_1 to X_4), for example, if the cases were evenly divided between an outcome of 0 and an outcome of 1 (that is, four of each), it would have been difficult to assign an output value to this row of the truth table. There are several possible solutions to this

TABLE 3: Representative Truth Table with Four Causal Conditions

Condition				Outcome	Number of
X_1	X_2	X_3	X_4	Y	Instances
0	0	0	0	0	8
0	0	0	1	0	6
0	0	1	0	1	10
0	0	1	1	0	5
0	1	0	0	1	13
0	1	0	1	0	7
0	1	1	0	1	11
0	1	1	1	1	5
1	0	0	0	1	9
1	0	0	1	1	3
1	0	1	0	0	12
1	0	1	1	0	23
1	1	0	0	0	15
1	1	0	1	1	5
1	1	1	0	0	8
1	1	1	1	1	6

problem, which are addressed in detail in Chapter 7. For the moment, assume that the data in the examples are unusually straightforward and that no contradictory rows exist. The important concept is that Boolean techniques of qualitative comparison use truth tables, which are constructed from binary raw data on cases sorted into their different combinations of values on the causal variables.

In a Boolean analysis, the number of instances of each combination of causal conditions does not enter directly into any computations. In other words, frequency criteria are not as important as they are in statistical analysis. This practice is consistent with a focus on types of situations (that is, rows of the truth table) as the basic analytic unit. This does not mean that frequency criteria cannot or should not be incorporated in any way. There are several possible ways to incorporate frequency criteria (see, for example, the third application in Chapter 8). One simple way to incorporate such criteria would be to establish cutoff values for rows of the truth table. For example, an investigator might decide that if there are not at least four instances of a certain combination of input values, as in row 2 of the hypothetical truth table (Table 3) where there are only three, then that combination of values should be excluded from consideration. Of course, there are simple statistical rules that can be used for such decisions which certainly should be applied when appropriate. (Ragin and others 1984 present one rudimentary technique.)

BOOLEAN ADDITION. In Boolean algebra, if $A + B = Z$, and $A = 1$ and $B = 1$, then $Z = 1$. In other words, $1 + 1 = 1$. The basic idea in Boolean addition is that if any of the additive terms is satisfied (present), then the outcome is true (occurs). Addition in Boolean algebra is equivalent to the logical operator OR. (In this discussion uppercase OR is used to indicate logical OR.) Thus, the statement $A + B = Z$ becomes: if A equals 1 OR B equals 1, then Z equals 1.

The best way to think of this principle is in logical terms, not arithmetically. For example, there might be several things a person could do to lose his or her job. It does not matter how many of these things the person does. If the employee does any one (or all) of them, he or she will be fired. Doing two of them will not cause one employee to be more fired than another employee who does only one of them. Fired is fired, a truly qualitative state. This example succinctly illustrates the nature of Boolean addition: satisfy any one of the additive conditions and the expected outcome follows. This aspect of Boolean addition is very useful in social scientific analysis, especially qualitative comparison, although its value is not generally recognized.

Consider the collapse of military regimes. Assume that there are three general conditions that cause military regimes to fall: sharp conflict between older and younger military officers (A), death of a powerful dictator (B), or CIA dissatisfaction with the regime (C). Any one of these three conditions may be sufficient to prompt a collapse. The truth table for a number of such regimes in different countries is shown in Table 4 (with 1 = present and 0 = absent). Each combination of causes produces either regime failure or an absence of regime failure—there are no contradictory rows.

With uppercase letters indicating the presence of a condition and lowercase letters indicating its absence (a convention used throughout this discussion), the "simplified" Boolean equation

$$F = A + B + C$$

TABLE 4: Hypothetical Truth Table Showing Three Causes of Regime Failure

Condition			Regime Failure	Number of
A	*B*	*C*	*F*	Instances
0	0	0	0	9
1	0	0	1	2
0	1	0	1	3
0	0	1	1	1
1	1	0	1	2
1	0	1	1	1
0	1	1	1	1
1	1	1	1	3

A = Conflict between older and younger military officers
B = Death of a powerful dictator
C = CIA dissatisfaction with the regime

expresses the relation between the three conditions and regime failure simply and elegantly for both negative and positive instances. Simply stated: if any one (or any two or all three) of these conditions obtains, then the regime will fall.

It would be difficult to achieve this same directness in a statistical analysis because a linear, additive combination of these three presence/absence variables would predict that cases with more than one of the three conditions present should somehow experience more of a regime failure. But a regime either falls or it does not (assuming the investigator has applied the relevant criteria correctly and consistently); the distinction is qualitative.

In order to model these data with statistical methods, many more cases would have to be found and added to the set. Assuming this, the investigator might apply discriminant analysis or some type of log-linear analysis to the data. The goal of the discriminant analysis would be to estimate a linear, arithmetic combination of causal variables in a way that maximizes the separation of the scores of predefined groups on a "discriminant function" while minimizing within-group variation on these scores. To use this technique effectively it would be necessary to include terms modeling the statistical interaction between the causal variables (with negative coefficients) as predictors to correct for the fact that when two or more relevant conditions are present, the score on the discriminant function should remain constant (that is, be equal to 1) within the regime failure group. Similarly, a log-linear

analysis of this hypothetical (dramatically enlarged) data set would show interaction. Thus, a simple (and clear) model from a logical (that is, Boolean) point of view would be awkward to model statistically.

A statistician's immediate response to this problem would be to argue that the investigator should use a different dependent variable—perhaps number of deaths associated with the collapse of each regime, a convenient interval-scale dependent variable. But this would be a different analysis and a different question. It would be an analysis of the bloodiness of regime changes, not of the conditions that prompt the collapse of military regimes.

Historical and comparative social scientists are often interested in outcomes of this type—events and formations that are best viewed as historically emergent and therefore qualitative. It is difficult to transform such qualitative occurrences into meaningful interval-scale dependent variables suitable for conventional multivariate statistical analysis. This is not to say, of course, that statistical methods cannot be applied to categorical dependent variables. The point is simply that the Boolean model is more consistent with how we often think about and understand qualitative phenomena.

BOOLEAN MULTIPLICATION. Boolean multiplication differs substantially from normal multiplication. Boolean multiplication is relevant because the typical social science application of Boolean algebra concerns the process of simplifying expressions known as "sums of products." A product is a specific combination of causal conditions. With uppercase letters indicating presence and lowercase letters indicating absence, the data on collapsed military regimes from Table 4 can be represented in "primitive" (that is, unreduced) sums-of-products form as follows:

$$F = Abc + aBc + abC + ABc + AbC + aBC + ABC$$

Each of the seven terms represents a combination of causal conditions found in at least one instance of regime failure. The different terms are products because they represent intersections of conditions (conjunctures of causes and absences of causes). The equation shows the different primitive combinations of conditions that are linked to the collapse of military regimes.

Boolean multiplication, like Boolean addition, is not arithmetic. The expression *Abc* does not mean that the value of *A* (1) is multiplied by the value of *B* (0) and by the value of *C* (0) to produce a result value of 0. It means simply that a presence of *A* is combined with an absence of *B* and an

absence of *C*. The total situation, $F = Abc$, occurs in the data twice. This conjunctural character of Boolean multiplication shapes the interpretation of the primitive sums-of-products equation presented above: *F* (regime failure) occurs if any of seven combinations of three causes is obtained. In Boolean algebra, therefore, addition indicates logical OR and multiplication indicates logical AND. The three causes are ANDed together in different ways to indicate different empirical configurations. These intersections are ORed together to form an unreduced, sums-of-products equation describing the different combinations of the three causes linked to regime failure.

COMBINATORIAL LOGIC. Boolean analysis is combinatorial by design. In the analysis of regime failures presented above, it appears from casual inspection of only the first four rows of the truth table (Table 4) that if any one of the three causes is present, then the regime will collapse. While it is tempting to take this shortcut, the route taken by Boolean analysis is much more exacting of the data. This is because the absence of a cause has the same logical status as the presence of a cause in Boolean analysis. As noted above, Boolean multiplication indicates that presence and absence conditions are combined, that they intersect.

Consider the second row of the truth table (Table 4), which describes the two instances of military regime failure linked to causal configuration *Abc*. Simple inspection suggests that in this case *F* (regime failure) resulted from the first cause, *A*. But notice that if the investigator had information on only this row of the truth table, and not on any of the other instances of regime failure, he or she *might* conclude that *A* causes *F* only if causes *B* and *C* are absent. This is what the *Abc* combination indicates. This row by itself does not indicate whether *A* would cause *F* in the presence of *B* or *C* or both. All the researcher knows from these two instances of *Abc* is that for *A* to cause *F*, it may be necessary for the other conditions (*B* and *C*) to be absent. From a Boolean perspective, it is entirely plausible that in the presence of one or both of these other conditions (say, configuration *AbC*), *F* may not result. To return to the original designations, it may be that in the presence of CIA meddling (*C*), conflict between junior and senior officers (*A*) will dissipate as the two factions unite to oppose the attempt by outsiders to dictate events.

To push this argument further, assume the investigator had knowledge of only the first four rows of the truth table. The data would support the idea

that the presence of any one of the three conditions causes *F*, but again the data might indicate that *A* causes *F* only when *B* and *C* are absent (*Abc*), *B* causes *F* only when *A* and *C* are absent (*aBc*), and so on. A strict application of combinatorial logic requires that these limitations be placed on conclusions drawn from a limited variety of cases. (Chapter 7 discusses how these restrictions can be addressed.)

This feature of combinatorial logic is consistent with the idea that cases, especially their causally relevant features, should be viewed holistically. The holistic character of the Boolean approach is consistent with the orientation of qualitative scholars in comparative social science who examine different causes in context. When the second row of the truth table (Table 4) is examined, it is not interpreted as instances of *F* caused by *A* but as instances of *F* caused by *Abc*. Thus, in Boolean-based qualitative comparison, causes are not viewed in isolation but always within the context of the presence and absence of other causally relevant conditions.

BOOLEAN MINIMIZATION. The restrictive character of combinatorial logic seems to indicate that the Boolean approach simply compounds complexity on top of complexity. This is not the case. There are simple and straightforward rules for simplifying complexity—for reducing primitive expressions and formulating more succinct Boolean statements. The most fundamental of these rules is:

> If two Boolean expressions differ in only one causal condition yet produce the same outcome, then the causal condition that distinguishes the two expressions can be considered irrelevant and can be removed to create a simpler, combined expression.

Essentially this minimization rule allows the investigator to take two Boolean expressions that differ in only one term and produce a combined expression. For example, *Abc* and *ABc*, which both produce outcome *F*, differ only in *B*; all other elements are identical. The minimization rule stated above allows the replacement of these two terms with a single, simpler expression: *Ac*. In other words, the comparison of these two rows, *Abc* and *ABc*, as wholes indicates that in instances of *Ac*, the value of *B* is irrelevant. Cause *B* may be either present or absent; *F* will still occur.

The logic of this simple data reduction parallels the logic of experimental design (Chapter 2). Only one causal condition, *B*, varies and no difference in outcome is detected (because both *Abc* and *ABc* are instances of *F*). According to the logic of experimental design, *B* is irrelevant to *F* in the presence of

Ac (that is, holding these two conditions constant). Thus, the process of Boolean minimization mimics the logic of experimental design. It is a straightforward operationalization of the logic of the ideal social scientific comparison.

This process of logical minimization is conducted in a bottom-up fashion until no further stepwise reduction of Boolean expressions is possible. Consider again the data on military regime failures presented above. Each of the rows with one cause present and two absent can be combined with rows with two causes present and one absent because all these rows have the same outcome (F) and each pair differs in only one causal condition:

Abc combines with *ABc* to produce *Ac*.

Abc combines with *AbC* to produce *Ab*.

aBc combines with *ABc* to produce *Bc*.

aBc combines with *aBC* to produce *aB*.

abC combines with *AbC* to produce *bC*.

abC combines with *aBC* to produce *aC*.

Similarly, each of the rows with two causes present and one absent can be combined with the row with all three present:

ABc combines with *ABC* to produce *AB*.

AbC combines with *ABC* to produce *AC*.

aBC combines with *ABC* to produce *BC*.

Further reduction is possible. Note that the reduced terms produced in the first round can be combined with the reduced terms produced in the second round to produce even simpler expressions:

Ab combines with *AB* to produce *A*.

Ac combines with *AC* to produce *A*.

aB combines with *AB* to produce *B*.

Bc combines with *BC* to produce *B*.

aC combines with *AC* to produce *C*.

bC combines with *BC* to produce *C*.

Although tedious, this simple process of minimization produces the final, reduced Boolean equation:

$$F = A + B + C$$

True enough, this was obvious from simple inspection of the entire truth table, but the problem presented was chosen for its simplicity. The example directly illustrates key features of Boolean minimization. It is bottom-up (that is, inductively oriented). It seeks to identify ever wider sets of conditions (that is, simpler combinations of causal conditions) for which an outcome is true. And it is experiment-like in its focus on pairs of configurations differing in only one cause.

IMPLICATION AND THE USE OF "PRIME IMPLICANTS." A further Boolean concept that needs to be introduced is the concept of implication. A Boolean expression is said to imply another if the membership of the second term is a subset of the membership of the first. For example, A implies *Abc* because A embraces all the members of *Abc* (that is, *Abc* is a subset of A). This concept is best understood by example. If A indicates economically dependent countries, B indicates the presence of heavy industry, and C indicates centrally coordinated economies, A embraces all dependent countries while *Abc* embraces all dependent countries that lack both centrally coordinated economies and heavy industry. Clearly the membership of *Abc* is included in the membership of A. Thus, A implies *Abc*.

The concept of implication, while obvious, provides an important tool for minimizing primitive sums-of-products expressions. Consider the hypothetical truth table shown in Table 5, which summarizes data on three causal conditions thought to affect the success of strikes already in progress (S): a booming market for the product produced by the strikers (A), the threat of sympathy strikes by workers in associated industries (B), and the existence of a large strike fund (C).

The Boolean equation for S (successful strikes) showing unreduced (primitive) Boolean expressions is

$$S = AbC + aBc + ABc + ABC$$

The first step in the Boolean analysis of these data is to attempt to combine as many compatible rows of the truth table as possible. (Note that this

TABLE 5: Hypothetical Truth Table Showing Three Causes of Successful Strikes

Condition			Success	Frequency
A	*B*	*C*	*S*	
1	0	1	1	6
0	1	0	1	5
1	1	0	1	2
1	1	1	1	3
1	0	0	0	9
0	0	1	0	6
0	1	1	0	3
0	0	0	0	4

A = Booming product market
B = Threat of sympathy strikes
C = Large strike fund

part of the minimization process uses rows with an output value of 1—strike succeeded.) This first phase of the minimization of the truth table produces the following partially minimized Boolean equation, which in effect turns a primitive Boolean equation with four three-variable terms into an equation with three two-variable terms:

ABC combines with *AbC* to produce *AC*.

ABC combines with *ABc* to produce *AB*.

ABc combines with *aBc* to produce *Bc*.

$S = AC + AB + Bc$

Product terms such as those in the preceding equation which are produced using this simple minimization rule—combine rows that differ on only one cause if they have the same output values—are called prime implicants. Usually, each prime implicant covers (that is, implies) several primitive expressions in the truth table. In the partially minimized equation given above, for example, prime implicant *AC* covers two primitive Boolean expressions listed in the truth table: *ABC* and *AbC*.

This partially reduced Boolean expression illustrates a common finding in Boolean analysis: often there are more reduced expressions (prime implicants) than are needed to cover all the original primitive expressions. Prime implicant *AB* implies primitive terms *ABC* and *ABc*, for example, yet these

two primitive terms are also covered by *AC* and *Bc*, respectively. Thus, *AB* may be redundant from a purely logical point of view; it may not be an essential prime implicant. In order to determine which prime implicants are logically essential, a minimization device known as a prime implicant chart is used. Minimization of the prime implicant chart is an optional, second phase of Boolean minimization.

Briefly stated, the goal of this second phase of the minimization process is to "cover" as many of the primitive Boolean expressions as possible with a logically minimal number of prime implicants. This objective derives from a straightforward desire for parsimony. The prime implicant chart maps the links between prime implicants and primitive expressions. The prime implicant chart describing these links in the data on strike outcomes is presented in Table 6. Simple inspection indicates that the smallest number of prime implicants needed to cover all of the original primitive expressions is two. (For very complex prime implicant charts, sophisticated computer algorithms are needed; see Mendelson 1970, Roth 1975, and McDermott 1985.) Prime implicants *AC* and *Bc* cover all four primitive Boolean expressions. Analysis of the prime implicant chart, therefore, leads to the final reduced Boolean expression containing only the logically essential prime implicants:

$S = AC + Bc$

This equation states simply that successful strikes occur when there is a booming market for the product produced by the workers AND a large strike fund (*AC*) or when there is the threat of sympathy strikes by workers in associated industries combined with a low strike fund (*Bc*). (Perhaps the threat of sympathy strikes is taken seriously only when the striking workers badly need the support of other workers.)

TABLE 6: Prime Implicant Chart Showing Coverage of Original Terms by Prime Implicants (Hypothetical Strike Data)

		Primitive Expressions			
		ABC	*AbC*	*ABc*	*aBc*
Prime Implicants	*AC*	×	×		
	AB	×		×	
	Bc			×	×

These simple procedures allow the investigator to derive a logically minimal equation describing the different combinations of conditions associated with a certain outcome. The final, reduced equation shows the two (logically minimal) combinations of conditions that cause successful strikes and thus provides an explicit statement of multiple conjunctural causation.

Note that this final phase of Boolean minimization, use of the prime implicant chart, is used only when the investigator seeks a *logically* minimal equation (that is, maximum logical parsimony). In some analyses the determination of prime implicants may be the endpoint of the Boolean analysis. If, for example, the investigator's theory emphasized combination AB (the coincidence of a booming market and the threat of sympathy strikes) as an important cause of successful strikes, the fact that AB never exists in a "pure" form (that is, in the absence of either AC or Bc) might be considered irrelevant, and the cases that combine AB with either AC or Bc might be considered "overdetermined" (and possibly more interpretable) according to this reasoning and deserve special attention. The important point here is that in all applications of these procedures there is an element of investigator input that is crucial. The techniques should not be used mechanically. The issue of parsimony is addressed in more detail in Chapters 7 and 8 where I examine the use of theory to evaluate the results of Boolean analysis.

The hypothetical analysis presented here shows the major steps in using Boolean techniques to unravel complexity: (1) construct the truth table, (2) determine the prime implicants, and (3) use the prime implicant chart to select the essential prime implicants (if maximum parsimony is desired). The truth table shows primitive expressions. An equation with prime implicants is a partially reduced Boolean expression. The equation that results from use of the prime implicant chart is a logically minimal Boolean expression.

USE OF DE MORGAN'S LAW. Once a truth table has been minimized and the different combinations of conditions associated with an outcome have been determined, it is often useful to assess the combinations of conditions associated with the absence of an outcome (such as unsuccessful strikes in the example above). Rather than start from the very beginning and construct and minimize a new truth table, it is possible to apply De Morgan's Law to the solution already derived for positive outcomes to obtain the solution for negative outcomes.

The application of De Morgan's Law is straightforward. Consider the solution to the hypothetical analysis of successful strikes presented above: $S = AC + Bc$. Elements that are coded present in the reduced equation (say, A in the term AC) are recoded to absent, and elements that are coded absent (say, c in the term Bc) are recoded to present. Next, logical AND is recoded to logical OR, and logical OR is recoded to logical AND. Applying these two rules, $S = AC + Bc$ becomes

$$\begin{aligned} s &= (a + c)(b + C) \\ &= ab + aC + bc \end{aligned}$$

According to this equation, strikes fail when (1) the market for the relevant product is not booming AND there is no serious threat of sympathy strikes, (2) the market for a product is not booming AND there is a large strike fund, OR (3) there is no threat of sympathy strikes AND only a small strike fund. (The combination aC—nonbooming market and large strike fund, which seems contradictory—may suggest an economic downturn after a period of stability. In this situation a shutdown might be welcomed by management.) De Morgan's Law thus provides a convenient shortcut for minimizing negative instances. It can also be used in conjunction with advanced Boolean techniques discussed in Chapter 7.

NECESSARY AND SUFFICIENT CAUSES. An additional aspect of the Boolean approach to consider is the relation between the results of Boolean minimization and necessary and sufficient causes in social research. A cause is defined as necessary if it must be present for a certain outcome to occur. A cause is defined as sufficient if by itself it can produce a certain outcome. This distinction is meaningful only in the context of theoretical perspectives. No cause is necessary, for example, independent of a theory that specifies it as a relevant cause. Neither necessity nor sufficiency exists independently of theories that propose causes.

Necessity and sufficiency are usually considered jointly because all combinations of the two are meaningful. A cause is both necessary and sufficient if it is the only cause that produces an outcome and it is singular (that is, not a combination of causes). A cause is sufficient but not necessary if it is capable of producing the outcome but is not the only cause with this capability. A cause is necessary but not sufficient if it is capable of producing an outcome in combination with other causes and appears in all such combinations.

Finally, a cause is neither necessary nor sufficient if it appears only in a subset of the combinations of conditions that produce an outcome. In all, there are four categories of causes (formed from the cross-tabulation of the presence/absence of sufficiency against the presence/absence of necessity).

In contrast to the results of most types of statistical analysis, the results of Boolean analysis are easy to interpret in terms of necessity and sufficiency. Consider the following hypothetical:

$S = AC + Bc$ (No cause is either necessary or sufficient.)

None of the four causal conditions in the equation (A, B, C, c) is either necessary or sufficient because all terms contain combinations of causes, and no causal condition appears in every term. If, instead, the final equation had been

$S = AC + BC$ (C is necessary but not sufficient.)

it would have been possible to conclude that C is a necessary but not sufficient condition because it appears in every term but never by itself. Other examples showing other patterns of necessary and sufficient causation are

$S = AC$ (Both A and C are necessary but not sufficient.)

$S = A + Bc$ (A is sufficient but not necessary.)

$S = B$ (B is both necessary and sufficient.)

These examples are very simple, but they show clearly that the Boolean approach is highly compatible with the vocabulary of necessary and sufficient causation. This feature enhances its value as a tool for qualitative comparative analysis, especially in studies examining a variety of cases experiencing the same or similar outcomes.

FACTORING BOOLEAN EXPRESSIONS. Often it is useful to factor the results of Boolean analysis. Boolean factoring does not differ dramatically from standard algebraic factoring. For example, the Boolean statement

$S = AB + AC + AD$

can be factored to show that A is a necessary condition:

$S = A(B + C + D)$

Factoring is useful not only to show which conditions are necessary; it also identifies conditions that are causally equivalent. In the example given above, for instance, it is clear that conditions B, C, and D are causally equivalent (in combination with A) with respect to outcome S.

Factoring can also be used to clarify an equation, even when factoring the equation does not simplify it. For example, an investigator might find the following equation for S:

$S = abc + AbC + abd + E$

Theory might stress the contrary effects of A in different contexts, and the results seem to support this emphasis. In some contexts A must be present for S to occur; in others it must be absent. The equation can be factored in a way that highlights condition A in its presence and absence states:

$S = a(bc + bd + E) + A(bC + E)$

The equation shows which contexts require A to be present for S to occur and which contexts require A to be absent. Note that condition E appears in both sets. Because this second use of factoring does not simplify an equation, but clarifies it according to theoretical criteria, it is better to distinguish it by labeling it "theoretical factoring."

SUMMARY

The brief overview of Boolean techniques presented in this chapter illustrates some of the key features of the Boolean approach. It is holistic in its orientation toward cases because it views them in terms of combinations of values and compares cases with different combinations holistically. This feature of Boolean-based qualitative comparison makes it an ideal instrument for identifying patterns of multiple conjunctural causation. The approach has a strong inductive element (which mimics case-oriented research) because it proceeds from the bottom up, simplifying complexity in a methodical, stepwise manner. It starts with a bias toward complexity—every logically possible combination of values is examined—and simplifies this complexity through experiment-like contrasts—procedures which approximate the logic of the ideal social scientific comparison. Finally, it is highly compatible with the vocabulary of necessary and sufficient causation, a feature that enhances its value for assessing the limits of social scientific generalizations.

This chapter leaves many basic questions unanswered, however. For example, what should an investigator do if some of the logically possible combinations of values on the independent variables do not exist? As noted in Chapter 2, this is a crucial question because naturally occurring data almost never display patterns allowing experiment-like comparisons. This and related issues are examined in Chapter 7.

7

Extensions of Boolean Methods of Qualitative Comparison

The hypothetical examples used in Chapter 6 to introduce Boolean techniques of qualitative comparison were unrealistically straightforward. Their simplicity eased the task of presenting basic Boolean principles but left many important issues unaddressed. This chapter also uses hypothetical data, but the examples are more complex. These hypothetical data come much closer to the empirical examples used in Chapter 8 to illustrate various applications of Boolean methods. Thus, this chapter bridges Chapters 6 and 8.

Several key issues were skirted in Chapter 6. The most important of these is one of the issues that motivated the development of Boolean techniques in the first place—the fact that naturally occurring data lack sufficient variety to allow experiment-like comparative analyses (see Chapters 2 and 3). As noted previously, techniques of statistical control were developed in part to address this problem of limited diversity. Boolean techniques respond to this same problem, but in a dramatically different way. Statistical techniques are able to approximate experiment-like comparisons by making (sometimes strained and unrealistic) assumptions about the nature of social causation. The Boolean approach seeks to avoid these assumptions and allows maximum causal complexity, at least initially. The Boolean approach to the problem of limited diversity is to incorporate the question of diversity directly into the analysis. This strategy is explained in detail in the first major section below.

Another important issue skirted in Chapter 6 is the problem of "contradictory rows." To construct a truth table, cases are sorted into their different combinations of values on the independent variables to form rows of the truth table, and then each row is assigned an output value—a score of 1 or 0 on the dependent variable. If clear tendencies are not apparent among the cases with the same combination of input values, then it is difficult to determine the appropriate score for the dependent variable (the output value of the row). This problem is addressed in the second major section below.

A third issue concerns evaluating theoretical arguments. The rudimentary material presented in Chapter 6 left the false impression that theory enters into Boolean-based comparative analysis only in the selection of causal conditions and the construction of the truth table. From there on, the process appears to be relatively inductive. In fact, theoretical arguments about causal combinations can be incorporated into Boolean analysis. The third major section of this chapter outlines procedures for evaluating theoretically based causal arguments. These techniques illustrate the flexibility of the Boolean approach and its compatibility with the goals of theory testing and theory building.

The final section of this chapter summarizes major features of the Boolean approach and evaluates it relative to ideal features of a synthetic strategy outlined in Chapter 5.

THE PROBLEM OF LIMITED DIVERSITY

Social scientists have a love-hate relationship with the fact that naturally occurring social phenomena display limited diversity. On the one hand, as previously noted, limited diversity places severe constraints on possibilities for testing causal arguments. This is what makes comparative social science a challenge. On the other hand, however, social phenomena are limited in their diversity for very good reasons. The fact that all U.S. presidents have been white males, for example, is an obviously meaningful instance of limited diversity. The fact that there are no non-Catholic South American countries is both meaningful and historically interpretable; it is not an unfortunate accident that confounds the work of scholars who study Latin America. While such restrictions on diversity pose clear obstacles to assessing social causation, they also constitute profound testimony to the social forces that have shaped the modern world. The tendency for features of cases to be confounded and to clump into interpretable combinations is as much

the stuff of social science as attempts to construct exhaustive experiment-like comparisons of causal conditions. That only a subset of the logically possible combinations of features of cases exists is prima facie evidence of a socially constructed order.

Because of limited diversity, statements about causation (in the absence of simplifying assumptions) are necessarily restricted to the combinations of causally relevant conditions that actually exist. If an analysis were to show, for example, that rapid commercialization combined with traditionalism in peasant societies causes peasants to revolt, the general statement would be limited to existing peasant societies with known combinations of causally relevant features. It is entirely possible that peasant societies with different configurations of causally relevant features may have existed in the past or may exist in the future (or were simply overlooked) and that these peasant societies experience revolts for entirely different reasons. Rapid commercialization and traditionalism might be irrelevant in these cases. This, of course, would not change the results of the analysis, but it is important to have some sense of the limitations on diversity.

Recall that one of the primary goals of the qualitative comparative approach is to allow maximum causal complexity—to avoid making simplifying assumptions about causes *at the outset*, as is done in most conventional statistical analyses. As I show below, simplifying assumptions might be considered later, but only after conducting an analysis allowing maximum complexity.

As an illustration of this problem consider the following simple truth table. An investigator believes that there are three causes relevant to the emergence of ethnic political parties in peripheral regions: ethnic inequality (A), centralization of government (B), and the erosion of ethnic institutions by national (that is, dominant-culture) mass media (C). The truth table for several nations with ethnic minorities concentrated in peripheral regions is shown in Table 7.

Simple inspection indicates that condition C is the only cause of party formation (F) because there is a perfect correspondence between the presence/absence of erosion and the presence/absence of ethnic political parties, at least among existing causal combinations. But note that there are no cases combining erosion of ethnic institutions, ethnic inequality, and centralized government. It is quite possible that in the presence of both these conditions, the erosion of ethnic institutions might not prompt the formation of ethnic political parties. A *conservative* statement of what the truth table shows,

TABLE 7: Hypothetical Truth Table on Formation of Ethnic Political Parties

Condition			Party Formation	Cases
A	*B*	*C*	*F*	
0	0	0	0	5
0	0	1	1	3
0	1	0	0	7
0	1	1	1	8
1	0	0	0	9
1	0	1	1	4
1	1	0	?	0
1	1	1	?	0

A = Ethnic inequality
B = Centralized government
C = Erosion of ethnic institutions

therefore, is $F = aC + bC$, not $F = C$. In the first statement, *C* is necessary but not sufficient; in the second, *C* is both necessary and sufficient. Note that it is evident from the first equation what *simplifying* assumption is needed to produce the simpler causal statement ($F = C$): in the presence of both *A* and *B*, *C* causes *F*. This approach to diversity is quite different from making general assumptions about the operation of causes at the outset.

In most statistical analyses the problem of limited diversity is obscured because of the assumptions that are made about populations and samples, about variables and their relationships, and about the nature of causation (for example, that causes are additive; see Chapter 4). In qualitative comparative research these assumptions are avoided because cases are treated as interpretable combinations of characteristics, not as arrays of sample values.

It is possible to use a Boolean truth-table approach to address diversity. Causally relevant features of cases are used as input variables, following the pattern in the examples of Chapter 6, but the output variable is not an outcome or some type of historically emergent phenomenon. It is simply a presence/absence dichotomy indicating whether or not a certain combination of causes exists. The analysis thus focuses directly on the degree of diversity among cases. When all combinations of causal conditions exist (maximum diversity), the equation simplifies to unity (all combinations present; none absent). Applying these procedures to the simple truth table (Table 7) produces the following Boolean equation modeling diversity:

$$\text{Existing combinations} = a + b$$

This equation shows that all existing combinations display an absence of *A* or an absence of *B* (or, by logical implication, an absence of both *A* and *B*). Using De Morgan's Law (see Chapter 6) it is a simple matter to convert this into an explicit statement of the causal combinations that do not exist:

$$\text{Nonexistent combinations} = AB$$

Consider a more complex example. Table 8 presents hypothetical data on four causes of peasant revolts. Before attempting to assess the different combinations of conditions that cause revolts, it is possible, as a preliminary, to assess the diversity of causal combinations among peasant societies that

TABLE 8: Hypothetical Truth Table on Causes of Peasant Revolts (Includes Contradictory Rows)

Conditions				Number of Instances	Output Code Presence/ Absence *P*	Output Code Revolt *R*
A	*B*	*C*	*D*			
0	0	0	0	4	1	0
0	0	0	1	10	1	0
0	0	1	0	0	0	?
0	0	1	1	5	1	1
0	1	0	0	4	1	0
0	1	0	1	2	1	0
0	1	1	0	0	0	?
0	1	1	1	4	1	1
1	0	0	0	10	1	0
1	0	0	1	0	0	?
1	0	1	0	2	1	0
1	0	1	1	0	0	?
1	1	0	0	0	0	?
1	1	0	1	5	1	1
1	1	1	0	0	0	?
1	1	1	1	9	1	1

A = Peasant traditionalism
B = Commercialization of agriculture
C = Middle peasants
D = Absentee landed elites

exist. This step is important because the results of any analysis of the causes of peasant revolts are limited to causal combinations exhibited by peasant societies actually included in the analysis.

In the truth table presented in Table 8, four conditions are examined: *A* indicates the persistence of peasant traditionalism (1 = yes, 0 = no); *B* indicates the commercialization of agriculture (1 = yes, 0 = no); *C* indicates the existence of a substantial class of middle peasants (1 = yes, 0 = no); and *D* indicates the residential preferences of the landed elite (1 = absentee, 0 = resident). Not all logically possible combinations of these four characteristics exist. Thus, the output variable *P* is coded 1 if there are instances of peasant societies with the combination of characteristics described in the row and coded 0 otherwise; the output variable *R* shows the subset of existing peasant societies with revolts.

In order to assess the limitations on the diversity among these cases, it is necessary simply to apply the minimization algorithms presented in Chapter 6 to this truth table, using *P* rather than *R* as the output value. An equation modeling existing combinations is derived; then De Morgan's Law is applied to this equation to create an explicit Boolean statement of the causal combinations that do not exist.

The first step of the Boolean analysis is to produce the prime implicants. Generally, the greater the variety of primitive expressions that enter into this part of Boolean minimization, the smaller the number of prime implicants. A small number of prime implicants indicates greater diversity because more combinations of conditions are covered.

There are many compatible rows in this truth table. The first two, for example, are compatible (they both produce *P*—that is, they exist—and differ on only one causal variable) and can be combined to form the expression *abc*. The specification of each step in the process of combining compatible rows would be tedious and therefore is not reported. This process of combining compatible rows, which involves only rows with 1's as output values, results in a partially reduced sums-of-products equation, which can be reduced further through the use of a prime implicant chart (see Chapter 6). The results of this further reduction are

$$P = ac + aD + BD + Abd$$

The equation shows that there are four basic types of peasant societies: those combining a low level of peasant traditionalism (*a*) and few middle peasants (*c*); those combining a low level of peasant traditionalism (*a*) and absentee landlords (*D*); those combining commercialized agriculture (*B*) and absentee landlords (*D*); and those combining peasant traditionalism (*A*), little commercialization of agriculture (*b*), and resident landed elites (*d*). Referring to the truth table, we see that several examples of mixed types exist. Peasant societies conforming to combination *aBcD*, for example, have elements from the first three terms identified in the preceding equation.

De Morgan's Law can be used here to formulate an explicit statement of causal combinations that do not exist in the truth table:

$$p = ABd + aCd + AbD + BCd$$

This equation states the limits of any analysis of the truth table. Of course, this is all preliminary to an analysis of the causes of peasant revolts. These two equations (of the causal combinations that exist and those that do not) simply establish the substantive boundaries of the analysis of the causes of revolts.

Because instances of peasant revolt are a subset of instances of peasant societies, the equation for revolts is a subset of the equation for peasant societies. The simplest way to approach the causes of revolts is to assume that if any of the types of peasant societies that do not exist actually did exist, they would not experience revolts. (The fact that these combinations do not exist may indicate that they combine incompatible elements and therefore are unlikely ever to exist, much less experience revolts.) In this approach, combinations of causes that do not exist in the data should be coded as instances of nonrevolts. (Thus *?* in the column for *R* in Table 8 is recoded to 0.) A reduction of this truth table shows (after producing prime implicants and applying the prime implicant chart procedure):

$$R = ABD + aCD$$

It is apparent from simple inspection that these two terms embrace a subset of the terms covered in the equation modeling causal combinations that exist. Specifically, the term *ABD* from the equation for *R* is a subset of the term *BD* from the equation for *P*, and the term *aCD* (*R* equation) is a subset of the term *aD* (*P* equation). (This is logically necessary because, as noted, instances of revolt form a subset of instances of relevant peasant societies.) Thus, peasant revolts are found only in two of the four basic types of peasant societies revealed in the Boolean analysis of diversity.

The preceding equation states that there are two major combinations of

conditions that produce peasant revolts. The first type combines traditionalism (A), commercialization of agriculture (B), and absentee landlords (D). The second combines low traditionalism (a), middle peasants (C), and absentee landlords (D). The two types are best distinguished by the presence/absence of traditionalism and thus are mutually exclusive. One commonality, according to these results, is absentee landlords (D), which can be considered a necessary condition for revolts because it appears in both terms. In subsequent phases of research on peasant revolts, the investigator would use these two causal combinations to classify revolts and to interpret cases within each category.

While this might be an adequate stopping point for the Boolean analysis, it is possible to reduce the equation for revolts (R) further through simplifying assumptions. Recall that in the simple truth table on the formation of ethnic parties (Table 7) it was possible to simplify $F = aC + bC$ to $F = C$ by *assuming* that in the presence of AB (ethnic inequality and centralized government) C (erosion of ethnic institutions) would stimulate F. (There were no instances of ethnic inequality combined with centralized government.) Parallel assumptions can be made here in the analysis of peasant revolts to simplify further the equation $R = ABD + aCD$.

Here it is important to point out that this procedure involves selecting terms from the equation for combinations that do not exist (the equation for p) and adding these terms to the equation for R. Of course, only a subset of the terms covered by the equation for p are actually useful. Rather than go through the nonexistent combinations one by one to see if they might help, a simple shortcut algorithm can be used.

This shortcut has two steps. Both steps involve minor alterations of the procedures used to derive an equation for R. First, in the derivation of prime implicants, nonexistent combinations are treated as instances of the output variable (in this analysis, as instances of revolts). Second, when using the prime implicant chart to simplify the equation further, these terms (the nonexistent terms) are *excluded* from the primitive expressions that must be covered by the prime implicants. Essentially, these two alterations allow the derivation of simpler prime implicants without expanding the number of primitive expressions that must be covered in the prime implicant chart.

Applying these procedures to the truth table on peasant revolts (Table 8) results in the following reduced equation (with R primed to indicate that simplifying assumptions have been incorporated):

$$R' = AB + CD$$

It is clear that this is a superset of the previous equation ($R = ABD + aCD$) because the two terms have been expanded—the first to include in its coverage both $ABcd$ and $ABCd$ (that is, ABd) and the second to include in its coverage $AbCD$ ($ABCD$ was already covered by ABD). There are no instances of these three terms ($ABcd$, $ABCd$, and $AbCD$) in the original truth table. By assuming that if these causal combinations existed they would produce revolts, it was possible to reduce further the equation for R, modeled as R'.

This last equation states that peasant revolts are likely if peasant traditionalism (A) and commercialization of agriculture (B) are combined, or if a substantial class of middle peasants (C) is combined with absentee landlords (D). In order to produce a solution this minimal, it was necessary to assume (1) that in the presence of resident landlords (d) the combination of peasant traditionalism (A) and commercialized agriculture (B) would result in peasant revolts (R) and (2) that in the presence of peasant traditionalism (A) and little commercialization (b) the combination of middle peasants (C) and absentee landlords (D) would produce peasant revolts.

Essentially, these procedures formalize (and objectify) what many case-oriented researchers do in the course of their research. While the ideal social scientific comparison has the form of an experiment—only one causal condition at a time is allowed to vary—this rarely happens in practice. Almost all social scientific comparisons are incomplete—several causally relevant variables will differ across each pair of cases. When a comparativist cites these incomplete comparisons as evidence in support of a causal argument, assumptions are made concerning what would happen if various nonexistent combinations of causal conditions actually existed. Rarely are these assumptions made explicit, and as a consequence the charge is frequently made that comparativists let their interests (ideological and otherwise) impinge on their work. These interests, the charge continues, are hidden by comparativists in assumptions.

While there is certainly truth to the charge of hidden (and not so hidden) interests, it is usually difficult, if not impossible, for the comparativist to keep track of the many incomplete comparisons, and the implicit assumptions about nonexistent causal combinations these entail, when an investigation examines a variety of causal conditions in a range of cases. The Boolean

approach to qualitative comparison not only makes it possible to keep track of the complexity of the comparisons but also requires objectification of assumptions about nonexistent causal combinations. In many respects these assumptions constitute an important part of the theory that a comparativist brings to an investigation. They are clear evidence of the use of theory to further causal generalization.

Of course, it is not necessary to make such assumptions, and both assumptions in the example involving peasant revolts could be questioned on theoretical and empirical grounds. The point is simply that the truth table approach makes explicit what is often implicit in other procedures. It allows direct consideration of combinations of causal conditions that do not exist in the data and thereby forces the investigator to confront the theoretical assumptions that permit more general causal statements.

It is important at this point to summarize at a more abstract level the logic of these procedures for addressing limited diversity. First, an equation describing configurations of causal conditions in existing cases was derived. The equation modeled diversity and was represented by the set P, indicating presence. De Morgan's Law was applied to this equation to produce an explicit statement (labeled p) describing nonexistent cases. Then an equation describing the combination of causes for the subset of P (peasant societies) experiencing revolt (R) was derived. Finally, an equation describing *possible* instances of peasant revolts (R') was derived by using a subset of the cases that do not exist (p) to simplify further the equation for revolts (R). Note that R is the intersection of P (combinations of causes that exist) and R' (possible combinations of causes of peasant revolts). Thus, R' can be seen as the model of peasant revolts that *might* be obtained if peasant societies were not limited in their diversity—that is, if peasant societies exhibiting all possible combinations of causes of peasant revolts could be examined.

Thus, Boolean techniques of qualitative comparative analysis provide a very direct approach to the problem of limited diversity. Limitations on diversity are modeled; implicit, simplifying assumptions are clarified and brought forward for examination; and an equation incorporating these assumptions can be derived if desired. In effect, the investigator is able to circumvent the problem of limited diversity in a way that objectifies the specific, empirical assumptions that allow the problem to be circumvented. The result is a model based on available evidence that, in effect, permits speculation about combinations of causes that do not exist.

Of course, these procedures are not mandatory. It is entirely possible that

the more complex equation (the equation for R) might be preferred for several reasons. Certainly it is more conservative. Moreover, no simplifying assumptions about nonexistent combinations have been made. And, finally, maximum parsimony may not be desired, especially if the goal of interpretation, of appreciating and comprehending complexity, is given precedence over the goal of parsimony. Generally, when the number of relevant cases is relatively small, as in the present example, it is feasible to interpret individual cases or groups of similar cases. This situation favors using the more complex equation ($R = ABD + aCD$) over the equation incorporating simplifying assumptions ($R' = AB + CD$).

THE PROBLEM OF CONTRADICTIONS

In order to use the truth table approach presented above, it is necessary to determine an output value for each row (that is, a 1 or 0 for every combination of causes that exists in the data). So far, it has been assumed that this is not a problem. Empirical cases are only occasionally this neat, however, and it is necessary to consider what to do when the cases conforming to some of the combinations of causes do not exhibit clear tendencies toward presence or absence of the phenomenon of interest.

There are several ways to approach this problem. The best is to follow the lead of case-oriented researchers. Recall that when case-oriented researchers are confronted with inconsistencies or paradoxes comparable to contradictory rows, they typically examine the troublesome cases in greater detail and attempt to identify omitted causal variables (see Chapter 3). If five of the ten cases of *Abcd* in the hypothetical analysis of peasant revolts experienced revolts, for example, following the lead of case-oriented researchers would involve examining these ten cases in greater detail. This examination might lead to the conclusion that there is a fifth cause, E, that had been overlooked. If the addition of variable E divided the ten cases into groups more consistent with the revolt/nonrevolt distinction, then this fifth cause could be added to the truth table before reducing it. To follow the case-oriented approach, then, is to treat any specification of relevant causal conditions as tentative and to use theoretical and substantive knowledge to achieve a proper specification of causal conditions before reducing the truth table.

It is possible to use a truth table approach to aid the analysis of troublesome causal combinations and thereby simplify the task of identifying omitted causal variables. Essentially, an equation modeling contradictory causal

TABLE 9: Revised Truth Table on Peasant Revolts

Conditions				Number of Total Instances	Number of Instances of Revolt	Output Code Revolt
A	*B*	*C*	*D*			*R*
0	0	0	0	4	1	0
0	0	0	1	10	3	0
0	0	1	0	0	—	—
0	0	1	1	5	5	1
0	1	0	0	4	0	0
0	1	0	1	2	0	0
0	1	1	0	0	—	—
0	1	1	1	4	4	1
1	0	0	0	10	5	?
1	0	0	1	0	—	—
1	0	1	0	2	1	?
1	0	1	1	0	—	—
1	1	0	0	0	—	—
1	1	0	1	5	3	?
1	1	1	0	0	—	—
1	1	1	1	9	5	?

A = Peasant traditionalism
B = Commercialization of agriculture
C = Middle peasants
D = Absentee landed elites

combinations is derived. This equation is then used to guide the search for additional causal variables or to refine the existing analysis in some way. Consider the revised version of the truth table on peasant revolts (Table 8) presented in Table 9.

Note that four causal combinations (denoted with question marks) are split fairly evenly between revolts and no revolts. To analyze the commonalities shared by these four combinations, it is necessary simply to code them 1 and code other existing combinations 0. (Rows coded 0 or 1 on *R* in the truth table are recoded to 0 because they exhibit clear tendencies toward revolts or the absence of revolts.) The new output is labeled *X* and indicates contradictory causal combinations.

This new truth table can be reduced by using standard minimization procedures. The first step in the reduction treats nonexistent combinations (those coded "—" in the truth table) as though they were coded 0 (non-

contradictory). The assumption is that if there were instances of these causal combinations, they could be coded 1 or 0 on *R* unambiguously. The results of this analysis are

$$X = ABD + Abd$$

The equation shows that when these two basic combinations of causes occur in peasant societies, revolts may or may not occur. In other combinations, revolts either tend to occur or tend not to occur.

This equation can be further reduced through simplifying assumptions. As in the analysis of *R* and *R'*, it is possible to produce an equation for *X'*—an equation that models the causal combinations that might be contradictory if all logically possible combinations of causes existed. This procedure follows the outline given above: first, prime implicants are produced by using recoded nonexistent combinations (now coded 1); then, the prime implicant chart procedure is used, excluding the nonexistent combinations from the primitive terms that must be covered by the prime implicants. The results of this analysis show

$$X' = A$$

(Refer to Table 9 for verification.) Both the equation for *X* and the equation for *X'* are unambiguous in the guidance they give. The equation for *X* shows that contradictory causal combinations occur whenever *A* (peasant traditionalism) is combined with either *BD* or *bd*. The equation for *X'* shows that contradictory causal combinations occur whenever *A* (peasant traditionalism) is present.

This (hypothetical) result suggests two possible avenues for resolving the contradictions in the truth table. One is to attempt to clarify what is meant by peasant traditionalism. It may be that in some contexts peasant traditionalism is rigid adherence to an ancient and enduring way of life. In others, it may indicate a system of expectations and obligations linking peasant communities to landed elites and the state. In short, the results of this Boolean analysis might indicate problems in the conceptualization of traditionalism.

Alternatively, the results might indicate that the search for a fifth variable should focus on the (as yet unspecified) conditions that make peasant traditionalism revolutionary. It could be that peasant traditionalism has to be combined with conditions not included in the table (such as direct exposure of peasants to world market forces) for peasant traditionalism to take on a revolutionary cast.

The procedures outlined above for addressing ambiguous causal combinations are mainly oriented toward refining the investigator's concepts or understanding of cause. Thus, they force the investigator to return to the data and ultimately to construct a new truth table for the analysis of revolts. Sometimes it is difficult to return to the data, and alternative strategies, which do not follow the lead of the case-oriented approach, must be used. Several are addressed briefly here.

One simple solution is to code all ambiguous causal combinations 0. The argument here is that if no clear tendency (such as presence or absence of revolts) is apparent among the cases conforming to a certain causal combination, then the output should be coded conservatively (with respect to the investigator's confidence in the specification of conditions causing revolts). Thus, the analysis would show which causal combinations are unambiguously associated with the outcome (peasant revolts). Applying this rule to Table 9 results in the following reduced equation:

$$R = aCD$$

Essentially, this equation is a subset of the original equation for revolts, which showed $R = ABD + aCD$.

Alternatively, the investigator might want to recode contradictory combinations to nonexistent combinations, in which case the rows with "?" would be coded "—" to indicate that these combinations are being treated as though they do not exist. The effect of this procedure is to allow the algorithm to determine which final output value the contradictory rows should receive. If they help to produce a more minimal solution, they receive a coding of 1; if they do not, they receive a coding of 0. The results of this analysis also show that

$$R = aCD$$

A third alternative along these same lines would be to argue that a wide net should be cast so that all possible combinations of causes of peasant revolts are captured by the equation. This approach would be consistent with a general goal of allowing greater complexity. As noted in previous chapters, greater sensitivity to causal complexity is a hallmark of interpretive approaches. Thus, an equation that allows more causal combinations to be included among those thought to cause peasant revolts might be produced if ambiguous causal combinations are coded as 1 (revolts present) in the truth table. The results of this analysis reveal that

$$R = ABD + aCD + Abd$$

It is easy to see that this equation is a superset of the original equation for R. It adds causal combination Abd (peasant traditionalism combined with little commercialization and resident landlords). This is one of the causal combinations that originally appeared in the equation for C (contradictory causal combinations) above. Note that this equation answers the question: under what conditions are peasant revolts possible?

In general, it is better to resolve contradictions through examination of cases, the first strategy mentioned above, than to resolve them by assuming that contradictory rows are instances of the phenomenon of interest (1), instances of its absence (0), or nonexistent causal combinations (—).

The problem of contradictory causal combinations is not as serious as it might seem. In some investigations it is possible to incorporate frequency or statistical criteria to resolve contradictions. In general, if there are few cases there will be few contradictions. As the number of cases increases, so will the number of contradictions. But as the number of cases increases, it also becomes more feasible to apply simple statistical criteria to aid the construction of truth tables.

In some investigations every causal combination may be contradictory, and the investigator may be faced with an array of probabilities of success (that is, of positive outcome) for each causal combination. In order to recode these probabilities into positive (1) and negative (0) outcome combinations, it is possible to assess the significance of the difference between each probability and a substantively meaningful probability defined as a standard (for example, the probability of success in the entire set of cases considered as a single set). Causal combinations with probabilities significantly less than the standard could be coded as failures (0); causal combinations with probabilities significantly greater than the standard could be coded as successes (1); and causal combinations with probabilities not significantly different from the standard could be used selectively to produce a more minimal solution, as nonexistent combinations were used in the preceding example. (A variation of this procedure was used by Ragin and others 1984 in a study of discrimination.) Generally, these significance tests probably should use a high cutoff value (for example, significantly different at the 0.33 level) to minimize the number of causal combinations relegated to the third category (ambiguous outcome).

A second, more complex statistical procedure might be to use an additive,

logit model of the outcome of interest to compute expected values for each combination of values on the independent variables. The deviations of the observed proportions from the expected values could then be used as a basis for coding the output value in the truth table. (Large positive deviations would be coded 1; large negative deviations would be coded 0.) Using these procedures would orient the analysis toward an exhaustive examination of *patterns* of statistical interaction using Boolean techniques. Of course, if there are very many cases it is also possible to conduct a Boolean analysis *and* a log-linear analysis (testing for complex statistical interactions) of the same data and use one to aid the interpretation of the other.

All solutions to the problem of contradictions, except the first, violate the spirit of case-oriented qualitative research and should be used only when it is impossible to return to the original cases and construct a better truth table. In many respects, once a truth table is completed (or at least treated as final), the investigation is oriented toward deciphering complexity as represented in the truth table. The lesson here is that an existing data set should not be considered an irrevocable starting point. In qualitative comparative work, the representation of the empirical world in terms of a truth table is a crucially important part of the investigation.

EVALUATING THEORETICAL ARGUMENTS

Theories do more than specify causal variables; they also specify causal combinations. A review of theoretical literature on peasant revolts, for example, could be used as a basis for specifying several causal conjunctures. One theory might argue that the simple commercialization of peasant societies is what stimulates revolts. Another might argue that peasant societies which are less traditional and have a large class of middle peasants living in communities with resident landed elites might be the most likely to revolt. These two theoretical arguments are easy to express in Boolean terms. The first (using the same notation as above) is simply $T = B$, where T indicates that the expectation is theoretically derived. The second is $T = aCd$. The two can be expressed in a single equation:

$$T = B + aCd$$

Obviously, this is not what the analysis of hypothetical data on peasant revolts showed. The less conservative equation (the one that incorporated simplifying assumptions about nonexistent combinations) from the analysis of peasant revolts revealed that

$$R' = AB + CD$$

(This simpler equation for revolts is used in the examples that follow to streamline the presentation.)

It is a simple matter to use Boolean algebra to map areas of agreement and disagreement between the theoretically derived model (T) and the results of the analysis of the truth table (R'). This analysis is important because it provides a basis for evaluating theory and interpreting empirical cases relative to theoretical expectations.

The intersection of T and R', for example, shows the subset of causal combinations that were both hypothesized and found:

$$\begin{aligned}(T)(R') &= (B + aCd)(AB + CD)\\ &= AB + BCD\end{aligned}$$

Essentially, this result shows that a subset of the causal conditions hypothesized by the first theory was confirmed. This theory predicted that all peasant societies experiencing commercialization should experience revolts. The results showed that only a subset of such societies actually experienced revolt.

It is also possible to use these procedures to model causal combinations that were found to produce revolts but were not hypothesized to do so by theory. This set is formed from the intersection of R' and t. Set t embraces all causal combinations not hypothesized to produce revolts and results from the application of De Morgan's Law to the equation for T:

$$\begin{aligned}t &= Ab + bc + bD\\ (t)(R') &= (Ab + bc + bD)(AB + CD)\\ &= AbCD + bCD\\ &= bCD\end{aligned}$$

The term bCD pinpoints the major shortcomings of existing theories. Specifically, the results show that these theories are off the mark when it comes to the causes of peasant revolts in the absence of commercialization (B). When commercialization is absent, revolts occur in peasant societies combining middle peasants and absentee landed elites.

This equation for $(t)(R')$ is important because it suggests a route for interpreting peasant revolts in peasant societies that are not experiencing commercialization. The equation states simply that in the absence of commercialization (a hypothesized cause), CD (the combination of middle peasants and resident landed elites) causes peasant revolts. In interpreting cases of

CD, an investigator might want to determine what it is about the CD combination that makes it causally equivalent to B (commercialization) or equivalent to the combination of commercialization and traditionalism (AB). This interpretive lead would be important if existing theory alone is used as a guide in interpreting peasant revolts.

Finally, it is also possible to model causal combinations that were hypothesized but not found to cause revolts. This set is formed from the intersection of T and r'. Set r' embraces all nonrevolts and can be derived by applying De Morgan's Law to R':

$$\begin{aligned} r' &= ac + ad + bc + bd \\ (T)(r') &= (B + aCd)(ac + ad + bc + bd) \\ &= aBc + aBd + aCd \end{aligned}$$

These results show that the second theory, which emphasizes causal combination aCd, is not supported in any way by the evidence because the causal combination it proposes (aCd) appears in the preceding equation. The equation also shows that the first theory overstates the power of commercialization (B). When commercialization is combined with an absence of peasant traditionalism and either few middle peasants (c) or resident landed elites (d), revolts do not occur. This last equation shows the major shortcomings of existing theories; it refines the first theory and completely rejects the second.

These procedures show one of the decisive benefits of the Boolean approach to qualitative comparison. When theories are tested with traditional statistical techniques, investigators rarely are forced to consider causal conjunctures. These analytic techniques bias investigators toward viewing different causes as competitors in the struggle to explain variation. In the Boolean approach, by contrast, arguments about causal conjunctures are favored over arguments about single causes. Thus, investigators are forced to think in terms of conjunctures. At a minimum, the typical Boolean analysis forces an investigator who favors a single-variable explanation to consider the conjunctural limitations on its effects.

Generally, Boolean techniques should not be used mechanically; they are conceived as aids to interpretive analysis. The results of Boolean analysis do not take the place of interpretive analysis; the task of applying the results to cases remains once a solution has been obtained. Furthermore, it is important to emphasize that the construction of a truth table involves considerable effort—an intellectual labor that has been taken for granted in all these

examples. To construct a useful truth table, it is necesaary to gain familiarity with the relevant theories, the relevant research literature, and, most important of all, the relevant cases. Thus, a truth table presupposes an enormous amount of background research.

In all the examples presented above (and across the three issues examined—limited diversity, ambiguous causal combinations, and the evaluation of theories), the general flexibility of the Boolean approach to qualitative comparison was emphasized. Of course, it is much easier to demonstrate this flexibility with actual data, the goal of Chapter 8, because data that are not hypothetical are both more demanding and more interpretable. Before presenting analyses of empirical data, however, I want to review the basic characteristics of the Boolean approach and evaluate its potential as a basis for a broadly comparative research strategy.

THE BOOLEAN APPROACH AS A MIDDLE ROAD

In Chapter 5, five ideal features of a synthetic comparative research strategy were proposed. These included:

1. An ability to examine a large number of cases
2. An ability to address complex causal conjunctures
3. An ability to produce parsimonious explanations (if desired)
4. An ability to investigate cases both as wholes and as parts
5. An ability to evaluate competing explanations

Does the Boolean approach provide the necessary tools?

First, it is clear that the Boolean approach can handle many cases. In fact, the actual number of cases is not a major consideration. If many cases have the same combination of values on the causal variables of interest, they are all coded together as a single row of the truth table because they are identical. The Boolean approach is more concerned with the different combinations of values that exist—and their output values—than with the actual number of instances of each combination. More relevant than the number of cases is the number of logically possible combinations of relevant causal conditions—a figure which is determined by the number of causal conditions considered.

Second, it is clear that the Boolean approach addresses complex patterns of interaction—patterns of multiple conjunctural causation. Essentially, the Boolean approach begins by assuming maximum causal complexity, and each combination of causal conditions is assigned its own output value. This

complexity is then simplified logically by using a few basic Boolean principles. This procedure contrasts sharply with the statistical approach which begins by assuming simplicity.

Note that the Boolean approach accomplishes what case-oriented investigators attempt, but on a much larger scale. In case-oriented studies, investigators analyze similarities and differences in order to identify common underlying patterns and types. As noted in Chapter 3, however, the web of similarities and differences frequently gets out of hand. The Boolean truth-table approach and its rules for simplifying complexity provide a basis for managing this complicated web. It allows case-oriented investigators to see and comprehend complex patterns and conjunctures.

Third, the Boolean approach, through its minimization procedures, is capable of producing parsimonious explanations. The problem of parsimony is fundamentally a question of theoretically guided data reduction. All data reduction techniques produce parsimony. The construction of a raw data matrix is a form of parsimony—as is the construction of a truth table from a raw data matrix—because complexity has been greatly reduced. It has been captured and transformed into coded variables. A parsimonious *explanation* goes beyond these simple data reductions by linking causes and effects in a theoretically based and meaningful (that is, interpretable) manner. This further reduction of complexity is accomplished in statistical analyses in the estimation of the unique additive contribution of each independent variable to some outcome variable. In the Boolean approach a parsimonious explanation is achieved by determining the largest classes of conditions for which a certain outcome is obtained. Simply stated, applications of Boolean techniques of data reduction culminate in logically minimal statements of the different combinations of conditions that produce certain outcomes.

Fourth, the Boolean approach is both holistic and analytic; it examines cases as wholes and as parts. In a Boolean analysis cases are seen as combinations of parts. These combinations can be interpreted as different situations. A fundamental principle of holism provides the metatheoretical basis for this way of seeing cases: to alter any single part of a whole, any element, is—potentially at least—to alter the character of the whole. This approach contrasts directly with most statistical approaches where the goal is to estimate the average effect of each variable (the causal importance of each part) across all values of other variables.

Yet the Boolean approach is not extreme in its holism. In its most extreme form, a holistic philosophy argues that each entity is unique, that

cases cannot be compared with each other once they are understood in all their complexity and individuality. Obviously, the Boolean approach does not go this far. Cases with identical combinations of values on relevant causal variables are pooled in the construction of the truth table. For the purpose of Boolean analysis, they are equivalent wholes. Furthermore, the boundaries of uniqueness, of variation, are set by the causal conditions selected for examination. This constraint restricts the individuality that cases may display. If there are four causal conditions selected for analysis, for example, there are only sixteen possible wholes. In short, the Boolean approach is analytic in its approach to cases because it examines the same causal conditions in each setting. However, it is holistic in the way it compares different situations and in this manner preserves one of the best features of the case-oriented approach.

Fifth, and finally, the Boolean approach can be used to evaluate different explanations. One shortcoming of case-oriented studies is the fact that they are usually organized around a single perspective. Often, cases are used selectively to illustrate or elaborate a certain theory. In the Boolean approach, competing explanations can be operationalized in causal variables in a manner that is similar to statistical approaches. In statistical analyses, however, variables compete with each other. If one set of variables wins, then the theory they represent is supported. In the Boolean approach this competition between theories is transcended. Different combinations of causal conditions define different situations. In some situations the variables associated with a certain theory may be important. In others they may not. This feature provides a basis for evaluating competing explanations and for advancing theory. The typical end product of a Boolean analysis is a statement of the limits of the causal variables identified with different theories, not their mechanical rejection or acceptance.

A NOTE ON IMPLEMENTING BOOLEAN ALGORITHMS

While it is possible to use the simple pencil and paper techniques outlined above to address relatively small problems, it is far easier to use a computer to implement these algorithms. An experienced programmer can implement them on a microcomputer, for example, in BASIC. McDermott (1985: 401–415) lists a BASIC program implemented on a TRS-80 microcomputer that will minimize Boolean truth tables. Several minimal modifications of this program are necessary before it can be run on an MS-DOS computer

(for example, an IBM-PC): first, replace the variables in the DIM statements with actual numbers, assuming a moderate number of inputs; second, delete the DATA statements (lines 18000–20170) and replace them with a front-end procedure to read a truth table from a file, using INPUT (to supply the name of the file containing the truth table), CLOSE, and OPEN statements; third, delete the statements beginning with CMD, substituting a GOTO 20 for the CMD statement in line 920; and, fourth, change the bracket character in the program listing ([) to BASIC's exponentiation character. The program will keep looping to request a file name with a truth table. Pressing the enter or the break key instead of naming a file will allow an exit from the program. The major drawback in applying McDermott's program to social data is that a clean and more or less fully specified truth table must be input into the program. Also, the program is not completely trouble free in the implementation just described, but for do-it-yourself types it is a good place to start.

Drass and Ragin (1986) have implemented Boolean algorithms in a microcomputer package called QCA (Qualitative Comparative Analysis) designed specifically for social data. It has a lot of bells and whistles compared to McDermott's program and allows greater flexibility in the handling of social data. Further, it expects a data matrix as input, not a clean and fully specified truth table.

8

Applications of Boolean Methods of Qualitative Comparison

Boolean methods of qualitative comparison have a variety of research applications. The major emphasis of this book, of course, is their use in comparative social science. The principles of qualitative and holistic comparison these techniques embody, however, are relevant to a variety of research questions. Three representative applications are presented in this chapter. The examples, of necessity, are brief. The intent is simply to convey the general flavor of Boolean-based qualitative analysis in a range of research areas. All the examples involve use of relatively straightforward categorical data. As noted previously, the principles of qualitative, holistic comparison are much easier to implement and to grasp when applied to categorical data.

The three applications are presented in macro to micro order, beginning with a reanalysis of some of Stein Rokkan's data on nation building in Western Europe and concluding with an analysis of data on organizations (juvenile courts in the United States). An application to individual-level data is presented in Ragin and others (1984), which addresses the use of Boolean methods to analyze data on discrimination. Finally, a truly microsociological application—to typifying processes in the production of official records in the criminal justice system—is presented by Drass and Spencer (1986).

The first application presented here is a reanalysis of data used by Rokkan (1970) in his work on nation building in Western Europe. Rokkan used a "configurational" approach that bears many similarities to the Boolean approach presented in this work. His main substantive interest was the growth of mass democracy and the emergence of different cleavage structures in

Western European polities. One outcome that interested him was the division of *some* working-class movements in these countries following the Russian Revolution into internationally oriented wings and some into nationally oriented wings. He considered the distribution of this outcome important because of its implication for the future of working-class mobilization (and cleavage structures in general) in Western Europe.

The second application addresses the use of Boolean techniques in the study of comparative ethnic political mobilization. Three theories are used to guide the analysis of data on the causes of ethnic mobilization among territorially based linguistic minorities in Western Europe: the developmental perspective, the reactive ethnicity perspective, and the ethnic competition perspective. This application of Boolean techniques emphasizes their use to examine multiple conjunctural causation, to evaluate theories, and to lay a foundation for historical examination of specific cases or categories of cases.

The third application addresses organizations. It is an analysis of organizational characteristics of juvenile courts in the United States. The goal of this analysis is not to examine a causal outcome, per se, but to examine limitations on the diversity of organizational forms that exist among juvenile courts. In addition to showing how Boolean techniques can be used to construct empirical typologies, this example also shows how frequency criteria can be incorporated to produce both fine- and coarse-grained analyses.

APPLICATION TO NATION BUILDING: A REANALYSIS OF ROKKAN (1970)

Many of the methodological sentiments expressed in this study echo those voiced by Stein Rokkan in his pioneering work on nation building published in the late 1960s and early 1970s. Rokkan was disturbed by the gulf between case-oriented and variable-oriented study and proposed an explicitly configurational approach to comparative social research as a way to bridge the two strategies. The research strategy he outlined resembles the Boolean approach presented in this book in its emphasis on combinations of characteristics and holistic comparison of cases.

In a typical application of his configurational approach, Rokkan would establish three or four theoretically important dichotomies and then elaborate their different logically possible combinations. Countries manifesting each combination of values would then be selected, compared, and interpreted. These results, in turn, would be used as a basis for evaluating the heuristic

value of the conceptual framework represented in the dichotomies. If the empirical examples of the different combinations of characteristics differed in predicted ways from each other, this was taken as evidence in favor of the value of the scheme as a guide to historical interpetation.

One of the issues that especially interested Rokkan was the timing and speed of the extension of the franchise in Western European countries and, by implication, the amount of conflict associated with the growth of mass democracy in each country. Three historical conditions defining different starting points in this process, he argued, shaped the progress of democratization: "medieval consolidation"—whether the country was a separate dynasty or a collection of cities and provinces within successive continental empires; "continuity of representative organs"—whether or not the country experienced extensive periods of absolutist rule; and "status in the international system"—whether a country was, or was part of, a *major* power or a *lesser* power. After examining the extension of the franchise in cases representative of each combination of values (there were only a few combinations lacking empirical instances), Rokkan concluded that the character of franchise extension was indeed shaped by different combinations of these three historical conditions—by the different starting points.

Often, Rokkan's configurational approach had a somewhat nebulous quality to it. In the example cited above, the dependent variable was the *character* of the growth of mass democracy. Thus, the analysis examined different historical conditions shaping the *nature* of this growth, not any particular feature of it. This aspect of Rokkan's work tilts it in a holistic, case-oriented direction—despite the generalizing, variable-oriented character that follows from applying the same framework to a range of cases.

Occasionally, however, Rokkan did address specific historical outcomes. One feature of the history of Western European polities that interested him, for example, was the variation among them in the impact of the Russian Revolution on working-class organizations. In some countries it had little impact, but in others it created deep and lasting divisions. A cursory examination of the cross-national distribution of these divisions does not yield simple conclusions. For example, Sweden and Norway are neighboring countries and share many features. Yet the success of the Russian Revolution, according to Rokkan, created only minor divisions in Swedish working-class organizations but major divisions in Norwegian organizations. True to form, Rokkan addressed this variation configurationally. In essence, he argued that the origins and nature of a polity's existing cleavage structure

shaped the reaction of a country's working-class movement to the Russian Revolution.

It would be difficult, of course, to reproduce his entire argument on cleavage structures in this brief treatment. His main concern was the interests and alliances of the state-builders and how these factors shaped the nature of the opposition to the state-builders. Of necessity, these interests and alliances were historically grounded. Rokkan argued that the important historical factors shaping cleavage structures in Western European polities and their reactions to the Russian Revolution were the outcome of the Reformation, the outcome of the "Democratic Revolution" (1970 : 116), the outcome of the Industrial Revolution, and the timing of state formation. The important dichotomies related to these four factors were:

1. Whether the state established a national church or remained allied with the Roman Catholic church. Rokkan labels this outcome "*C*" for national church.
2. Whether or not the state allowed Roman Catholic participation in nation-building institutions, especially mass education. In countries with national churches, this indicates deep religious division. In countries that remained allied with the Roman Catholic church, this represents a failure to establish a more secular state. Obviously, this dichotomy is relevant only to countries with large numbers of Roman Catholics. Rokkan labels this outcome "*R*" for Roman Catholic.
3. Whether the state maintained an alliance with landed interests or favored commercial and industrial interests over landed interests from the outset. Rokkan labels this outcome "*L*" for landed interests.
4. Whether a state formed early (such as Spain) or late (such as Belgium). Rokkan labels this outcome "*E*" for early.

These four dichotomies yield sixteen different combinations of conditions. Rokkan identified empirical instances of ten of these combinations. (See Table 10.) The outcome variable in Table 10 is labeled "*S*" and indicates working-class parties that were split in their reaction to the Russian Revolution. (The codings presented in the table faithfully reproduce those supplied by Rokkan. The goal of this discussion is to present a methodology suitable for configurational comparisons, not to challenge Rokkan's substantive interpretations of specific cases.)

After examining the different combinations of conditions and their associated outcomes, Rokkan (1970 : 132–138) concludes that in Protestant countries (that is, those with national churches) the working-class movement tended to be much more divided if the nation-building process was

TABLE 10: Rokkan's Data on Divided Working-Class Movements in Western Europe

Country	*C*	*R*	*L*	*E*	*S*
Great Britain	1	0	1	1	0
Denmark	1	0	0	1	0
Sweden	1	0	0	1	0
Norway	1	0	0	0	1
Finland	1	0	0	0	1
Iceland	1	0	0	0	1
Germany	1	1	1	0	1
Netherlands	1	1	0	1	0
Switzerland	1	1	0	1	0
Spain	0	0	1	1	1
France	0	0	0	1	1
Italy	0	0	0	0	1
Austria	0	1	1	0	0
Ireland	0	1	1	0	0
Belgium	0	1	0	0	0
Luxembourg	0	1	0	0	0
No Instance	0	0	1	0	?
No Instance	0	1	0	1	?
No Instance	0	1	1	1	?
No Instance	1	0	1	0	?
No Instance	1	1	0	0	?
No Instance	1	1	1	1	?

C = National church (vs. state allied to Roman Catholic church)
R = Significant Roman Catholic population and Roman Catholic participation in mass education
L = State protection of landed interests
E = Early state
S = Major split in working-class movement provoked by Russian Revolution (outcome variable)

NOTE: Question marks indicate that no clear prediction is made.

more recent and, by implication, national identity less settled. In Catholic countries, by contrast, the deeper and more persistent the church–state conflict, the greater the division in the working-class movement. In general, it appears from these two combinations that the *less settled* polities (Protestant ones because of recency; Catholic ones because of continuing religious conflict) were the ones that experienced divided working-class movements.

It is easy to express Rokkan's conclusion in Boolean terms (with uppercase letters indicating presence and lowercase letters indicating absence), and it is roughly confirmed through simple inspection of the empirical data presented in truth table form in Table 10.

$$S = Ce + cr$$

The equation states simply that the Russian Revolution divided working-class movements (1) in countries with national churches that had experienced nation building more recently (Norway, Finland, Iceland, Germany) and (2) in countries without national churches (that is, Catholic countries) that had denied the Roman Catholic church a major role in mass education (Spain, France, Italy).

Rokkan's results are duplicated when the Boolean algorithms described in Chapters 6 and 7 are applied to these data, but *only if* the combinations of conditions without empirical instances (the last six rows in Table 10) are allowed to take on *any* output value. In this type of analysis, the algorithm may assign these rows 1's or 0's, whichever assignment produces the most logically minimal solution possible. As noted in Chapter 7, this is equivalent to incorporating simplifying assumptions that, in effect, make allowances for the limited diversity of social phenomena (in this case, the limited diversity of Western European countries).

Boolean analysis of Rokkan's data without these simplifying assumptions does *not* reproduce his results. The most conservative way to approach the data in the truth table is to assume that the six combinations of characteristics for which there are no empirical instances would not have divided working-class movements. This strategy is conservative only in the sense that it treats the division of the working class as an unusual phenomenon and, by implication, considers no division following the Russian Revolution (a likely consequence of sheer inertia) the normal state of affairs. This assumption is operationalized simply by coding the output for these six combinations of values to zero in Table 10.

Applying the Boolean minimization algorithms to the resulting truth table yields the following reduced expression:

$$S = rle + crE + CRLe$$

This equation is considerably more complex than the one allowing simplifying assumptions (that is, Rokkan's). It describes three different (mutually exclusive) combinations of conditions leading to divided working-class movements: (1) low Roman Catholic involvement in mass education in a more recently formed state that favored urban interests from the outset: Italy, Norway, Finland, and Iceland; (2) low Roman Catholic involvement in mass education in a Catholic country with a long history of state building: Spain and France; and (3) Roman Catholic involvement in mass education in a Protestant country with a recent history of state building allied with landed interests: Germany.

The two conditions identified by Rokkan (*Ce* and *cr*) are clearly visible in the last two terms of the second equation. Thus, the second and third terms in this equation could be considered elaborations of his basic argument which emphasized recency in Protestant countries and religiously based conflict in Catholic countries. Note, however, that the last term (the one relevant to his *Ce* combination) also includes religious conflict—Catholic involvement in mass education in a Protestant country. Thus, these elaborations of Rokkan's simpler terms give greater weight to a history of religious conflict. In many respects, therefore, both of these terms describe national situations where the pressure or weight of historically rooted conditions on political institutions and arrangements was great. (In many respects, the weight of history was comparably great in Russia.)

Considering these two terms alone, there is some resonance of the results with arguments made by Mann (1973) and echoed by Giddens (1973). Mann and Giddens present elaborate historical arguments concerning conditions that prompt the development of revolutionary working-class consciousness. They both argue that where the confrontation between a feudal past and modern institutions was most sudden and acute, revolutionary consciousness was most likely. To the extent that a divided working-class movement signals a greater reservoir of potential revolutionary consciousness, this argument is loosely supported by the last two terms in the equation.

The first term in the equation, however, is not consistent with Rokkan's argument or with the argument concerning the weight of historical cleavages developed above. The image conveyed by this combination is of a highly secular state (whether it is Protestant or Catholic is irrelevant) that is *relatively* free from historical constraints: it is not allied with landed interests, nor is it encumbered by historically rooted political institutions. This combination of conditions casts a very different light on the question of reactions to the Russian Revolution. It suggests that the Russian Revolution had a strong impact on polities (and working-class movements) that were less constrained by historical cleavages and more open to change. In short, the inertia of the past was easier to overcome in these cases.

Together, the three terms in the equation suggest that divided working-

class movements were found in countries where the burden of historically rooted conditions on the polity was either relatively light or very heavy. This conclusion is qualitatively different from Rokkan's, which emphasized the degree to which different polities were "settled." Of course, this generalization is limited to Western Europe after the Russian Revolution. It would be hazardous to extend this statement beyond this region and period.

There is still another way to evaluate Rokkan's analysis. I noted above that if the six combinations lacking empirical instances are allowed to take on any output value, then it is possible to reproduce Rokkan's conclusion ($S = cr + Ce$) with Boolean techniques. However, this simpler solution requires simplifying assumptions. The important question to answer from this perspective is "what was Rokkan required to assume in order to produce this tidy solution?" This can be ascertained by contrasting the first solution, which incorporates simplifying assumptions, with the second, which does not.

An analysis of these differences shows that Rokkan assumed—implicitly—that countries with the following combinations of conditions, if they had existed, would have experienced divided working-class movements following the Russian Revolution: *CRle*, *rLe*. The first term describes a more recently formed Protestant nation-state with heavy Roman Catholic involvement in mass education and a bias toward urban interests. The second describes a recently formed nation-state with a bias toward landed interests and with low Catholic involvement in mass education. Of course, there are no clear instances of these two combinations within Western Europe, and Rokkan did not intend his argument to be applied outside this region. However, there are countries that roughly approximate these combinations outside of Western Europe, and these cases could be examined to see if they are consistent with Rokkan's expectations. This examination would provide an avenue for establishing a crude check on Rokkan's simplifying assumptions. The important point is not that these cases were not checked but that simplifying assumptions were implicitly incorporated. Boolean techniques provide a direct avenue for uncovering simplifying assumptions, which makes it possible to bring them forward for examination.

The intent of this application has not been to criticize Rokkan but simply to show how Boolean methods elaborate his configurational approach. Rokkan indicated that his conclusions were tentative. The ones offered here based on his classifications are even more tentative than Rokkan's. Rokkan's primary goal was to establish a foundation for examining the development and structure of cleavage systems in Western Europe. If anything, the re-

analysis offered here simply confirms that the scheme he developed is useful, perhaps in ways he did not intend. Nevertheless, the goal of the reanalysis is compatible with Rokkan's—to provide a foundation for *understanding* historical patterns and political developments in Western European polities, not to *test* theory per se.

The next application of Boolean methods of comparison examines several perspectives and many more cases. It provides an opportunity to demonstrate in more detail the interplay between theory, qualitative comparative analysis, and historical investigation.

APPLICATION TO THE COMPARATIVE STUDY OF SUBNATIONS

From a nation-building perspective, the map of Western Europe is cluttered with territorially based ethnic minorities or "subnations" (Petersen 1975: 182). At the periphery of most countries are linguistically distinct populations that differ substantially from the dominant or core cultural groups. France has Alsatians, Bretons, and Corsicans, among others; Great Britain has a variety of Celtic-speaking populations residing in its peripheral areas. Some countries are collections of subnations, and dominance is hotly contested. No Western European country is free from linguistically based ethnic diversity.

The political mobilization of territorially based linguistic minorities in industrialized countries is anomalous from the viewpoint of classic social theory. The dominant theme of this body of thought is developmental. According to this reasoning, economic and political forces associated with Western capitalism erode local cultures and gradually erase intranational cultural differences. Ethnic and cultural differences decline in importance as a basis for social action, and the possibility of ethnic political mobilization decreases. The experience of the last several decades, especially the late 1960s and early 1970s, however, contradicts these expectations. In all corners of Western Europe, and the world, there was a resurgence of ethnic political mobilization. The idea that the countries of Western Europe are integrated, modern polities free from serious ethnically or culturally based opposition has been discarded.

This section examines the conditions of ethnic political mobilization among territorially based linguistic minorities in Western Europe and attempts to shed some light on the diversity of subnations. Its primary goal is

to illustrate the Boolean algorithms outlined in Chapters 6 and 7 with typical, if imperfect, comparative data. The outcome variable in these analyses is ethnic political mobilization. The causal variables describe different aspects of subnations relevant to such mobilization. These analyses are introduced with a discussion of current theories and research strategies in the study of ethnic political mobilization. I hope to show that the Boolean approach is particularly well suited for the analysis of comparative ethnic political mobilization because it is capable of comprehending the diversity of subnational situations.

THEORIES OF ETHNIC POLITICAL MOBILIZATION. Contemporary theories of ethnic political mobilization do not allow conceptualization of the diversity of subnations. Each of the major perspectives—the developmental perspective, the reactive ethnicity perspective, and the ethnic competition perspective—either focuses on a single subnational situation or simply assumes intranational ethnic variation and emphasizes the general conditions that prompt ethnic political mobilization.

In the developmental perspective, ethnicity is viewed as a primordial sentiment (Geertz 1963) destined to wither away in societies that experience significant social structural differentiation (Parsons 1975). In a modern setting, therefore, ethnic mobilization is viewed as aberrant. It is possible only if there has been some failure to draw subnations into national economic life. This view of ethnic mobilization has been applied to the analysis of political cleavages in Western European countries by Lipset and Rokkan (1967: 1–64). They argue that in Western European polities, culturally based political cleavages were superseded by functional cleavages reflecting economic interests.

In this perspective, the classic subnation is a culturally distinct, geographically peripheral collectivity that has remained relatively isolated economically and socially from the national center. The subnation may inhabit a resource-poor region of the nation, and its members may tend to specialize in primary economic activities such as farming. Ethnic political mobilization occurs because of the growing economic, cultural, and political divergence of the subnation from the rest of the nation. Ethnic mobilization resulting from regional economic inequality is not incompatible with this divergence, but the underlying basis for mobilization according to developmental logic is the failure to integrate the subnation, not its relative poverty per se. Rokkan

(1970 : 121), for example, argues that three conditions are responsible for the emergence and consolidation of territorial countercultures: territorial concentration (a condition common to all subnations examined here); social isolation (usually linked to the existence of strong linguistic differences); and economic isolation (especially, weak economic ties to the national core).

The second view, the reactive ethnicity perspective, argues that a particularistic allocation of valued roles and resources to the dominant ethnic group is the primary cause of ethnic political mobilization. In contrast to the developmental perspective, which argues that a particularistic allocation of scarce goods is incompatible with structural differentiation, the reactive ethnicity perspective argues that it can occur in societies at any level of structural differentiation. Thus, ethnic identity is preserved in modern societies by a coincidence of ethnicity and social class (Gellner 1969). This "cultural division of labor," Hechter (1975) argues, can exist even in an advanced industrial society. He asserts that urbanization and industrialization intensify the link between social class and ethnicity by concentrating members of subnations in low-status positions and neighborhoods (1975 : 39–43). Class mobilization, of course, exists as an alternative to ethnic mobilization in such societies, and, in fact, it may precede ethnic mobilization. However, should national working-class organizations fail to meet the demands of the culturally subordinate lower strata, ethnic political mobilization is likely (1975 : 309).

In common with the developmental perspective, the reactive ethnicity perspective sees the classic subnation as a relatively disadvantaged cultural minority residing in the periphery of an advanced nation-state. However, in this perspective the subnational area is not isolated; it has been infiltrated by members of the dominant cultural group. Typically, the members of the dominant collectivity see themselves as developers bearing the fruits of modern society. The development they bring to the subnational area is often stunted and distorted, however, because the region is developed as an appendage of the national economy. Its interests are subordinated to national interests, and capital may be drained from the subnation. Furthermore, peripheral social structure is distorted by the cultural division of labor that is instituted. The dominant strata come to be seen as alien by the lower strata, and the culture of the lower strata becomes stereotyped as inferior by members of the dominant strata. The peripheral region may be industrial, but typically it is poorer than the core region.

The ethnic competition perspective, the third major view, argues that social structural modernization affects nations and subnations in two ways.

First, modernization reduces ethnic diversity within subnations and within the dominant culture by eroding small-scale, local cultural identities. Second, modernization increases the importance of large-scale ethnic identities by altering the conditions of competition between politically definable collectivities (Hannan 1979). Specifically, because the size of the most powerful competitor (the core in a modern nation-state and the associated dominant cultural group) increases with modernization, organized resistance to the core succeeds only when it is organized around large-scale identities. Thus, modernization actually increases the political viability of broadly defined ethnic identities (Nielsen 1985). Ethnic political mobilization is sparked when ethnic groups (dominant and subordinate) are forced to compete with each other for the same rewards and resources. A competitive situation is especially likely when a stable cultural division of labor is disrupted by economic change (Ragin 1977, 1979; Nielsen 1980).

In the ethnic competition perspective, the classic subnation may or may not be peripheral. The primary requirement is one of size—it must be big enough in potential membership to muster a significant challenge to the core. In general, this perspective follows the lead of the resource mobilization perspective (Tilly 1978; McCarthy and Zald 1977; see Jenkins 1983, Nagel and Olzak 1982, Olzak 1983) in arguing that anything which adds to the resources of the subnation enhances its ability to challenge the core. According to this reasoning, rich subnations are more likely to mobilize successfully than poor subnations. A second major requirement is for some form of structurally based provocation. Many different contexts might provide a basis for this. Typically, however, this provocation involves a change in the structure of rewards and resources available to ethnic collectivities that intensifies the competition between them.

TESTING THEORIES OF ETHNIC POLITICAL MOBILIZATION. These three theories have been set against each other in several studies, and a more or less standard approach to testing them has emerged. (Recent investigations include Hechter 1975; Ragin 1977, 1979, 1986; Ragin and Davies 1981; Nielsen 1980; Olzak 1982; see also Nagel and Olzak 1986.) These studies typically examine cross-sectional and longitudinal data on the aggregate political tendencies of territorial units within single countries (such as vote percentages for different political parties in electoral districts in Belgium). This strategy is comparable to Shorter and Tilly's use of France to

test general arguments about the political mobilization of workers in advanced countries. This general strategy has been strongly criticized by Lieberson (1985) and others.

Existing studies of ethnic mobilization pinpoint kinds of areas supportive of ethnic parties and shifts in these patterns over time. Different theories of ethnic political mobilization provide researchers with different images of subnations and different images of ethnic political mobilization. The images provided by these theories, in turn, are used to aid the formulation of hypotheses about aggregate patterns of support for ethnic parties, and quantitative data are used to test the hypotheses. Thus, only the implications of theories for patterns of support in different countries, considered one at a time, are examined. The theories have not been used to examine differences among a large number of instances of ethnic political mobilization across several countries. This limitation is important because the theories emphasize polity-level phenomena. The disruption of a stable cultural division of labor, for example, tends to be polity-wide.

While these studies have enriched social scientists' understanding of ethnic political mobilization, several basic questions remain unanswered. Many different subnations in Western Europe mobilized during the 1960s and 1970s, and there are striking differences among them. Did the same causal conditions prompt ethnic mobilization in each case? Are there underlying patterns or types? There is little reason to expect all instances of ethnic political mobilization to be alike. Further, not all subnations mobilized. No one has examined the subnations that failed to mobilize. The Boolean analysis presented here examines these questions. As I hope to show, it is useful for this kind of investigation because it allows conceptualization of the diversity of subnations.

A BOOLEAN APPROACH TO ETHNIC MOBILIZATION. The first step in a Boolean analysis is to identify the relevant causal conditions. Using the three perspectives outlined above as guides, we can identify four major characteristics of subnations: the subnation's size, the strength of its linguistic base, its relative wealth, and its economic status (declining versus expanding). The outcome variable is ethnic political mobilization as indicated by a variety of achievements: formation of an ethnic political party, substantial membership in ethnic organizations, representation in national or regional legislative bodies, ethnic demonstrations and political violence, and so on. The data

used to code these variables are based on reports by Allardt (1979), Kidron and Segal (1981), and McHale and Skowronski (1983).

The size of subnations is relevant primarily to the ethnic competition perspective. This perspective argues that challenges to the core cultural group must be based on the mobilization of broad minority identities embracing many members. While only the competition perspective emphasizes this factor, the other perspectives would not deny that size makes a difference. Thus, this variable does not sharply distinguish the three perspectives.

Good data on the size of ethnic groups are notoriously hard to obtain because they tend to be politically sensitive and because self-assignment to ethnic groups tends to be somewhat variable. It is possible to distinguish smaller and larger subnations in Western Europe, however, using 100,000 members as a cutoff value. This value was selected for two reasons: most subnations are clearly smaller or clearly larger than 100,000; moreover, the cutoff value is consistent with the goal of distinguishing collectivities capable of mounting a serious challenge. In the analysis that follows, subnations estimated to have fewer than 100,000 members were coded as small (0) and subnations estimated to have more than 100,000 members were coded as large (1).

The strength of the linguistic base is most relevant to the developmental perspective. This perspective argues that the persistence of minority culture is what causes ethnic political mobilization. This variable is also relevant to the ethnic competition perspective because a strong minority linguistic base is a resource that both enhances mobilization and intensifies ethnic competition. In the reactive ethnicity perspective, however, the expectation is that the dominant cultural group has launched an assault on the subnation's language and culture. Thus, a politically mobilized subnation may not have a strong linguistic base according to this perspective.

In the following analysis only subnations in which it is clear that the minority language is known to the vast majority of minority members (in both oral and written form) are coded as having a strong linguistic base (1). If the language is unknown to at least a substantial minority, it is coded as having a weak linguistic base (0). This strict coding is consistent with the emphases of all three theories.

Relative wealth of the subnation is most relevant to the reactive ethnicity perspective. This theory sees ethnic mobilization as a reaction to inequality and exploitation. The perception of exploitation is more likely if the subnation is poorer than core areas of the nation. A lower relative wealth could also, however, indicate divergence resulting from economic isolation, a major concern of the developmental perspective. Thus, relative wealth is also a concern of the developmental perspective. Finally, the ethnic competition perspective sees wealth as a resource and would argue that subnations with *greater* relative wealth are more likely to mobilize. Thus, this variable clearly distinguishes the ethnic competition perspective from the other two perspectives.

Data on regional differences in production per capita are used to assess relative wealth. If a subnation's gross production per capita is substantially less than that of the remainder of the nation, relative wealth is coded 0. Relative wealth is coded 1 if it is equal to or greater than that of the rest of the nation.

Economic status is relevant to all three perspectives. In the developmental perspective, the typical subnation is an isolated, declining region. This description is consistent with the idea that it is a backwater area. In the reactive ethnicity perspective, however, mobilization is stimulated by exploitation. Either decline or advance might signal more exploitation. Decline may indicate an accumulation of misery; advance may indicate that the dominant group has found new ways to exploit the subnation's resources, which, in turn, might further peripheralize it. Thus, the specific predictions of this perspective are unclear. Similarly, the ethnic competition perspective argues that any economic change (advance or decline) that alters the structure of rewards and resources is likely to provoke ethnic mobilization. This is because such changes are likely to stimulate ethnic competition.

Data on immigration are used to assess economic status. If immigration into a subnation exceeds emigration from a subnation, it is coded 1 (advancing) on economic status. If emigration exceeds or equals immigration, it is coded 0 (declining). Note that if immigration is greater than emigration, then economic ties linking the subnation to the national center are probably increasing in strength.

The three theoretical perspectives are compared with respect to their predictions concerning the four causal variables in Table 11. As noted, the perspectives do not contradict each other absolutely. There are significant areas of overlap, especially when the different causal variables are considered one at a time and not in combinations.

The values in each column, considered as a set, describe different theoretically based types of subnations. The coding "1" indicates that the perspec-

TABLE 11: Summary Presentation of Predictions of Three Theories of Ethnic Political Mobilization

	Guiding Perspective		
CHARACTERISTIC	DEVELOPMENTAL	REACTIVE	COMPETITIVE
Size of Subnation (*S*)	(1)[a]	(1)[a]	1
Linguistic Base (*L*)	1	0	(1)[a]
Relative Wealth (*W*)	(0)[a]	0	1
Economic Status (*G*)	0	?[b]	?[b]

[a]Predictions in parentheses are only weakly indicated by the theories.
[b]Question marks indicate that no clear prediction is made.

tive views the presence of the feature as important; "0" indicates that the perspective views the absence of the feature as important; "?" indicates that no clear position is discernible—the prediction is context-specific; parentheses are used to indicate predictions that are only weakly indicated by the theories.

It is clear from Table 11 what the main concerns of each perspective are; these, in turn, can be represented in Boolean terms. The developmental perspective emphasizes linguistic base and economic status. The image portrayed is that of a culturally distinct, economically isolated subnation. (Using variable names, this is represented as *Lg*, where uppercase letters indicate presence, lowercase indicate absence, and multiplication indicates logical AND.) The main concerns of the reactive ethnicity perspective, by contrast, center on the predatory behavior of the dominant cultural group. Thus, this perspective emphasizes the damage inflicted on the subnation's language and economy (*lw*). Finally, the ethnic competition perspective emphasizes the power of the subnation vis-à-vis the core cultural group. Size and wealth are important because these are the resources that increase the likelihood that mobilization will bear fruit (*SW*).

The next step of the Boolean analysis is to construct a truth table with data on subnations, using the four variables described above and an outcome variable. In this analysis the outcome is ethnic political mobilization as indicated by several possible achievements: the formation of an ethnic political party, the mobilization of a substantial membership or following, election of representatives to national or regional legislative assemblies, and initiating other forms of political action (demonstrations, ethnic political violence, and the like). Subnations were sorted into three categories of ethnic political mo-

TABLE 12: Data on Territorially Based Linguistic Minorities of Western Europe

Minority	*S*	*L*	*W*	*G*	*E*
Lapps, Finland	0	0	0	0	0
Finns, Sweden (Torne Valley)	0	0	0	0	0
Lapps, Sweden	0	0	0	0	0
Lapps, Norway	0	0	0	0	0
Albanians, Italy	0	0	0	0	0
Greeks, Italy	0	0	0	0	0
North Frisians, Germany	0	0	0	1	1
Danes, Germany	0	0	0	1	1
Basques, France	0	0	0	1	1
Ladins, Italy	0	0	1	0	0
Magyars, Austria	0	1	0	0	0
Croats, Austria	0	1	0	0	0
Slovenes, Austria	0	1	0	0	1
Greenlanders, Denmark	0	1	0	0	1
Aalanders, Finland	0	1	1	0	2
Slovenes, Italy	0	1	1	1	1
Valdotians, Italy	0	1	1	1	2
Sards, Italy	1	0	0	0	1
Galicians, Spain	1	0	0	0	1
West Frisians, Netherlands	1	0	0	1	1
Catalans, France	1	0	0	1	1
Occitans, France	1	0	0	1	1
Welsh, Great Britain	1	0	0	1	2
Bretons, France	1	0	0	1	2
Corsicans, France	1	0	0	1	2
Friulians, Italy	1	0	1	1	1
Occitans, Italy	1	0	1	1	1
Basques, Spain	1	0	1	1	2
Catalans, Spain	1	0	1	1	2
Flemings, France	1	1	0	0	1
Walloons, Belgium	1	1	0	1	2
Swedes, Finland	1	1	1	0	2
South Tyroleans, Italy	1	1	1	0	2
Alsatians, France	1	1	1	1	1
Germans, Belgium	1	1	1	1	2
Flemings, Belgium	1	1	1	1	2

S = Size of subnation
L = Linguistic ability
W = Relative wealth of subnation
G = Growth vs. decline of subnational region
E = Degree of ethnic political mobilization

bilization (E): little or no evidence of mobilization (0), some evidence of mobilization (1), and considerable evidence of mobilization (2).

Table 12 reports the different combinations of values for thirty-six subnations and their scores on the crude mobilization measure. Thus, $S = 1$ if the subnation is large; $L = 1$ if members of the subnation speak and write the minority language; $W = 1$ if the subnation is as rich as or richer than the larger nation; $G = 1$ if immigration into the subnation exceeds emigration from the subnation; $E = 2$ if there is substantial evidence of ethnic political mobilization; $E = 1$ if there is at least some evidence of ethnic political mobilization; otherwise $E = 0$.

The first major task is to code a single dichotomous outcome (1 or 0) for all cases conforming to each combination of causal conditions. As noted in Chapter 7, if the cases conforming to a certain combination of values do not show clear tendencies, then some method for resolving the contradiction must be devised. The data presented above present no ambiguous combinations of values. The one possibly troublesome combination is the coincidence of small size, weak linguistic base, low relative wealth, and economic advance (0001). The three cases that display these values (North Frisians and Danes in Germany and Basques in France) all display some evidence of ethnic political mobilization, but not strong evidence. Generally, a combination of input values was not coded as a positive instance of ethnic political mobilization in the Boolean analysis unless half of the cases conforming to the combination displayed clear evidence of mobilization (that is, had scores of 2 in Table 12). There were no combinations that embraced cases with little mobilization (0) and clear evidence of mobilization (2). Thus, the one troublesome combination of values was coded 0 (little or no evidence of mobilization). The resulting truth table, with ethnic political mobilization (E) coded as a presence/absence dichotomy, is presented in Table 13.

Table 13 summarizes the different combinations of conditions associated with ethnic political mobilization among Western European subnations. Application of the minimization algorithms described in Chapters 6 and 7 to the truth table (treating nonexistent combinations as instances of no ethnic mobilization) results in the following logically minimal reduced Boolean expression for instances of ethnic political mobilization. In the equations that follow, a variable name in uppercase letters indicates that it must be present (1); a variable name in lowercase letters indicates that it must be absent (0).

$$E = SG + LW$$

TABLE 13: Truth Table Representation of Data on Causes of Ethnic Political Mobilization

S	L	W	G	E	N
0	0	0	0	0	6
0	0	0	1	0	3
0	0	1	0	0	1
0	0	1	1	?	0
0	1	0	0	0	4
0	1	0	1	?	0
0	1	1	0	1	1
0	1	1	1	1	2
1	0	0	0	0	2
1	0	0	1	1	6
1	0	1	0	?	0
1	0	1	1	1	4
1	1	0	0	0	1
1	1	0	1	1	1
1	1	1	0	1	2
1	1	1	1	1	3

S = Size of subnation
L = Linguistic ability
W = Relative wealth of subnation
G = Growth vs. decline of subnational region
E = Degree of ethnic political mobilization

The reduced equation indicates that there are two basic combinations of conditions linked to ethnic political mobilization. The first combines large size and economic advance (more immigration than emigration); the second combines strong linguistic base and high relative wealth. It is possible at this point to apply De Morgan's Law to this result to produce an equation (with e in lowercase to denote absence) describing the subnations that fail to mobilize:

$$\begin{aligned} e &= (s + g)(l + w) \\ &= sl + sw + gl + gw \end{aligned}$$

The equation is most consistent with the ethnic competition perspective because it shows that subnations which suffer more than one deficiency (from a resource mobilization point of view) are not likely to mobilize. The only

pairs of deficiencies that subnations can possess and still mobilize are *lw* and *sg*, as we shall see.

Several features of this analysis should be noted. First, the equation for the presence of ethnic political mobilization ($E = SG + LW$) is logically minimal. Using the procedures outlined in Chapter 7 for incorporating simplifying assumptions does not result in a simpler solution. Second, all prime implicants produced in the first phase of the algorithm appear in the final reduced equation. Thus, there are no prime implicants that were eliminated by applying the prime implicant chart procedure. (As noted in Chapter 7, these considerations are important because they are relevant to the issue of parsimony.)

At first glance, the equation for the presence of ethnic political mobilization (E) offers greatest support for the ethnic competition perspective. Although neither term reproduces the core prediction of this perspective (SW), both terms are compatible with this perspective because the images they evoke are those of powerful subnations with the resources necessary for challenging the core cultural group. Not all is lost, however, for the other perspectives. It is important at this stage of the investigation to apply the techniques for evaluating theories outlined in Chapter 7. To simplify the presentation, the three theories are examined one at a time, not in a combined equation.

The core of the reactive ethnicity argument, at least as outlined above, emphasizes low relative wealth (w) and a weak linguistic base (l). These expectations derive from a theoretically based interest in the predatory actions of core cultural groups. Using the techniques outlined in Chapter 7, it is possible to identify subnations that conform to both the predictions of the reactive ethnicity perspective (designated by R, for reactive ethnicity) and the equation derived for ethnic political mobilization (E). This set is formed from the intersection of R and E:

$$\begin{aligned} R &= lw \\ E &= SG + LW \\ R(E) &= SlwG \end{aligned}$$

Thus, the two equations (the equation derived from the reactive ethnicity perspective and the equation modeling the results of the analysis of ethnic political mobilization) intersect. The term that results from their intersection combines large size, weak linguistic base, low relative wealth, and economic advance. A total of six subnations conform to this combination of

conditions. They are West Frisians (Netherlands), Catalans (France), Occitans (France), Bretons (France), Corsicans (France), and Welsh (Great Britain).

Two conclusions follow from this result. First, the reactive ethnicity perspective (at least as presented above) is incomplete in the specification of conditions likely to generate ethnic political mobilization. Peripheralization (specifically, the *lw* combination) is linked to ethnic political mobilization only among larger subnations experiencing economic advance. As noted, economic advance might indicate disruption of an existing cultural division of labor (a condition emphasized by the ethnic competition perspective; see Ragin 1979) or a new interest in the resources of the peripheral region by the core cultural group. Second, the reactive ethnicity perspective can be usefully applied to these six subnations by using the *SlwG* combination to guide the analysis and interpretation of these six cases.

One conflict in the study of ethnic political mobilization over the last few years has concerned the applicability of the three major perspectives to Wales. Alford (1963), Cox (1967, 1970), and Butler and Stokes (1969) applied the developmental perspective. Hechter (1975) applied the reactive ethnicity perspective. And I have applied the ethnic competition perspective (Ragin 1977, 1979, 1986; Ragin and Davies 1981). The results presented here indicate that when viewed in comparative perspective a combination of the last two theories may be usefully applied to this case.

These same procedures can be used to evaluate the ethnic competition perspective. This perspective (designated C) emphasizes resources of size and wealth (SW). The Boolean interesection of this theoretically based expectation with the final equation for E shows that their area of overlap is

$$\begin{aligned} C &= SW \\ E &= SG + LW \\ C(E) &= SWG + SLW \\ &= SW(G + L) \end{aligned}$$

The equation states simply that ethnic political mobilization occurs when large size and greater relative wealth are combined with either economic advance or strong linguistic base. Referring back to the original data reveals that a larger number of subnations are covered by the intersection equation based on the ethnic competition perspective than are covered by the intersection equation based on the reactive ethnicity perspective. Altogether, nine subnations are covered by this intersection equation: Germans (Belgium),

Flemings (Belgium), Swedes (Finland), Alsatians (France), Friulians (Italy), Occitans (Italy), South Tyroleans (Italy), Basques (Spain), and Catalans (Spain).

Again, two conclusions are immediately apparent. First, the ethnic competition perspective is incompletely specified. Large size and greater relative wealth are linked to ethnic political mobilization only in the presence of either economic advance or a strong linguistic base. Thus, the intersection equation provides a basis for elaborating this perspective. Both economic advance and strong linguistic base are resources that undoubtedly enhance ethnic political mobilization. Second, with these refinements the perspective can be applied usefully to nine subnations.

Finally, these same procedures can be used to evaluate the developmental perspective (designated D). This perspective emphasizes strong linguistic base and economic decline (Lg). Intersection with the equation for E shows

$$\begin{aligned} D &= Lg \\ E &= SG + LW \\ D(E) &= LWg \end{aligned}$$

The intersection equation for the developmental perspective states that when a strong linguistic base is combined with high relative wealth and economic decline, ethnic political mobilization occurs. A total of three subnations conform to this combination: Aalanders (Finland), Swedes (Finland), and South Tyroleans (Italy). Note, however, that two of these subnations (Swedes in Finland and South Tyroleans in Italy) are also covered by the intersection equation for the ethnic competition perspective. Furthermore, the combination of conditions that these two subnations share (large size, strong linguistic base, greater relative wealth, and economic decline) give the impression not of an isolated, peripheral cultural minority (the image conveyed in the developmental perspective) but of a resource-rich, competitive minority (the image presented in the ethnic competition perspective). Thus, these two subnations should be treated as instances of ethnic political mobilization covered by the ethnic competition perspective. This leaves one subnation uniquely covered by the intersection equation for the developmental perspective: Aalanders in Finland. Note that this subnation is *physically* isolated from its larger nation (Finland), a characteristic highly compatible with the logic of the developmental perspective.

Two conclusions follow. First, the combination of a strong linguistic base and economic decline stimulates ethnic political mobilization only in the presence of greater relative wealth. Thus, the range of conditions consistent with developmental logic is narrow. Second, the developmental perspective can be usefully applied to the one case that clearly conforms to this combination.

Finally, it is useful to derive an equation for subnations that exhibit ethnic political mobilization but were not hypothesized to do so by any of the three theories. This equation can be derived by deducing the intersection of the equation for E with the negation of the equation for all subnations hypothesized by any of the three perspectives to display ethnic mobilization. The term H is used to designate such subnations and is formed simply by applying logical OR to the three hypothesis equations given above. The negation of hypothesized instances (which would show subnations not hypothesized to exhibit ethnic political mobilization and is designated h) is derived by applying De Morgan's Law to the equation for hypothesized instances:

$$\begin{aligned} H &= lw + SW + Lg \\ h &= (L + W)(s + w)(l + G) \\ &= slW + sLG + sWG + LwG \\ h(E) &= (slW + sLG + sWG + LwG)(SG + LW) \\ &= sLWG + SLwG \end{aligned}$$

There are surprisingly few subnations with ethnic political mobilization that were not hypothesized by one of the three perspectives to display mobilization. There are two instances of the first term, which combines small size, strong linguistic base, high relative wealth, and economic advance: Slovenes of Italy and Valdotians of Italy. There is only one instance of the second term, which combines large size, strong linguistic base, lower relative wealth, and economic advance: Walloons of Belgium. The first two cases both exist as subnations because of relatively unusual historical circumstances. The Walloons of Belgium in many respects are not a subnation (they are the dominant cultural group in Belgium) and have mobilized as an ethnic group partially in response to Flemish mobilization. Thus, it is possible to account for these theoretical outliers by citing additional historical and political evidence.

SUMMARY. Overall, the results indicate that the reactive ethnicity and ethnic competition perspectives are both applicable to a substantial number

of instances of ethnic political mobilization. Consistent with the results of the case studies cited above, it is apparent that the developmental perspective is not a useful tool for understanding contemporary ethnic mobilization in Western Europe. The reactive ethnicity perspective is applicable to six cases at most, while the ethnic competition perspective is applicable to nine cases and probably to some of the cases covered by the reactive ethnicity perspective (such as Wales), as well.

To some extent it is surprising that the reactive ethnicity perspective, even in its emended form, is applicable to many Western European subnations. One is surprised for two reasons. First, Western Europe has had formally constituted, modern nation-states on its soil for centuries. There have been many boundary changes over this period, and subnations have been created in the wake of these changes. Most of these subnations were spared demotion to the status of internal colony. Thus, the historical conditions surrounding the formation of many Western European subnations do not conform well to the scenario outlined in the reactive ethnicity perspective. Second, in most of Western Europe industrialization preceded or accompanied democratization. Thus, the class cleavage was favored in the development and maturation of these polities (Lipset and Rokkan 1967; Rokkan 1970). This sequence of events may have stunted the mobilization of ethnic lower strata as ethnic as opposed to class collectivities. Consistent with this historical pattern, it should be noted that of the six subnations covered by the reactive ethnicity perspective, five traditionally have displayed relatively high levels of voting for socialist and social democratic parties. Thus, these subnations have tended to mobilize along class lines in concert with polity-wide efforts (see Ragin and Davies 1981; Ragin 1986).

The results indicate that both of the major perspectives, as initially specified, are incomplete. The intersection equations show the shortcomings of these theories quite explicitly. The ethnic competition perspective, as formulated, ignores the importance of having either economic advance or strong linguistic base coincide with large size and relative wealth. The reactive ethnicity perspective ignores the fact that large size and economic advance must accompany the conditions it emphasizes (weak linguistic base and low relative wealth) for ethnic mobilization to occur. The more elaborate versions of these perspectives, presented in the intersection equations $R(E)$ and $C(E)$, should be used as guides when interpreting specific cases.

The goal of interpreting cases is important. Boolean-based techniques of qualitative comparison are not used simply to assess multiple conjunctural causation or to evaluate theories, but also to establish a strong comparative foundation for interpretive analysis of specific cases or sets of cases. Thus, the completion of this study of ethnic political mobilization would involve further specification of these two types of ethnic political mobilization (the reactive type and the competitive type) and the elaboration of a more detailed account of mobilization in specific cases. This would entail use of the method of agreement to establish further similarities among the cases conforming to each type and, further, use of the method of difference to refine the specification of differences between types (see Chapter 3). Essentially, the Boolean analysis establishes the important signposts for a more detailed investigation of ethnic mobilization in Western Europe.

The results support the idea that there is great diversity among subnations and among instances of ethnic political mobilization. It is not possible to embrace all instances within a single framework. In some respects, this conclusion is too easy, for it simply affirms that there is a great deal of complexity to social phenomena, a conclusion that few would challenge. The Boolean analysis does more than simply confirm complexity, however. It shows the key combinations of causal conditions linked to ethnic political mobilization. It maps the complexity of ethnic mobilization and provides a basis for limited generalization and further investigation.

APPLICATION TO EMPIRICAL TYPOLOGIES OF ORGANIZATIONS

Empirical typologies are valuable because they are formed from interpretable combinations of values of theoretically or substantively relevant variables which characterize the members of a general class. The different combinations of values are seen as representing types of the general phenomenon. (See Barton 1955 : 40–45 for an early discussion of basic principles of empirical typology; see also McKinney 1965, Simon 1969 : 292–300, and Diesing 1971 : 197–202.) Empirical typologies are best understood as a form of social scientific shorthand. A single typology can replace an entire system of variables and interrelations. The relevant variables together compose a multidimensional attribute space; an empirical typology pinpoints specific locations within this space where cases cluster. The ultimate test of an empirical typology is the degree to which it helps social scientists (and, by implication, their audiences) comprehend the diversity that exists within a general class of social phenomena.

The third application of Boolean techniques involves using them to construct an empirical typology. The data used in this example describe organizations (juvenile courts in the United States) and are thus on a smaller scale than the data used in the previous examples (though still macrosocial). The problem is to construct an empirical typology of these courts, a model of their diversity. Thus no causal outcome, per se, is examined. The techniques presented are not limited to organizations. Similar techniques could be used, for example, to develop an empirical typology of Third World countries using criteria specified in dependency theories. The result would be a specification of types of dependent countries, an important issue in the study of dependency and development.

The Boolean approach is appropriate for constructing typologies because it explicitly examines combinations of characteristics and produces a logically minimal statement describing their diversity. In this example, the Boolean analysis addresses the question "how are juvenile courts organized?" by examining the different combinations of organizational features that they exhibit. The analysis is relevant to theories about organizations because it addresses limitations on the variety of organizational forms evident among instances of one type of organization, juvenile courts.

To structure the discussion, the work of Stapleton and others (1982) is extended and elaborated. Stapleton and colleagues develop an empirical typology of juvenile courts using relatively conventional techniques: factor analysis, to identify underlying dimensions of variation among juvenile courts, and cluster analysis to identify key locations in the multidimensional attribute space formed by these underlying dimensions. After reviewing their work, I reanalyze their data by using Boolean techniques.

STAPLETON AND COLLEAGUES' EMPIRICAL TYPOLOGY. Much of the literature on American juvenile courts portrays them as varying along a single traditional–due process continuum (Handler 1965; Dunham 1966; Stapleton and Teitelbaum 1972; Erikson 1974; Tappan 1976; Cohen and Kluegel 1978). While recent contributions have noted that juvenile courts range from all-inclusive bureaucracies to a variety of decentralized structures, the conception of these courts as varying along a single continuum has persisted. Stapleton and colleagues (1982) argue that a unidimensional characterization of juvenile courts neglects both the intricacy of their organizational differences and the different normative systems and work expectations such features reflect.

TABLE 14: Results of Stapleton and Colleagues' Factor Analysis

Factor	Description	Key Indicator/Highest Loading Variable
1	Status offenders processed/scope (*S*)	Intake or probation officer can refer status offender to voluntary agency
2	Centralization of authority (*C*)	Court or judge administers probation department
3	Formalization of procedure (*F*)	Mandatory interval between adjudication and disposition exists and can be formally waived
4	Task specification/ differentiation (*T*)	Prosecutor must be involved in the decision to file a formal petition
5	Discretion (*D*)	Intake or probation staff may arrange informal probation for law violators

Source: Based on Stapleton and others (1982 : tables 1 and 2).

Stapleton and colleagues conducted factor analyses of 96 dichotomously coded characteristics of 150 metropolitan juvenile courts in order to provide a basis for developing an empirical typology. The basic assumption of the factor analytic approach is that observed correlations between variables are the result of underlying regularities in the data and that any variation in the data which is peculiar to single variables does not reflect general, shared features. The five interpretable factors they found are summarized in Table 14.

The indicator for factor 1 (scope) indicates the courts which have jurisdiction over status offenders. Overall, variables loading on this factor distinguish juvenile courts with jurisdiction over the adjudication and disposition of cases involving status offenders from those lacking such jurisdiction. The key indicator for factor 2 (centralization) concerns the power of the central executive. This variable indicates its control over the probation department. Other variables on this factor also concern subinstitutional loci of decision making. The indicator for factor 3 (formalization) indicates that a mandatory interval between adjudication and disposition exists and that it can be formally waived. Many juvenile courts do not bifurcate adjudication and disposition and thus have less formalized proceedings. The indicator for factor 4 (task specificity) concerns specificity of positions within the court. The participation of the prosecuter in the decision to file formal petitions indicates greater task specificity. The indicator for factor 5 (discretion) assesses intake discretion—how cases are screened prior to court appearance. The indicator distinguishes juvenile courts with greater discretion assigned to staff.

In order to assess the degree to which juvenile courts form interpretable clusters, Stapleton and colleagues selected these five indicators to serve for the five factors in cluster analyses. This procedure ensured the maximum homogeneity within clusters and at the same time minimized the number of clusters because all five variables used to cluster courts were presence/absence dichotomies. Stapleton and colleagues used an agglomerative hierarchical clustering technique (Johnson 1967) and allowed no distance between cases within each cluster. This procedure, which is equivalent to a simple sorting of cases into their different combinations of values on the five dichotomous variables, produced initial clusters. Stapleton and coworkers found a total of twenty-five different combinations of values represented in the data, a number not dramatically smaller than the thirty-two (2^5) logically possible combinations of five dichotomies. Of these twenty-five combinations of values, however, only twelve contained three or more courts. Stapleton and colleagues regarded these twelve as substantively important; thus, thirteen residual clusters and twenty deviant courts were eliminated from further consideration.

The twelve clusters delineated by Stapleton and colleagues supported the received notion that there are two major types of juvenile courts, but they also revealed substantial variation within the two main types and several additional types, as well. Table 15 reports these twelve clusters. Courts in clusters 1 through 4 ($N = 68$) approximate the traditional juvenile court system. These courts combine inclusivity, highly centralized authority, and a low degree of formalization. Courts in clusters 5 and 6 ($N = 7$) were treated by Stapleton and colleagues as a variation of this basic type, the important distinction being that courts in clusters 5 and 6 did not have inclusive jurisdictions. Courts in clusters 7 through 9 ($N = 38$) were considered representative of the decentralized, due process juvenile court—the polar ideal type. In these courts, authority was not centralized and task specificity was high. Courts in cluster 10 ($N = 4$) were treated as a variation of the due process type, similar in most respects to courts in cluster 9. Finally, courts in clusters 11 and 12 were considered to be historical artifacts—the consequence of an atypical regional (mostly New York State) legal system. These last two clusters were not considered representative of either major type and therefore were treated as residual.

Thus, Stapleton and colleagues delineate five aggregate clusters (composed of simple clusters 1–4, 5–6, 7–9, 10, and 11–12) and show that most (82 percent) of the 130 courts examined in the cluster analysis fall at either

TABLE 15: Results of Stapleton and Colleagues' Cluster Analysis

	Structural Dimensions				
CLUSTER NUMBER[a]	SCOPE OF JURISDICTION (*S*)	CENTRALIZATION OF AUTHORITY (*C*)	FORMALIZATION (*F*)	TASK SPECIFICATION (*T*)	INTAKE DISCRETION (*D*)
1 (32)	Inclusive	High	Low	Low	High
2 (16)	Inclusive	High	Low	High	High
3 (7)	Inclusive	High	Low	High	Low
4 (13)	Inclusive	High	Low	Low	Low
5 (3)	Exclusive	High	Low	High	High
6 (4)	Exclusive	High	Low	Low	High
7 (20)	Inclusive	Low	Low	High	High
8 (14)	Inclusive	Low	High	High	High
9 (4)	Exclusive	Low	Low	High	Low
10 (4)	Exclusive	High	Low	High	Low
11 (4)	Inclusive	Low	Low	Low	Low
12 (9)	Inclusive	Low	Low	Low	High

[a]Frequency is given in parentheses.

end of the traditional–due process continuum (in aggregate clusters 1–4 or 7–9). They also identify the key features of both major types of courts. In traditional juvenile courts, the scope of jurisdiction is wide; authority is centralized; and there is a low degree of formalization. In due process juvenile courts, authority is decentralized and task specificity is high. While these two polar types predominate, Stapleton and colleagues show substantial variation within each of these two types, and they show additional types as well. They conclude that bipolar conceptions of juvenile courts, though valuable, are simplistic.

While Stapleton and colleagues' treatment of types of juvenile courts is thorough and convincing, their procedures for transforming the twelve simple clusters (the most frequent combinations of scores) into five aggregate clusters or types do not follow any specific methodological guidelines. Yet the major conclusions of their paper rest on these aggregate clusters, not on the twelve simple clusters pinpointed in the rudimentary cluster analysis. They emphasize the contrast between aggregate clusters 1–4 and 7–9 because these two constitute the two major types—traditional and due process. Yet there are no strong methodological arguments offered for grouping the

simple clusters in this manner. Ultimately, their specification of aggregate clusters rests on a general, theoretically based expectation that at least these two dominant types should emerge.

A BOOLEAN APPROACH TO EMPIRICAL TYPOLOGY. Boolean techniques offer a more structured approach to the construction of empirical typologies. These techniques can be used to compare clusters holistically and to identify their key underlying differences. The goal of Boolean analysis here is to produce aggregate clusters, or types, from the simple clusters reported by Stapleton and colleagues (which resulted from sorting cases into their different combinations of scores). The Boolean approach is appropriate because it provides explicit, logical rules for simplifying complexity. This feature converges with the purpose of empirical typology: to provide a useful shorthand for describing the diversity that exists within a given class of social phenomena. In the Boolean approach, the fully reduced Boolean equation that results from application of the minimization algorithms to a truth table specifies the combinations of characteristics defining each major type. In short, this technique pinpoints essential combinations of characteristics in a way that logically summarizes the diversity displayed in the truth table.

Stapleton and colleagues' twelve clusters (presented above) can be used to construct a truth table, as shown in Table 16. The column headings refer to the five structural variables. The output (E) indicates whether or not a certain combination of features is found in at least three courts. This truth table is a faithful reproduction of the results of Stapleton and colleagues' simple clusters. Stapleton and coworkers used five dichotomies to identify twelve clusters of ju· ·nile courts. They used a frequency criterion of three to distinguish substantively important clusters from unimportant clusters. All that has been added is an output code (1 indicates that the combination of values exists with sufficient frequency to be considered significant by Stapleton and colleagues) and the remaining rows (that is, combinations of values that are infrequent or simply do not exist in the data).

Application of the minimization algorithms presented in Chapters 6 and 7 to this truth table results in the following fully reduced Boolean equation:

$$E(\text{exists}) = Sft + CfT + CfD + ScTD + sfTd$$
$$\text{Type:} \qquad 1 \qquad 2 \qquad 3 \qquad 4 \qquad 5$$

Variable names in uppercase letters indicate that the characteristic is present (1); variable names in lowercase letters indicate that it is absent (0). Multiplication indicates logical AND; addition (+) indicates logical OR. The symbol S indicates inclusiveness of jurisdiction (1 = inclusive jurisdiction); C indicates that authority is centralized (1 = high); F indicates degree of formalization of procedures (1 = high); T indicates task specificity (1 = high); and D indicates intake discretion (1 = high).

The equation delineates five different types of juvenile courts. The first three types overlap to some degree. The first combines inclusive scope with a low degree of formalization and a low degree of task specificity. This type conforms roughly to Stapleton and colleagues' traditional court. Note, however, that this Boolean term embraces not only courts in clusters 1 and 4 but

TABLE 16: Truth Table Representation of Results of Stapleton and Colleagues' Cluster Analysis

	Combination of Values on Structural Dimensions					Output Value (1 = Frequency > 2)
Row	S	C	F	T	D	E
1	1	1	0	0	1	1
2	1	1	0	1	1	1
3	1	1	0	1	0	1
4	1	1	0	0	0	1
5	0	1	0	1	1	1
6	0	1	0	0	1	1
7	1	0	0	1	1	1
8	1	0	1	1	1	1
9	0	0	0	1	0	1
10	0	1	0	1	0	1
11	1	0	0	0	0	1
12	1	0	0	0	1	1
13	0	0	0	0	0	0
14	0	0	0	0	1	0
15	0	0	0	1	1	0
16	0	0	1	0	0	0
17	0	0	1	0	1	0
18	0	0	1	1	0	0
19–32	. . . (remaining terms)					0

S = Scope of jurisdiction
C = Centralization
F = Formalization
T = Task specificity
D = Intake discretion
E = Combination exists

also those in clusters 11 and 12. Stapleton and colleague's traditional type embraced clusters 1, 2, 3, and 4; 11 and 12 were considered deviant. The second type reported in the equation combines centralized authority with a low degree of formalization and a high degree of task specificity. This type covers courts defined by Stapleton and colleagues as traditional (those in clusters 2, 3, and, to a lesser extent, 5) and courts identified as similar to the due process type (courts in cluster 10). The third type is very similar to the second. It combines centralized authority, a low degree of formalization, and a high degree of intake discretion. Courts covered by this type include courts in clusters 1, 2, 5, and 6. These courts were identified as traditional or as similar to traditional courts by Stapleton and colleagues. With the exception of cluster 6, the courts covered by this type overlap with the courts covered by the first two types. (Although types identified in Boolean analysis are often mutually exclusive, this outcome is not automatic.) Thus, the first three types identified in the Boolean analysis appear to be cousins of the traditional type specified by Stapleton and colleagues.

The fourth type combines four elements: inclusive scope, low centralization of authority, high task specificity, and high intake discretion. This type conforms well to Stapleton and coworkers' description of the due process juvenile court and embraces courts in clusters 7 and 8. The last term in the equation also combines four terms. The elements combined—limited scope, low formalization, high task specificity, and low intake discretion—conform very loosely to what Stapleton and colleagues call the felony justice model, a variation of the due process model. Courts in clusters 9 and 10 conform to this type. These two clusters are treated in a residual manner by Stapleton and coworkers.

Overall, the results of the Boolean analysis of the truth table reported in Table 16 are roughly compatible with Stapleton and colleagues' typology, but there is substantial disagreement. First, courts considered by Stapleton and colleagues to be historical artifacts (those in clusters 11 and 12) are shown to conform to one of the Boolean specifications of the traditional court (type 1). Second, the Boolean analysis shows at least two distinct subtypes of traditional courts (types 1 and 2 in the Boolean equation above), as well as a third traditional type overlapping with the first two. Type 1 courts deviate from the ideal-typic traditional court delineated by Stapleton and colleagues in that these courts may or may not be centralized. Type 2 courts deviate by manifesting a high degree of task specificity, a characteristic usually associated with due process juvenile courts. Also, type 2 courts may or

may not be inclusive in scope, a key feature of the ideal-typic traditional court. Type 3 courts, which overlap with type 1 and type 2 courts, also may be either inclusive or exclusive and may or may not have a high level of task specificity. Still, all the clusters of courts conforming to the third type were defined by Stapleton and coworkers as traditional courts or as similar to traditional courts.

The clearest support for Stapleton and colleagues' typology is in the Boolean specification of due process juvenile courts, which included courts in clusters 7 and 8. The elements combined in the fourth type above—inclusiveness, low centralization of authority, high task specificity, and high intake discretion—are all ideal-typic features of due process courts. There is an important incompatibility between the Boolean results and Stapleton and colleagues' typology, however. In the Boolean analysis, cluster 9, a member of Stapleton and coworkers' due process aggregate cluster, is shown to belong to a distinct type. Cluster 9 is grouped with cluster 10 by the Boolean analysis, forming a fifth type.

The Boolean analysis presented above is not entirely satisfactory from a minimization point of view because of the overlap, conceptual and empirical, that exists among the first three types. Furthermore, the analysis also falls short from the perspective of substantive interests because it fails to delineate a coherent traditional type. These shortcomings suggest that the analysis is too fine-grained because far too many types are delineated relative to theoretical expectations. Of course, if the goal of the analysis had been simply to confirm that complexity exists (one of Stapleton and colleagues' goals), then the results are clearly satisfactory. Still, a less fine-grained analysis would be valuable given the expectation in the literature of two main types of juvenile courts.

To produce a less fine-grained Boolean analysis it is necessary simply to alter the frequency criterion used to define substantively important clusters. Stapleton and colleagues use a frequency criterion of three as a cutoff for substantive significance. It easily could be argued that this cutoff is too low, especially considering that slight measurement errors could produce spurious substantive significance. Two of the four courts in Stapleton and colleagues' cluster 9, for example, are included in this cluster "because of measurement error" (Stapleton and others 1982:562). Eliminating these two cases produces a frequency value of two for cluster 9 and a consequent reduction to substantive insignificance.

The frequency data reported by Stapleton and colleagues can be used to

select an alternative cutoff value (see Table 15). Specifically, there is a clear gap in the frequency distribution between four and seven. Using four instead of three as the cutoff changes little. Using seven as the cutoff value, however, reclassifies five clusters (numbers 5, 6, 9, 10, and 11) to false (that is, substantive insignificance). By recoding these rows, the truth table in Table 16 is modified so that only the seven high-frequency clusters are coded true (1). This new truth table can be minimized with the same Boolean algorithms applied to the original truth table.

The results of this second Boolean analysis are

$$E(\text{exists}) = SCf + ScTD + SfD$$
$$\text{Type:} \qquad 1 \qquad 2 \qquad 3$$

These results differ substantially from those reported for the first Boolean analysis. The first type combines inclusive scope, centralized authority, and a low degree of formalization. Courts conforming to this type (those in clusters 1–4) are clearly traditional. The second type combines inclusive scope, a low degree of centralization, a high degree of task specificity, and a high degree of intake discretion. This combination of traits characterizes due process juvenile courts and embraces those in clusters 7 and 8. The third type crosscuts the other two. It combines inclusive scope, low formalization, and high intake discretion. This type covers courts in clusters 1, 2, 7, and 12. The only cluster covered uniquely by the third type is cluster 12, a cluster that Stapleton and colleagues define as residual, a historical artifact.

This last combination of features, however, should be treated as an overlapping type, not as residual. The image suggested by this type is that of a court with a strong social service orientation. Procedures are informal and some violators are offered "relief from the law" at the discretion of the intake staff (see Stapleton and others 1982 : 555). By treating this third type as an overlapping type, it is possible to differentiate subtypes within the first two types. Within the traditional type, for example, courts in clusters 1 and 2 are social service–traditional courts, while courts in clusters 3 and 4 are nonsocial service–traditional courts. The feature of courts in clusters 3 and 4 that precludes them from being classified as social service–traditional courts is their low level of intake discretion. In a similar manner, courts in cluster 7 are social service–due process courts, while courts in cluster 8 are nonsocial service–due process courts. The feature of courts in cluster 8 that excludes them from the social service–due process category is their high level of formalization. Courts in cluster 12 appear to be pure social service courts, lacking both traditional and due process features.

The results presented above showing the different types that exist can be converted to an explicit Boolean statement of the combinations of organizational characteristics that do not exist or are unlikely. To produce this result, it is necessary simply to apply De Morgan's Law to the last equation modeling the three types:

$$E = SCf + ScTD + SfD$$
$$e = s + cd + Ft + FC$$

The first term in the equation shows that juvenile courts with exclusive scope are rare; most courts process all kinds of offenders. This is not a surprising finding; it is obvious from simple inspection of the frequency distribution for this variable. The other terms are more important from the standpoint of organizational theory because they show combinations of structural characteristics that are unlikely in juvenile courts. These unlikely or rare combinations include decentralization combined with a low level of discretion, a high degree of formalization combined with a low degree of task specificity, and a high degree of formalization combined with a high degree of centralization. From an organizational standpoint, it is possible to view these three pairs of features as structurally antagonistic. Generally, these pairs combine traditional features and due process features. This pattern of results reinforces the view of juvenile courts as either traditional or due process. Note, however, that the fourth term in the equation (formalization with centralization) combines classic features of bureaucracies. The fact that this combination of features (which is in line with the expectations of organizational theory) is unlikely in juvenile courts is consistent with the idea that there is a tension in criminal justice systems between the demands of the day-to-day processing of defendants and their rights.

To summarize: Stapleton and colleagues' analysis indicated that the key features of traditional courts are their inclusive scope, their centralization of authority, and their low level of formalization. These are the three features shared by the four clusters of courts they define as traditional. The Boolean analysis of high-frequency clusters confirms this specification of the traditional type. The due process court, according to Stapleton and colleagues, combines a low level of centralization of authority and a high level of task specificity. These are the features shared by courts in clusters 7–9, their due process aggregate cluster. According to the Boolean analysis of high-frequency clusters, due process courts are also inclusive in scope and have a high level of intake discretion. The Boolean analysis indicates further that courts in cluster 9 do not conform well to the due process type. These courts

are exclusive in scope and lack intake discretion. Finally, the Boolean analysis suggests that an overlapping social service type crosscuts the traditional–due process distinction, making it possible to distinguish subtypes of traditional and due process courts.

The Boolean approach to the formulation of empirical typologies offers several distinct advantages. First, it provides explicit procedural rules for identifying types. Second, the Boolean algorithms are logical and holistic in their approach to the task of reducing the complexity represented in the truth table. Third, as shown above, a Boolean analysis can be constructed in a variety of ways—it is flexible. An investigator can choose a finer-grained analysis by selecting a lower-frequency cutoff. A higher criterion value can be chosen if a simpler empirical typology is desired. One apparent drawback of the Boolean approach is that the types identified are not always mutually exclusive. However, this liability can be turned into an additional asset if the investigator anticipates imperfect conformity of cases to types. The empirical world provides many examples of mixed types—cases that combine features of conceptually pure types. Overlapping types identified in Boolean analysis provide a vocabulary for discussing such cases. Finally, using De Morgan's Law, the results of the Boolean analysis can be converted into an explicit statement of structural incompatibilities, a feature which enhances the theoretical relevance of the typology.

With a larger data set, the possibility of interpreting specific cases or categories of cases diminishes. However, the results of the Boolean analyses presented above could be used as a basis for a study of the development of the juvenile justice system in the United States. Most organizations bear the mark of their period of origin (Stinchcombe 1965). It may be that juvenile courts which were formed (or reformed) during the same period are of the same or overlapping types. An investigation of this sort, of course, is far beyond the scope of this brief overview of Boolean techniques of typology construction. It is important to note, however, that the construction of such typologies is rarely the endpoint of an investigation.

LIMITATIONS OF THIS CHAPTER

Currently, mainstream social science methodology favors a predominantly variable-oriented approach to social data, an approach that submerges cases into distributions and correlations. This tendency discourages thinking about cases as wholes—that is, as interpretable combinations of parts. Thus,

from the perspective of mainstream social science, the value of Boolean-based comparative analysis is not readily apparent. To view cases as wholes, however, makes it possible to interpret them as cases and thus reestablishes a link between social science and actual entities. In short, these techniques make it possible to maintain an interest in both social science theory and specific empirical instances of the processes that interest social scientists and their audiences.

The examples of Boolean methods of qualitative comparison presented in this chapter barely scratch the surface of potential applications. The first example contrasts Boolean methods with Rokkan's configurational approach in comparative political sociology. The second applies Boolean techniques to the study of ethnic political mobilization in Western Europe and tests three theories in a way that enhances their interpretive value. The third focuses on the general problem of empirical typologies using data on organizations. Many other applications are possible. The techniques are relevant to any investigation that is oriented toward viewing cases or instances as wholes—as combinations of characteristics.

The illustrations of Boolean methods presented in this chapter have several shortcomings. Some of these shortcomings follow directly from the selection of relatively simple examples, but they also reflect certain limitations of the approach. First, as presented, the techniques are limited to categorical data. This limitation contradicts the current preference in mainstream social science for techniques designed for interval-scale data. As I have noted elsewhere, however, the algorithms described here can be adapted to interval-scale data. These adaptations are not presented because they are complex, and they obscure my primary goal—to demonstrate and formalize the unique features and strengths of qualitative, holistic comparison and begin to bridge the gulf between variable-oriented and case-oriented research.

The second shortcoming is related to the first. A variety of statistical techniques specifically designed for categorical data and the analysis of complex statistical interaction have been introduced in the social sciences over the last decade. These include log-linear models, logit and probit models, and logistic regression (see Fienberg 1985). This chapter does not address the relation between these techniques and Boolean methods. In general, these statistical techniques require large numbers of cases, especially when statistical interaction is examined. The Boolean methods are designed specifically for analyses involving limited numbers of cases. Moreover, when examining statistical interaction these techniques approach the problem hierar-

chically. Thus, they are biased toward simpler models (a characteristic that many researchers find desirable). Boolean techniques, by contrast, start by assuming maximum complexity. These statistical techniques are further incapacitated by highly collinear interaction terms—when two interaction terms of the same order, for example, explain the same section of variation in the outcome variable. Boolean techniques do not share this liability. Yet even when statistical techniques successfully identify higher-order interaction, it is sometimes difficult to locate it in specific cells or sets of cells in a multiway cross-tabulation. Boolean techniques provide a direct route to this identification and provide a basis for contrasting specific theoretical expectations with specific patterns of interaction. This characteristic suggests a possible future direction: Boolean techniques and these statistical techniques might be usefully combined in studies with large numbers of observations. A preliminary analysis contrasting Boolean techniques and logistic regression has been presented elsewhere (Ragin and others 1984).

Third, the examples emphasize the compatibility of Boolean methods with the goal of interpretation; yet none of the examples takes on the task of interpreting specific cases or historical processes. This restriction exists primarily because of space limitations but also because extensive interpretation of cases (in the discussion of ethnic political mobilization, for example) would detract from the main goal of the work—to address methods of qualitative comparison.

The fourth shortcoming concerns the fact that the examples presented start with truth tables. In actuality, one of the most demanding aspects of the qualitative comparative approach is the construction of useful truth tables. A great deal of intellectual energy must be devoted to selecting appropriate causal variables and studying individual cases before a worthwhile truth table can be constructed.

Fifth, the examples presented are relatively static. This feature contradicts the emphasis on Boolean analysis as an aid to comparative *historical* analysis. Note that it is possible to include causal variables relevant to historical process in a truth table (such as "class mobilization preceded ethnic mobilization," true or false?) and to analyze combinations of such dichotomies. This strategy would enhance the usefulness of Boolean techniques as aids to comparative historical interpretation. It is also possible to investigate comparable outcomes in a single case (such as the causes of regime changes in a single, coup-ridden Third World country) or to pool comparable outcomes in a single country with those of comparable countries (such as the causes of

general strikes in several Western European countries). Characteristics specific to historical periods can be included as causes in the analysis of comparable events, both within and between cases.

The final chapter summarizes the special strengths of Boolean methods of qualitative comparison.