Gauging the *Import* and *Essentiality* of Single Conditions
in Standard Configurational Solutions

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Abstract. Standard Qualitative Comparative Analysis is especially suited to explain diversity but is often diagnosed with weak findings. Its protocol either can dismiss necessary conditions as irrelevant and make solutions that are untrue to observations, or add irrelevant conditions as causal and make incorrect solutions. Additionally, the algorithm may not recognize the functional dependencies among conditions. These claims call for different gauges to assess the nature of the single conditions that are retrieved by Standard minimizations. This article develops "import" and "essentiality" to establish whether a condition has explanatory merit alone and within the wider model. When applied in prominent studies, these gauges indicate that Standard solutions are more sound than is often conceded.

Keywords. Configurational models, homogeneous partitions, INUS Conditions, Non-probabilistic populations, Standard Qualitative Comparative Analysis.

Introduction

Capital accumulation, industrialization, urbanization, and education are the steps of the path along which democracies have historically been proven to thrive. Alone, however, these "social requisites" cannot guarantee the survival of a political regime: Endurance also requires stable institutions (Lipset 1959). The theory has a configurational nature and qualifies for Qualitative Comparative Analysis (QCA). The related hypothesis expected the survival of democracy in interwar Europe in *wealthy*, *industrialized*, *urbanized*, *literate* social systems with *stable* governments (Berg-Schlosser and De Meur 1994, Rihoux and De Meur 2009). The results brought forth a discomforting puzzle: Although *literate* was a condition shared by all the survived democracies, it was dismissed as irrelevant.

The phenomenon was diagnosed as a consequence of minimizing the observed and unobserved configurations with the Quine McCluskey algorithm. "Empirically necessary" conditions can disappear when the number of unobserved configurations is high and any of them can be used as counterfactuals to enhance the parsimony of solutions. To make Standard results truer to observations, Ragin and Sonnett (2004; Ragin 2008; Schneider and Wagemann 2012, 2013) established criteria to identify implausible unobserved configurations and procedures to remove them. As minimizations with "easy counterfactuals" restored all the necessary conditions in findings, "intermediate" solutions were recommended for discussion. Nevertheless, Baumgartner (2008, 2009) and Baumgartner and Thiem (2015, 2017a, 2017b) considered that plausibility concerns can lead to mistaking irrelevant conditions for causal, while the "row dominance" entailed in the algorithm prevents the full retrieval of functional dependencies and of the "true causal structure". The debate has contributed to questioning the capacity of Standard Analysis to yield credible findings.

This article advances two tests to assess whether Standard solutions include set-theoretic irrelevant conditions or dismiss empirically relevant ones. It understands the set-theoretic relevance of a condition as its power to partition the heterogeneous instances of the outcome from a population into homogeneous subpopulations. Because this power may or may not be independent of the wider conjunct, two gauges are defined: "Import" establishes whether the uncontrolled condition alone can identify at least one homogeneous partition of the instances of the outcome; "essentiality" reveals whether the explanatory conjunct loses its capacity to homogeneous partition without

the condition. These gauges' application to renowned studies shows the mistrust of the Standard protocol may prove fairly unjustified.

As a matter of clarification, this article understands Standard QCA as a theory-driven comparative method for ascribing configurational explanations in observational studies. Consistently with the related literature (Ragin 1987, 2008; Thomann and Maggetti 2017; Goertz 2017; Rohlfing 2012; Schneider and Wagemann 2010; Befani, Ledermann and Sager 2007; Elman 2005; Amenta and Poulsen 1994; Sartori 1991; Cartwright 2001; Salmon 1998; Verba 1967), it stipulates that credible explanations are the nonredundant, meaningful conjuncts of "right" conditions under which the outcome occurs. It maintains that a conjunct properly explains a subpopulation if it applies to each of its cases. It considers that empirical tests of the explanatory power of conjuncts in observational settings entail a meaningful scope condition and that the time-space specifications of this scope condition define the boundaries of the validity of the findings. Within such a design, this article holds Standard QCA can (*a*) assess the explanatory power of a conjunct and (*b*) ascribe conjuncts to single cases. It considers the first aim is achieved when the starting hypothesis yields a noncontradictory truth table. It considers the Quine-McCluskey algorithm suits the latter aim in observational studies due to its focus on invariant patterns: Because its minimizations identify same configurations to the same outcome, its comparisons do not require the assumption of instances' background homogeneity. This suitability, however, cannot exclude Standard QCA from yielding more general or more specific solutions than the cases at hand would justify.

Technically, this article adopts a Standard QCA lexicon and notation (Ragin 2008, Schneider and Wagemann 2012; Duşa 2018) with minimal adjustments. The explanatory conditions and outcomes are each a single property-set of which cases are instances from a population $\mathcal{P}$. $\mathcal{M}$ indicates a model in which whole conditions are elements. Conditions are always binary in nature; unless otherwise specified, slanted uppercase (X) denotes presence and slanted lowercase (x) denotes absence, while bold standard letters (**X**) indicate their whole independent of gauge and state. Subscript i means the condition is instantiated by the i-th observation from the population $\mathcal{P}$. A dot ($\cdot$) or no sign signals set intersection and Boolean conjunction, a plus sign ($+$) indicates set union and Boolean disjunction, and a backslash ($\backslash$) represents a set difference and complement in disjuncts. Configurations are intersections and conjunctions; the configurations that are listed in a truth table are "primitive" statements of sufficiency. A configuration is "positive" when it defines a homogeneous set of instances of the

presence of the outcome, is "negative" when it defines a homogeneous set of instances of the absence of the outcome, and is "contradictory" otherwise. Stars ($*$) represent the unobserved configurations in $\mathcal{P}$. Arrows ($\rightarrow$) indicate a set relationship and always point toward the superset. Finally, "N-cons" and "S-cons" are used as short labels for the Standard parameters of the consistency of necessity and sufficiency, respectively.

1. The Standard protocol and its limits

Standard QCA finds its first analytic momentum in the construction of the truth table (Schneider and Wagemann 2012). When the instances of the outcome are assigned to their matching primitives, these primitives become observed. Saturated truth-tables are a rare occurrence; more often, they display "limited diversity" as a gap between possible and observed primitives. Descriptively, this gap exposes the special ordering that causation imparts to diversity while unfolding in the real world. Ascription, however, may weaken if unobserved diversity is not treated properly (Ragin 2008). Disappearing necessary conditions proved this issue relevant to early QCA.

In its first version, the protocol allowed the Quine McCluskey to yield two types of solutions, namely, the "complex" and the "parsimonious", by minimizing unobserved configurations under the two opposite assumptions that either none or any of them could have produced the outcome if they were observed (Ragin 1987, 2000). Empirically necessary conditions were always retrieved under the former assumption, whereas some necessary conditions disappeared under the latter. Ragin and Sonnett (2004; Ragin 2008) and then Schneider and Wagemann (2012) maintained unconvincing results depend on the use of unobserved configurations: Parsimonious minimizations assume that all unobserved configurations are equally plausible, although this may not always hold true.

Plausibility has a special meaning in Standard QCA due to the particular rationale of the method as embodied in the Quine-McCluskey algorithm. Minimizations do not ascertain the *ceteris paribus* covariation of a factor and an outcome in a causally homogeneous sample; instead, they pinpoint the invariant parts of explanatory complexes across dissimilar cases with outcome of the same kind. The focus on invariance compels a definition of plausible counterfactuals as the unobserved configurations that *would* have led to the outcome if they were observed. Consistently with the theory-driven nature of the method, Ragin and Sonnett (2004) maintain that plausibility claims in Standard QCA rest on "directional expectations". Before minimizing, the researcher establishes the state under which a condition is expected to

contribute to the outcome. Thus, if the theory states that *A* contributes to *Y*, then the unobserved configuration *aBC** is an implausible match with the observed configuration *ABC* because it entails that in a hypothetical "twin" world *BC* would have generated *Y* under *a*. Once the implausible counterfactuals are barred from the minimizations, the Quine-McCluskey algorithm retrieves the disappearing conditions (Ragin 2008). As the process to the "intermediate solution", the minimization with plausible counterfactuals has become an integral part of the Standard protocol.

Schneider and Wagemann (2012, 2013) developed the plausibility principle further. They noted how directional expectations cannot ensure that each and every counterfactual is used non-contradictorily, in a way that does not embody any logical impossibility, so that the findings are perfectly true to the observations. Their Enhanced Standard Analysis (ESA) identifies the different nature of each logical remainder and establishes consistent minimization rules for each type. Applications have shown the ESA yields different parsimonious solutions but the same intermediate results as the Standard Analysis. This conclusion suggested the solutions from plausible minimizations are robust and, therefore, the credible findings to discuss.

The stances that disappearing necessary conditions indicate weak ascription and that plausible Standard solutions are more credible than parsimonious solutions have been questioned by Baumgartner (2008, 2009) and Baumgartner and Thiem (2017a, 2017b) in the light of a different epistemology. To them, configurational analysis is for retrieving the "true causal structure" to some effect and leaves no room for counterfactual reasoning: Observed configurations alone provide evidence that some conjunct obtains in the real world, whereas logical remainders are, "notwithstanding their truth, not amenable to a causal interpretation" (Baumgartner 2008:332, Baumgartner and Thiem 2017a). As observed configurations are redundant portrayals of these structures, a "correct" ascription still requires minimizations, although different from Standard QCA. Because the Quine-McCluskey minimizations may not report those implicants that are perfectly "dominated" by other solution terms, Standard QCA would fail to detect all the possible causal paths and the true structure of causation when causal factors are chained (Baumgartner and Thiem 2017a:967). Moreover, plausibility considerations may impart a confirmation bias in intermediate Standard solutions. The algorithm of the Super-/Sub-set analysis, instead, correctly yields all the implicants to an outcome, although its results are "fragmented" and "insufficient to warrant any causal inference" (Baumgartner and Thiem 2017b:5). As the Super-/Sub-Set analysis

also retrieves the parsimonious Standard solutions, however, this scholarship maintains the latter are the only findings that qualify for discussion.

The debate has made the Standard solutions seem seriously flawed. It may always be the case that the protocol yields biased results or results that are untrue to observations, and that the algorithm cannot recognize the functional dependencies among conditions. However, how can we know that the Standard solutions are flawed, independent of the minimization algorithms?

2. Criteria for assessing the merit of single conditions

To establish whether the parsimonious or the plausible minimizations are truly defective, we require some foundational criteria against which the nature of single conditions in configurational solutions can be assessed. The literature agrees the ideal configurational model is an Unnecessary yet Sufficient complex of Insufficient yet Necessary conditions (INUS: Mackie 1965; Ragin and Strand 2008; Baumgartner 2008; Schneider and Wagemann 2010, 2012). The common textbook example refers to fire. The outcome is generated by the chemical process of combustion that unfolds under four conditions: the presence of oxygen (O), fuel (F), and heat (H) as well as the absence of fire suppressors (s). When jointly given in a context, the four conditions are always enough to obtain the reaction: therefore, the conjunction $OFHs$ is a "Sufficient" complex. Nevertheless, it is not always the case that these conditions are jointly given; therefore, $OFHs$ is an "Unnecessary" complex. Moreover, each condition is "Insufficient" because it cannot obtain unless all the other components are given in the same context; and each condition is "Necessary" because the complex cannot obtain if the condition is given in the "wrong" state.

The INUS understanding of configurational causation has interesting epistemic consequences. Without bringing the suppressors into the picture, the fire model classifies as instances of the incomplete configuration OFH both those cases where the short circuit burned the house down and those twin cases where it did not. More generally, a complete INUS model sorts all the instances of the outcome into homogeneous subpopulations; to the contrary, when an INUS element is omitted, the model loses explanatory power and contradictions arise (Rihoux and de Meur 2009).

The explanatory significance of contradictions is recognized by any technique in the configurational family. The scholarships agree with Ragin (1987, 2008) that a

condition or a complex W is sufficient to an outcome Y in $\mathcal{P}$ when it arranges the instances of the outcome such that the distribution jointly satisfies the criteria of

co-occurrence: $\qquad W_i Y_i \neq \emptyset \qquad$ [R1]

variation: $\qquad w_i y_i \neq \emptyset \qquad$ [R2]

noncontradiction in sufficiency: $\qquad W_i y_i = \emptyset \qquad$ [R3]

Co-occurrence as in [R1] requires that in $\mathcal{P}$ at least some of the instances of the outcome are also instances of the condition. The criterion makes room for equifinality as the possibility that alternative conditions or complexes explain the outcome. Variation as in [R2] was especially emphasized by Goertz (2006) to disprove **W** is a trivial constant: The conditions that violate it only inflate the truth table with inert components and deserve dismissal. Finally, noncontradiction as in [R3] maintains that W is sufficient if it is never observed when the outcome is absent. Such a "negative existential claim" (Baumgartner 2009) is fundamental to establish the direction of causation. As this claim can only be proven in closed populations, it entails a scope condition for case selection and confines the validity of the findings within the related space-time region. When satisfied, however, noncontradiction ensures that W "makes a difference" to the instances of the outcome in $\mathcal{P}$ because it unravels heterogeneity into homogeneous classes.

The agreement on these criteria, and especially on [R3], is entailed by all configurational streams assessing sufficiency with the same parameter of fit. S-cons gauges how perfect the relationship is as the ratio of instances of W that are also co-occurrences. When [R3] is satisfied, all the co-occurrences are a subset of the set of the instances of the outcome, and the parameter gets the value of 1; the more the violations to [R3], the lower the fit. A long-standing convention (Ragin 1987) maintains that sufficiency is acceptably established for S-cons values that are higher than 0.75, although the default option implemented in the many versions of Ragin's software (fsQCA: Drass and Ragin 1992, Ragin and Davey 2016) raises the bar to 0.80. With crisp scores, these cutoffs allow the claim that **W** is sufficient if ¼ or ⅕ of the instances of W contradicts the relation, which provides a fairly relaxed standard for establishing the INUS nature of a factor. However, the convention has become popular as a fair treatment of the analysis with fuzzy-scores.

Fuzzy scores are meant to refine and enrich the original binary mapping of the conditions. Given $\mathbf{W}$, fuzzy scores still indicate whether case i is a positive ($\mathbf{W}_i > 0.5$) or a negative ($\mathbf{W}_i < 0.5$) instance of it and therefore retain the information regarding a categorical "difference in kind". Moreover, the reliance on log odds in the direct method of calibration (Ragin 2000, 2008) indicates that fuzzy scores quantify the degree of certainty that a case is an instance of a condition as its "classification error". The certainty of classification is null and the error is highest when $\mathbf{W}_i = 0.5$; certainty is full and the error null both when $\mathbf{W}_i = 1.0$ (which indicates that i certainly is an instance of W) and when $\mathbf{W}_i = 0.0$ (because such an i is certainly not an instance of W). This measurement impresses a rotation to the analytic space that slightly changes the understanding of sufficiency. Fuzzy scores translate subset relationships into inequalities so that sufficiency occurs when $\mathbf{W}_i < \mathbf{Y}_i$. The S-cons formula, then, treats any instance that falls below the bisector $\mathbf{Y}_i = \mathbf{W}_i$ as inconsistent to sufficiency. This formula cannot clearly know inconsistencies in degree from inconsistencies in kind, although only inconsistencies in kind signal a contradiction (Rubinson 2013). As a consequence, with fuzzy scores, even under a relatively demanding S-cons of 0.85, a contradictory condition or complex can be mistaken for sufficient, and this risk increases with the numerosity of the population. Nevertheless, an S-cons higher than 0.75-0.80 and an N-cons higher than 0.90-0.95 have become the norm of reference for assessing the local explanatory power of both complexes and single conditions in Standard Analysis and in Super-/Sub-Set analysis (Ragin, 1987, 2000, 2008; Goertz, 2006; Schneider and Wagemann, 2012; Baumgartner and Thiem, 2015, 2017). Instead of providing a yardstick to assess the bias in the results of Standard QCA, this usage of Ragin's parameters of fit adds to the concerns that Standard solutions may be flawed, and calls for a different measure of noncontradictoriness.

3. Introducing import and essentiality

A faithful gauge of INUS conditions renders the requisite of noncontradiction in sufficiency as the capacity to ensure that all the instances of the outcome in $\mathcal{P}$ are clustered into homogeneous partitions. This capacity can be assessed through a forward and a backward strategy. Forward is observed when the condition can isolate at least one homogeneous subpopulation from $\mathcal{P}$ when applied alone. Backward is established as the increase in the heterogeneity of the subpopulations in a truth table once the condition is dropped from the starting model. In the following, the forward assessment

will be referred to as the "import" of a condition, while the backward strategy defines its "essentiality".

The main differences from the Standard parameters rest on import and essentiality being based on numerosity instead of membership, and on them being calculated on the whole of $\mathcal{P}$ instead of subpopulations of only positive or negative instances. The choice is compelled by the need to assess the "ordering power" of a condition as a whole (**W**) instead of a special state (W separate from w). Import and essentiality, therefore, do not substitute Ragin's parameters in assessing sufficiency. Their aim is diagnostic instead, to detect the ordering power of single conditions within and before the overall model independent of minimizations, and to assess the nature of the components of Standard solution terms.

3.1. Import

This measure rests on the number of instances sharing the same kind of outcome that a condition singles out of a naturally heterogeneous population. The actual operation is almost banal.

Let:

- $\mathcal{M}$ be a model to explain **Y** by k conditions in a population $\mathcal{P}$ of $\mathcal{N}$ instances;
- **X** be the k-th explanatory condition in $\mathcal{M}$; and
- $m_\mathbf{X}$ be a submodel of $\mathcal{M}$ such that $m_\mathbf{X} = \{\mathbf{X}\}$.

$m_\mathbf{X}$ sorts the instances in $\mathcal{P}$ into two clusters — both, none, or one of which can be homogeneous with respect to **Y**. Therefore, let:

- $\wp_\mathbf{X}$ be the overall subpopulation of the homogeneous instances that are generated by $m_\mathbf{X}$ and
- $n_\mathbf{X}$ be the numerosity of $\wp_\mathbf{X}$.

The import of **X** in $\mathcal{P}$ ($imp_\mathbf{X}$) is then given by the following ratio:

$$imp_\mathbf{X} = \frac{\text{numerosity of the homogenous subpopulation } \wp_\mathbf{X}}{\text{numerosity of } \mathcal{P}} = \frac{n_\mathbf{X}}{\mathcal{N}}$$

The index can take any value between 0.00 and 1.00. The highest score proves a condition is necessary and sufficient to the outcome, as its partitions order the population in two homogeneous subgroups. To the contrary, the index's lowest score proves the condition alone has no ordering power in $\mathcal{P}$.

3.2. Essentiality

Imp$_\mathbf{X}$ can improve our knowledge of the explanatory power of single conditions but does not capture the configurational sense of it. The other side is decided by the contribution of single conditions to a noncontradictory truth table. **X** proves essential to the model if its removal results in higher truth table heterogeneity. Essentiality can therefore be gauged as the difference in the number of instances in contradictory primitives between the full model and the same model without this condition.

More precisely, if we let:

- $\mathcal{M}$ be the model that explains **Y** with k conditions in the population $\mathcal{P}$ of $\mathcal{N}$ instances,
- $\mathcal{Q}$ be the heterogeneous subpopulation of the instances from the contradictory primitives in $\mathcal{M}$,
- **X** be the k-th explanatory condition in $\mathcal{M}$,
- $m'_\mathbf{X}$ be a submodel of $\mathcal{M}$ such that $\mathcal{M} \setminus m'_\mathbf{X} = \{\mathbf{X}\}$,
- $q'_\mathbf{X}$ be the subpopulation of the instances from the contradictory primitives in $m'_\mathbf{X}$,
- $q''_\mathbf{X}$ be the difference $q'_\mathbf{X} \setminus \mathcal{Q}$, and $n''_\mathbf{X}$ its numerosity,

then the essentiality of **X** (*ess*$_\mathbf{X}$) reads as follows:

$$ess_\mathbf{X} = \frac{\text{numerosity of the heteroheneous subpopulation from } q''_\mathbf{X}}{\text{numerosity of } \mathcal{P}} = \frac{n''_\mathbf{x}}{\mathcal{N}}$$

Again, the index spans from 1.00 to 0.00. The ratio is null when the dropped condition is nonessential, because the number of instances in the contradictory primitives does not increase, and n''_X is 0.00. The index takes the value of 1.00 when the only necessary and sufficient condition is dropped so that $n''_X = \mathcal{N}$ and the entire population becomes heterogeneous.

3.3. The relationship between import and essentiality

Were $\mathcal{M}$ made of INUS factors only, and each INUS factor modeled at the proper level of abstraction (as are "heat" or "fuel"), the forward and the backward power of single conditions would align. However, we may have an interest in modeling the INUS factors at a lower level of abstraction (as "short circuits" and "unattended stoves" or "towels" and "oil"), and may mistake some conditions for causal in the process. Therefore, the reasonable default expectation shall rather maintain that import and essentiality do not align.

All the logically possible types of conditions can be found in a given model: essential and important, essential although unimportant, important although inessential, and unimportant and inessential. However, only the essential qualify as truly INUS conditions in $\mathcal{P}$, because essentiality proves that they are required for noncontradictory truth tables — that is, they are required for $\mathcal{M}$ to satisfy [R3]. Thus, we may consider configurational solutions:

(1) are seriously flawed if they cannot retrieve all the essential conditions, independent of their import;

(2) retain explanatory validity when they include important although inessential conditions.

The case that

(3) unimportant and inessential conditions are added to the explanation

would instead contribute to the doubts on the credibility of the results — unless a good reason can be provided for their retrieval.

4. Assessing the explanatory validity of Standard solutions

Import and essentiality can identify the nature of the conditions from different solutions and adjudicate on the relative flaws of the Standard Analysis. In the following section, such an assessment will comprise the results from two renowned studies: the configurational application of Lipset's theory to explain the survival of democracy in the interwar Europe, and the mechanism of shame in explaining governments' compliance with international fishery regimes.

4.1. The survival of democracy in the interwar Europe

According to the Standard protocol, the reliance on plausibility constraints in minimizations is mainly justified by the disappearing of necessary conditions, which makes the results untrue to the observations. The textbook example remains Lipset's hypothesis as applied by Berg-Schlosser and De Meur (1994) and Rihoux and De Meur (2009). With five conditions to gauge *wealthy* (*W*), *industrialized* (*I*), *urbanized* (*U*) and *literate* (*L*) social systems with *stable* (*S*) governments, the model generates 32 primitives of which the selected cases leave 23 unobserved, as displayed in Table 1(*a*).

– TABLE 1 –

As Table 1(*b*) shows, the consistency scores of individual conditions indicate that *L* is as necessary to *Y* as are *W* and *S*. Nonetheless, parsimonious minimizations drop it from the solutions to the positive outcome $WS \rightarrow Y$. When conditioned to the directional expectations that each condition contributes to the survival of democracy when present, the minimizations restore *L*, and the plausible solution reads $WSL \rightarrow Y$.

– TABLE 2 & TABLE 3 –

The new gauges attest that the puzzle of the disappearing condition does not depend on any forward ordering power. Table 2 again finds **W**, **L**, and **S** as the only factors with import in the model. From Table 3, however, we learn **W** and **S** are the only essential conditions that together can account for the entirety of $\mathcal{P}$'s diversity. The reason is the import of **L** depends on the subpopulation $\wp_L$, which clusters Greece, Italy, Portugal, Romania and Spain – all experiencing the breakdown of their democracies between the two World Wars, as displayed in Table 2(d). As Table 3(d) shows, all of these negative instances can be accounted for by the conjunctions of the remaining conditions.

From the analysis of the positive outcome, we learn that conditions with a N-cons value of 1.00 are important yet may disappear when the instances that confer them their sorting power can be ordered by the remaining essential conditions. The assessment also proves that the parsimonious minimizations have correctly retrieved from $\mathcal{M}$ all and only the essential conditions to *Y* in $\mathcal{P}$, while the plausible minimizations have restored in solutions the "important although inessential" conditions.

When we run the Standard Analysis of the negative outcome, however, we find that the parsimonious solution reads $s + w \rightarrow y$ but that plausibility constraints specify the result as $s + wui \rightarrow y$. Thus, here again the parsimonious minimizations retrieve all and only the essential conditions, whereas the plausible minimizations add to the essential term *w* two additional factors, *u* and *i*, although none of them has proven import.

The truth table provides the explanation for the retrieval of these unimportant conditions in Standard plausible solutions. Table 1(*a*) shows that in the primitives to the negative outcome from *(04)* to *(07)*, when **W** is absent, **I** and **U** are also absent. The unreported calculation of the consistency scores of *i* and *u* proves that they are fully necessary to *w*. Therefore, *i* and *u* are "co-invariant" conditions with the essential term *w* that have survived the plausibility test. Plausibility constraints emphasize that low

national wealth implies low urbanization and low industrialization in the negative cases at hand — a hardly surprising specification considering development theory but a fairly surprising specification considering the shared tenet that the Quine-McCluskey algorithm cannot recognize functional dependencies.

4.2. Shame and compliance with international regimes

A further illuminating example comes from Stokke's analysis on the role of shaming in governments' compliance with international fishery regimes. The original model renders the hypothesis that shaming can improve compliance "by exposing certain practices to third parties whose opinion matters to the intended target of shaming" (Stokke 2007:503). The analysis then focuses on the conditions under which noncomplying governments changed their behavior in response to shaming pressures.

The model pinpoints two factors that relate to regime design: *advice* (**A**), which gauges "whether the shamers can substantiate their criticisms by referencing explicit advice by the regime's scientific body"; and *commitment* (**C**), which captures "whether the target behavior violates commitments assumed under the regime." Three additional conditions are instead related to the direct institutional environment of the government: *inconvenience* (**I**) models the costs of compliance; the *shadow of the future* (**S**) indicates the perceived risk that shame will bring the government into international disrepute as a partner; and *reverberation* (**R**) refers to the shame that is echoed by strong domestic constituencies and that can undermine the voters' support of the government. The model is tested on a population of nine regimes that were implemented since the 1970s in the three regions of the Barents Sea, Northwest Atlantic, and Antarctic. The data generate a truth table of 32 primitives, only 8 of which are observed as displayed in Table 4(*a*).

-- TABLE 4 --

The Standard Analysis of individual consistency as in Table 4(*b*) pinpoints two individually necessary conditions: **A**, for which it is true that $A \leftarrow Y$ and $a \rightarrow y$; and **I**, for which it holds that $i \rightarrow Y$ and $I \leftarrow y$. Standard parsimonious minimizations to the positive outcome retain **I** and rule out **A** from the positive solution $i + SR \rightarrow Y$. Under the directional expectations that all conditions contribute to compliance when present with the exception of *inconvenience*, which must be absent, the Standard plausible minimizations bring **A** back and yield $A(i + SR) \rightarrow Y$.

The analysis of the positive outcome again begs the question of why, despite similar individual consistency scores, the Quine-McCluskey algorithm retrieves **A** under plausible assumptions only while **I** already appears in the parsimonious solutions. If we address the puzzle from the angle of ordering power, from Table 5 we again learn that the different treatment does not follow from import, because both **A** and **I** have it. Instead, the two conditions display different essentiality: Table 6 shows the explanatory capacity of the model is independent of **A** and highly dependent on **I** — without which contradictory configurations arise that cover four of the nine instances.

– TABLE 5 & TABLE 6 –

Table 5 highlights the import of **A** depends on two negative instances (lh and k1 in the table), which can be handled by the essential conditions **S**, **I**, **R**. What justifies the dismissal of A under parsimonious rules, and its retrieval under plausibility rules, again follows from its "co-invariance" with the essential compound. If we go back to Table $4(a)$, we see that A is constant across all the positive primitives, and it is easy to calculate that it is fully necessary to both solution terms i and SR.

The minimizations to the negative outcome arise a similar puzzle, although regarding a sufficient condition. Please note that the model generates an ambiguity in minimization: the prime implicant chart indicates sI and sR are alternative solution terms from the same primitives, although sR covers only one instance (m2 in the table) that can also be explained by sI. For the sake of brevity, sI only is considered in the following. Therefore, the parsimonious solution reads $I(r + s) \rightarrow y$, whereas the plausible minimizations find that $I(r + cs) \rightarrow y$. The puzzle arises because of **C.** Plausibility requires it in one term of the negative solutions although our gauges say it is an inessential element in the model which, moreover, also lacks import. Nevertheless, Table $4(a)$ again shows c is "co-invariant" with the essential component s. As easy calculations can prove, the absence of **C** is perfectly necessary to Is in the cases at hand.

Strictly speaking, the entire population's diversity can therefore be explained by the sole essential conditions **S**, **I** and **R**, which the parsimonious minimizations identify correctly. However, A maintains a perfect set-relationship with both the essential terms of the positive solution and c with one essential term of the negative solution; thus, the plausible minimizations retrieve them regardless of their essentiality, and of their import, as functionally dependent conditions on the essential terms.

5. Final considerations

The article has assumed that, although suitable for refining and ascribing an explanation, the Standard usage of the Quine-McCluskey algorithm may yield flawed solutions. Configurational scholars have recognized that the free use of unobserved configurations as counterfactuals in minimizations may prevent the retrieval of all the explanatory factors, especially when they are linked in functional dependence, whereas conditioning solutions to considerations of plausibility may lead to mistaking irrelevant conditions for causal.

To ascertain whether the Standard protocol really fails to ascribe causation properly, this article builds on the homogeneity of the subpopulations generated by an explanatory model as the test that the model "holds true". When applied to single conditions and understood as the capacity to unravel heterogeneity and prevent contradictions, homogeneity signals that a condition has import when applied alone and is essential with respect to the model.

Import and essentiality are not gauges for ascription. More basically, they assess whether the conditions in the solutions are all and only required to provide a consistent and valid causal story that applies to all the cases at hand. For the claim of explanatory validity to hold true, this article established that Standard solutions had to retrieve all and only the essential conditions, while important yet inessential conditions were the expected additions under plausibility restraints, and unimportant inessential conditions would signal the inability of the Standard protocol to yield sound results.

First applications show that, indeed, the Standard parsimonious solutions always and only include the essential conditions. Standard plausible solutions instead retrieve conditions beyond their import, when they "co-unvary" with the essential explanatory terms. Thus, plausible minimizations prove vulnerable to "spurious co-invariance"; at the same time, they retrieve the conditions that are implied by their joint essential term. This result suggests that high limited diversity does not affect the credibility of the parsimonious findings, and that plausible minimizations can detect functional dependencies as overlapping subsets. Essentiality and import thus give further meaning to the distinction between "core" and "peripheral" conditions in solutions (Fiss 2011): The core conditions coincide with the essential factors, and the peripheral conditions converge with the related dependencies. If only the core conditions qualify as proven INUS conditions, the peripheral conditions still are of interest to researchers as the possible catalysts of the essential chemical reaction.

However, *imp* and *ess* can do more than test the explanatory merit of the solutions in Standard configurational studies. They can also suggest the existence of latent compounds within the starting model, which is of interest to the research agenda on necessary conditions (e.g., Rohlfing 2012; Schneider 2008). A latent compound can be detected among conditions that maintain de Morgan's relationships across solutions so that they can be "compressed" into single super-conditions with higher individual explanatory power (Elman 2005; Berg-Schlosser and De Meur 1994, 2009). The existence of such latent compounds can be anticipated when the starting model includes conditions that qualify as essential yet lack import, as is the case of conditions **S** and **R** in Stokke's model.

Recall from Tables 4 and 5 the Standard parameters and import scores agree that neither the *shadow of the future* nor the *reverberation* of shame from important domestic constituencies can order the instances of failure and success of shaming when they are used alone. Nevertheless, essentiality scores in Table 6 prove they are required for a noncontradictory explanation of the cases at hand, together with the essential and important condition of the *inconvenience* from the high costs of compliance. In short, essentiality suggests that **S** and **R** constitute functional complements. The parsimonious Standard solutions corroborate this suggestion: SR provides a path to successful shaming, while $s + r$ is its de Morgan complement that leads to ineffective shaming when the inconvenience from complying is high. If the two are "compressed" into a single super-condition that only allows the conjunction of their presence and the disjunction of their absence, the new condition should prove essential and important, and its backward capacity be aligned with its forward capacity.

When the single factor **K** is computed such that $K = SR$ and $k = (s + r)$, Table 7(*a*) indeed shows that k is necessary to failure, while K is sufficient to success; moreover, Table 7(*b*) indicates that **K** has import on **Y**. Table 8 reports the effects that streamlining has on the analysis. When model $\mathcal{M}_1 = \{\mathbf{A}, \mathbf{C}, \mathbf{I}, \mathbf{K}\}$ is used instead of $\mathcal{M} = \{\mathbf{A}, \mathbf{C}, \mathbf{S}, \mathbf{I}, \mathbf{R}\}$ to explain **Y**, the number of the possible primitives lowers from 32 to 16; nevertheless, submodel $m'_{1\mathbf{A}}$ in Table 8(*a*) and submodel $m'_{1\mathbf{C}}$ in Table 8(*b*) show that the *essentiality* of **A** and **C** is still null. The creation of **K** mostly affects $m'_{1\mathbf{I}}$; as displayed in Table 8(*c*), a lower number of primitives improves the essentiality of **I**, without which now five instances of the nine cannot be classified properly. The same degree of essentiality is displayed by **K** in Table 8(*d*).

The gauges confirm that **K** is both an important and essential condition to **Y**. Its usage, however, has consequences on the plausible Standard solutions to the negative outcome. Table 9 makes clear the compression of **S** and **R** into **K** meaningfully modifies the observed diversity of the negative instances. All the instances of y are now contained in the primitives (*05*) to (*07*) across which condition **C** does not preserve its invariance anymore — therefore, should never be retrieved as a plausible catalyst. Indeed, it is easy to calculate that the parsimonious minimization of $\mathcal{M}_1$ still explains the positive outcome as $i + K \rightarrow Y$ (therefore, by condition design, as $i + SR \rightarrow Y$) and the plausible minimizations again retrieve $A(i + K) \rightarrow Y$. In the minimizations to the negative outcome, **K** instead prevents the ambiguity of the prime implicant chart and makes the plausible Standard solutions overlap the parsimonious reading $Ik \rightarrow y$ (that is, $I(r + s) \rightarrow y$ by condition design).

The exercise suggests that the *imp* and *ess* of single conditions can be aligned through compression, and that the consequent reduction of the logical diversity can prevent ambiguity in minimization. It also suggests that model streamlining does not affect the core component of the solutions, but it may come at the cost of ruling out some functional dependencies and the retrieval of the catalysts — that is, with information loss. Whether such a lossy compression has any value, it only depends on the substantive credibility of the starting model, and on the special knowledge that the analysis is expected to yield.

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Tables

Table 1. Survival of democracy in the interwar Europe:
(a) truth table from model $\mathcal{M} = \{\mathbf{W}, \mathbf{I}, \mathbf{U}, \mathbf{L}, \mathbf{S}\}$, and
(b) Standard consistency of single conditions in $\mathcal{M}$.

(a)

Prim itive	Conditions					Instances	Y
	W	**I**	**U**	**L**	**S**		
(01)	1	1	1	1	1	BE, CZ, NL, GB	1
(02)	1	0	0	1	1	FI, IE	1
(03)	1	1	0	1	1	FR, SE	1
(04)	**0**	**0**	**0**	0	0	GR, PT, ES	0
(05)	**0**	**0**	**0**	1	0	HU, PL	0
(06)	**0**	**0**	**0**	0	1	IT, RO	0
(07)	**0**	**0**	**0**	1	1	EE	0
(08)	1	1	0	1	0	AT	0
(09)	1	1	1	1	0	DE	0

Primitives (10) to (32) are unobserved, hence not reported $\mathcal{Q} = \{\ \varnothing\ \}$

(b)

Condition tested	Outcome: **Y**		Outcome: **y**	
	N-cons	*S-cons*	*N-cons*	*S-cons*
W	**1.00**	0.80	0.20	0.20
w	0.00	0.00	0.80	**1.00**
I	0.75	0.75	0.20	0.25
i	0.25	0.20	0.80	0.80
U	0.50	0.80	0.10	0.20
u	0.50	0.31	0.90	0.69
L	**1.00**	0.61	0.50	0.38
l	0.00	0.00	0.50	**1.00**
S	**1.00**	0.71	0.30	0.27
s	0.00	0.00	0.70	**1.00**

Data source: Rihoux and de Meur (2009).

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Table 2. Survival of democracy in the interwar Europe: *import* of single conditions in $\mathcal{M}$. ($\mathcal{N}$ =18)

(a)

W	*instances*	Y
1	AT, BE, CZ, FI, FR, DE, IE, NL, SE, GB	Cd
0	EE, GR, HU, IT, PL, PT, RO, ES	0

$\boldsymbol{p}_W$ ={EE, GR, HU, IT, PL, PT, RO, ES }

imp$_W$ = 0.44

(b)

I	*Instances*	Y
1	AT, BE , CZ, FR, DE, NL, SE, GB	Cd
0	EE, FI, GR, HU, IE, IT, PL, PT, RO, ES	Cd

$\boldsymbol{p}_I$ ={Ø}

imp$_I$= 0.00

(c)

U	*instances*	Y
1	BE , CZ, DE, NL, GB	Cd
0	AT, EE, FI, FR, GR, HU, IE, IT, PL, PT, RO, ES, SE	Cd

$\boldsymbol{p}_U$ ={Ø}

imp$_U$ = 0.00

(d)

L	*instances*	Y
1	AT, BE , CZ, EE, FI, FR, DE, HU, IE, NL, PL, SE, GB	Cd
0	GR, IT, PT, RO, ES	0

$\boldsymbol{p}_L$ ={GR, IT, PT, RO, ES}

imp$_L$ = 0.28

(e)

S	*instances*	Y
1	BE , CZ, EE, FI, FR, IE, IT, NL, RO, SE, GB	Cd
0	AT, DE, GR, HU, PL, PT, ES	0

$\boldsymbol{p}_S$ ={AT, DE, GR, HU, PL, PT, ES}

imp$_S$ = 0.39

Key: 'Cd' is for 'contradictory partition', '1' is for 'positive partition', '0' is for 'negative partition'.
Data source: Rihoux and de Meur (2009).

Table 3. Survival of democracy in the interwar Europe: *essentiality* of single conditions in $\mathcal{M}$.
($\mathcal{N}$ =18, $\mathbf{Q}$=Ø)

(a) $\mathbf{m'_W}$

Primi tive	Conditions I	U	L	S	instances	Y
(01)	1	0	1	0	AT	0
(02)	1	1	1	1	BE, CZ, NL, GB	1
(03)	0	0	1	1	EE, FI, IE	Cd
(04)	1	0	1	1	FR, SE	1
(05)	1	1	1	0	DE	0
(06)	0	0	0	0	GR, PT, ES	0
(07)	0	0	1	0	HU, PL	0
(08)	0	0	0	1	IT, RO	0

$\mathbf{q'_A}$ ={ EE, FI, IE }
ess$_A$ = 0.17

(b) $\mathbf{m'_I}$

Primi tive	Conditions W	U	L	S	instances	Y
(01)	1	0	1	0	AT	0
(02)	1	1	1	1	BE, CZ, NL, GB	1
(03)	0	0	1	1	EE	0
(04)	1	0	1	1	FI, IE, FR, SE	1
(05)	1	1	1	0	DE	0
(06)	0	0	0	0	GR, PT, ES	0
(07)	0	0	1	0	HU, PL	0
(08)	0	0	0	1	IT, RO	0

$\mathbf{q'_C}$ ={ Ø }
ess$_C$ = 0.00

(c) $\mathbf{m'_U}$

Primi tive	Conditions W	I	L	S	instances	Y
(01)	1	1	1	0	AT, DE	0
(02)	1	1	1	1	BE, CZ, FR, SE NL, GB	1
(03)	0	0	1	1	EE	0
(04)	1	0	1	1	FI, IE	1
(05)	0	0	0	0	GR, PT, ES	0
(06)	0	0	1	0	HU, PL	0
(07)	0	0	0	1	IT, RO	0

$\mathbf{q'_S}$={ Ø }
ess$_S$ = 0.00

(d) $\mathbf{m'_L}$

Primi tive	conditions W	I	U	S	instances	Y
(01)	1	1	0	0	AT	0
(02)	1	1	1	1	BE, CZ, NL, GB	1
(03)	0	0	0	1	EE, IT, RO	0
(04)	1	0	0	1	FI, IE	1
(05)	1	1	0	1	FR, SE	1
(06)	1	1	1	0	DE	0
(07)	0	0	0	0	GR, PT, ES, HU, PL	0

$\mathbf{q'_I}$ ={ Ø }
ess$_I$= 0.00

(e) $\mathbf{m'_S}$

Primi tive	conditions W	I	U	L	instances	Y
(01)	1	1	0	1	AT, FR, SE	Cd
(02)	1	1	1	1	BE, CZ, DE, NL, GB	Cd
(03)	0	0	0	1	EE, HU, PL	0
(04)	1	0	0	1	FI, IE	1
(05)	0	0	0	0	GR, PT, ES, IT, RO	0

$\mathbf{q'_R}$ ={AT, FR, SE, BE, CZ, DE, NL, GB }
ess$_R$= 0.44

Note: all the submodels generate 16 logical primitives; the unobserved ones are not reported.
Key: 'Cd' is for 'contradictory partition', '1' is for 'positive partition', '0' is for 'negative partition'
Data source: Rihoux and de Meur (2009).

Table 4. Shame and compliance to international regimes:
(a) truth table from model $\mathcal{M} = \{\mathbf{A}, \mathbf{C}, \mathbf{S}, \mathbf{I}, \mathbf{R}\}$, and
(b) Standard consistency scores of single conditions.

(a)

primi tives	*conditions*						
	A	**C**	**S**	**I**	**R**	*Instances*	**Y**
(01)	1	0	1	1	1	of	1
(02)	1	1	1	1	1	c	1
(03)	1	1	1	0	0	EC2	1
(04)	1	0	0	0	0	kR	1
(05)	1	**0**	**0**	1	1	m2	0
(06)	1	**0**	**0**	1	0	m1	0
(07)	0	**0**	**0**	1	0	lh,k1	0
(08)	1	1	1	1	0	EC1	0

Logical primitives (09) to (32) are unobserved, hence unreported $\mathbf{Q} = \{\ \varnothing\ \}$

(b)

conditions tested	*outcome*: Y		*outcome*: y	
	N-cons	*S-cons*	*N-cons*	*S-cons*
A	**1.00**	0.57	0.60	0.43
a	0.00	0.00	0.40	**1.00**
C	0.50	0.67	0.20	0.33
c	0.50	0.33	0.80	0.67
S	0.75	0.75	0.20	0.25
s	0.25	0.20	0.80	0.80
I	0.50	0.29	**1.00**	0.71
i	0.50	**1.00**	0.00	0.00
R	0.50	0.67	0.20	0.33
r	0.50	0.33	0.80	0.67

Data source: Stokke (2007).

Table 5. Shame and compliance to international regimes: *import* of single conditions in $\mathcal{M}$. ($\mathcal{N}$ =9)

(a)

A	*instances*	Y
1	of, m1, m2, cp, EC1, EC2, kR	Cd
0	lh, k1	0

$\wp_A$ ={ lh, k1 }
imp$_A$ = 0.22

(b)

C	*instances*	Y
1	cp, EC1, EC2	Cd
0	of, m1, m2, lh, k1, kR	Cd

$\wp_C$ ={ Ø}
imp$_C$ = 0.00

(c)

S	*instances*	Y
1	of, cp, EC1, EC2	Cd
0	m1, m2, lh, k1, kR	Cd

$\wp_S$ ={ Ø}
imp$_S$ = 0.00

(d)

I	*instances*	Y
1	of, **m1,m2** ,**lh**, cp, **EC1**, **k1**	Cd
0	EC2, kR	1

$\wp_I$ ={ EC2, kR }
imp$_I$ = 0.22

(e)

R	*instances*	Y
1	of, **m2**,cp	Cd
0	**m1**, **lh**, **EC1**, EC2, **k1**, kR	Cd

$\wp_R$ ={ Ø }
imp$_R$ = 0.00

Key: 'Cd' is for 'contradictory partition', '1' is for 'positive partition', '0' is for 'negative partition'
Data source: Stokke (2007).

Table 6. Shame and compliance to international regimes: *essentiality* of single conditions in $\mathcal{M}$. ($\mathcal{N}$ =9, $\mathcal{Q}$=Ø)

(a) $\boldsymbol{m'}_A$

primi tive	conditions				instances	Y
	C	S	I	R		
(01)	0	1	1	1	of	1
(02)	0	0	1	0	m1, lh, k1	0
(03)	0	0	1	1	m2	0
(04)	1	1	1	1	cp	1
(05)	1	1	1	0	EC1	0
(06)	1	1	0	0	EC2	1
(07)	0	0	0	1	kR	1

$\boldsymbol{q'}_A$ ={ Ø }
ess$_A$ = 0.00

(b) $\boldsymbol{m'}_C$

primi tive	conditions				instances	Y
	A	S	I	R		
(01)	1	1	1	1	of, cp	1
(02)	1	0	1	0	m1	0
(03)	1	0	1	1	m2	0
(04)	0	0	1	0	lh, k1	0
(05)	1	1	1	0	EC1	0
(06)	1	1	0	0	EC2	1
(07)	1	0	0	0	kR	1

$\boldsymbol{q'}_C$ ={ Ø }
ess$_C$ = 0.00

(c) $\boldsymbol{m'}_S$

primi tive	conditions				instances	Y
	A	C	I	R		
(01)	1	0	1	1	of, m2	Cd
(02)	1	0	1	0	m1	0
(03)	0	0	1	0	lh, k1	0
(04)	1	1	1	1	cp	1
(05)	1	1	1	0	EC1	0
(06)	1	1	0	0	EC2	1
(07)	1	0	0	0	kR	1

$\boldsymbol{q'}_S$={ of, m2 }
ess$_S$ = 0.22

(d) $\boldsymbol{m'}_I$

primi tive	conditions				instances	Y
	A	C	S	R		
(01)	1	0	1	1	of	1
(02)	1	0	0	0	m1,kR	Cd
(03)	1	0	0	1	m2	0
(04)	0	0	0	0	lh, k1	0
(05)	1	1	1	1	cp	1
(06)	1	1	1	0	EC1,EC2	Cd

$\boldsymbol{q'}_I$ ={ m1, kR, EC1, EC2}
ess$_I$= 0.44

(e) $\boldsymbol{m'}_R$

primi tive	conditions				instances	Y
	A	C	S	I		
(01)	1	0	1	1	of	1
(02)	1	0	0	1	m1,m2	0
(03)	0	0	0	1	lh,kl1	0
(04)	1	1	1	1	cp,EC1	Cd
(05)	1	1	1	0	EC2	1
(06)	1	0	0	0	kR	1

$\boldsymbol{q'}_R$ ={ cp, EC1 }
ess$_R$= 0.22

Note: all the submodels generate 16 logical primitives; the unobserved ones are not reported.
Key: 'Cd' is for 'contradictory partition', '1' is for 'positive partition', '0' is for 'negative partition'.
Data source: Stokke (2007).

Table 7. Shame and compliance to international regimes:
(*a*) consistency and (*b*) import of condition **K**.

($\mathcal{N}$ =9, $\mathcal{Q}$=Ø)

(a)

condition tested	outcome: Y		outcome: y	
	N-cons	*S-cons*	*N-cons*	*S-cons*
K (=SR)	0.50	**1.00**	0.00	0.00
k (=s+r)	0.50	0.29	**1.00**	0.71

(b)

K	*instances*	**Y**
1 (= *SR*)	of, cp	1
0 (= *s+r*)	EC2, kR, m1,m2,lh, EC1, k1	Cd

$$\wp_K \quad = \{of, cp\}$$
$$imp_K \quad = 0.22$$

Key: 'Cd' is for 'contradictory partition', '1' is for 'positive partition', '0' is for 'negative partition'.
Data source: Stokke (2007).

Table 8. Shame and compliance to international regimes:
Essentiality of the conditions in $\mathcal{M}_1 = \{\mathbf{A}, \mathbf{C}, \mathbf{I}, \mathbf{K}\}$.
($\mathcal{N}$ =9, $\mathcal{Q}$=Ø)

(a) $\boldsymbol{m}'_{1A}$

| primi | conditions | | | | |
tive	**C**	**I**	**K**	*instances*	**Y**
(01)	1	0	0	EC2	1
(02)	0	1	1	of	1
(03)	0	0	0	kR	1
(04)	1	1	1	cp	1
(05)	0	1	0	**lh,m1,k1,m2**	0
(06)	1	1	0	**EC1**	0

$\boldsymbol{q}'_{1A}$ ={ Ø }
ess$_{1A}$ = 0.00

a (b) $\boldsymbol{m}'_{1C}$

| primi | conditions | | | | |
tive	**A**	**I**	**K**	*instances*	**Y**
(01)	1	0	0	EC2, kR	1
(02)	1	1	1	of, cp	1
(03)	0	1	0	**lh, k1**	0
(04)	1	1	0	**m1, EC1 ,m2**	0

$\boldsymbol{q}'_{1C}$ ={ Ø }
ess$_{1C}$= 0.00

(c) $\boldsymbol{m}'_{1I}$

| primi | conditions | | | | |
tive	**A**	**C**	**K**	*Instances*	**Y**
(01)	1	1	0	**EC2**, EC1	Cd
(02)	1	0	1	of	1
(03)	1	0	0	kR, **m1, m2**	Cd
(04)	1	1	1	cp	1
(05)	0	0	0	**lh, k1**	0

$\boldsymbol{q}'_{1I}$ ={ **m1, m2, kR**, EC1, **EC2**}
ess$_{1I}$= 0.56

a (d) $\boldsymbol{m}'_{1K}$

| primi | conditions | | | | |
tive	**A**	**C**	**I**	*instances*	**Y**
(01)	1	1	0	EC2	1
(02)	1	0	1	of, **m1, m2**	Cd
(03)	1	0	0	kR	1
(04)	1	1	1	cp, **EC1**	Cd
(05)	0	0	1	**lh, k1**	0

$\boldsymbol{q}'_{1K}$={ of, **m1, m2**, cp, **EC1**}
ess$_{1K}$= 0.56

Note: all the submodels generate 8 logical primitives; the unobserved ones are not reported.

Key: 'Cd' is for 'contradictory partition', '1' is for 'positive', '0' is for 'negative'.

Data source: Stokke (2007).

Table 9. Shame and compliance to international regimes: truth table of $\mathcal{M}_1 = \{\mathbf{A}, \mathbf{C}, \mathbf{I}, \mathbf{K}\}$.

Primitive	Conditions				Instances	Y
	A	**C**	**I**	**K**		
(01)	1	1	0	0	EC2	1
(02)	1	0	1	1	of	1
(03)	1	0	0	0	kR	1
(04)	1	1	1	1	cp	1
(05)	0	0	1	0	lh,k1	0
(06)	1	0	1	0	m1,m2	0
(07)	1	1	1	0	EC1	0
Logical primitives (08) to (16) are unobserved, hence unreported					$\mathcal{Q}$ ={ Ø }	

Note: **K** calculated as in Table 4(*a*).

Key: 'Cd' is for 'contradictory partition', '1' is for 'positive partition', '0' is for 'negative partition'.

Data source: Stokke (2007).