

Retraction Notice

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Retraction initiative (m X All authors Some of the authors: Editor with hints from Date initiative is launched	ultiple responses allowed; Journal owner (publi Institution: Reader: Other: : 2016-8-15	mark with X): sher)	
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History Expression of Concern: □ yes, date: yyyy-mm-dd X no

Correction: yes, date: yyyy-mm-dd X no

Comment:

The paper does not meet the standards of "Theoretical Economics Letters".

This article has been retracted to straighten the academic record. In making this decision the Editorial Board follows <u>COPE's Retraction Guidelines</u>. Aim is to promote the circulation of scientific research by offering an ideal research publication platform with due consideration of internationally accepted standards on publication ethics. The Editorial Board would like to extend its sincere apologies for any inconvenience this retraction may have caused.

Editor guiding this retraction: Prof. Moawia Alghalith (EiC, TEL)



Defining "Context" with Institutions as Fuzzy Rule Bases

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Abstract

We propose considering an institutional context as a fuzzy control system, and, thereby, the role of any given institution to be akin to a database of fuzzy rules. We develop this analogy for a hierarchical institutional system and provide an overview of the method for designing the database structure using a hierarchical system of linguistic rules. This, we submit, is as an interesting way of looking at institutional development with nested institutions.

Keywords

Institutions, Context, Rules, Subjectivity, Control

1. Introduction

While there is a philosophical debate on the ontology of institutions resting in "rules", the notion is not new that rules in society are associated with its complex of institutions, even if they are not necessarily generated by it. The matrix of institutions" in North [1] is an example of the application of this idea to development, and it makes this connexion vivid. Moreover, within a society, a hierarchical arrangement of institutions is implicit in two ideas: first, that institutions evolve over time at different rates (Williamson [2]), and second, that rules are often formalized based on the informal, cultural context in which they are situated.

Relatedly, institutions are routinely seen as instruments for regulation, or, more broadly, "control". Since the systems that they are reified in order to control do not conform to strong theories such as those governing physical systems, they are enshrined with overarching codes and general rules instead. These rules then comprise the knowledge base that their managers can rely upon to exert control in trying to achieve objective behaviors, rather than deterministically achieving objective outcomes.

Economists usually recognize that these rules are not immutable in practice (they are often not even forma-

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lized) and neither is their validity necessarily axiomatic (indeed, they are routinely amended). How then can institutions be studied with a focus on the progressive evolution of the rules that inhere to them? This paper suggests an interesting and promising methodology. To adumbrate, we see institutions as rule bases where the rules themselves are fuzzy sets of "semantic terms" that permit partitioning control "efforts" allowing the assignment of contextually determined semantic terms to these sets; the rules thus act as parameters for institution managers to rely on as they attempt to control a system using their subjective assessments.

The benefit of using the fuzzy control system analogy for the rule bases of institutions is not trivial. Seen thus, institutions are always contextual: instantiated by individuals who share some subjectivity in expressing their desire and ambition for an institutional process, which is codified into a database of semantic terms—a fuzzy rule base—that can subsequently be relied upon by other institutional managers in their absence. The model thus precludes the very premise of considering institutions as first-best and context-free phenomena, a premise that has justifiably received criticism (Rodrik [3]).

2. Fuzzy Rules and Context

To see the structure and flexibility of the approach across types of institutions, consider, first, in attutional regulation as the 5-tuple: $(\Theta, D, \Gamma, (R \to Y), F)$, where, for any given institution Θ , *a* is its regulatory domain, γ is the "constitutional" remit for the institutional process, $(r \to y)$ is the process that links regulatory control to an outcome, and finally *f* is the feedback generated once *y* is realized. Here we might invisage *r* as having been derived from rules that describe strategies for subjective and qualitative regulation once an objective for control over *d* has been identified¹.

In the characterization of an institutional context the database of these "fuzzy rules" is, therefore, fundamental to institutional design. However, these rules are borrowed often from primitive institutions and sometimes from parallel institutions. Different approaches to solve the problem are discussed in [4]. Indeed, institutions are at the heart of defining "context" because they are almost always nested within other institutional environments--that is to say, the databases of their fuzzy rules have an hierarchical structure. Subjective opinion as well as objective data are usually relevant in constructing a qualitative, fuzzy regulatory model for an institution; likewise, in fuzzy control theory, databases of fuzzy rules are usually founded upon a combination of expert insight (or, perhaps, foresight) as well as amendments engendered through observed data. As an analog to the perspective of this approach, the function of Γ is that of coordinating across the opinions of key individuals, and resolving issues pertaining to the completeness and consistency of the fuzzy rule base. On the other hand, with only data being available, the initial problem is that of the identification of a relevant (and acceptable) Γ , such as in the case of transplanting institutions (or even entire institutional systems) across contexts.

As **Figure 1** portrays, the process of feedback occurs outside the rule base instantiated by γ for θ , and, as such, makes the process subject to exogenous variation; to the extent that such variation is systematically related to the environment of institutional regulation, such feedback would serve to further contextualize the process.



¹The degree of subjectivity may vary depending on the institution due to factors such as the consensus in understanding of the process.

Fuzzy control theory often employs hierarchical dimensions to its rules in order to deal with systems that differ in the extent of their fuzziness just as institutions differ in the degree to which they rely on imprecise, subjective or informally stated rules. Therefore, in what follows, we develop an approach that would permit examining nested regulatory control rules while parameterizing the dimensions of the database of fuzzy rules.

3. Fuzzy Rules for a Hierarchical Institutional System

Define a linguistic variable, x, using the 5-tuple $(x, \mathfrak{X}, U, \psi, \mu)$, where \mathfrak{X} is the semantic range of x, such that each assumed value constitutes a fuzzy variable in the universal set U that contains the real meaning of x; ψ is a methodology for yielding new categories for x over \mathfrak{X} . Finally, μ specifies a methodology to assign each new fuzzy variable an interpretation by way of a new a fuzzy subset on the universal set.

Now define Aas the ordered and finite linguistic scale of the terms, $\{\Lambda_i\}_{i\in[0,\mathfrak{X}]}$. The fuzzy rule base for an in-

stitution would rely on the characteristics of its attendant linguistic scale². For an individual providing subjective input within the institution, its linguistic scale is pivotal in guiding those qualitative assessments. The efficacy of a linguistic scale relates to the level of fuzziness, and the tradeoff is principally in its size; it must be sufficiently small to avoid unnecessary accuracy, yet sufficiently large to enable the requisite granular gradation by an informed individual³.

The idea of nested and hierarchical institutions relying on nested knowledge bases can be developed by introducing the notion of a linguistic level $\mathcal{L}(t, n_t)$ where the hierarchy is defined by n_t . The hierarchy of the knowledge base within nested institutions in a given context of institutions, Θ , can be represented by Ω^{Θ} and is a union of linguistic levels that differ in the degree of meir specificity $n_t \ge 2$ (dimensions of the linguistic scale of level t). Thus,

$$\Omega^{\Theta} = \bigcup_{t} \mathcal{L}(t, n_{t}).$$

Each level, $\mathcal{L}(t, n_t)$ is contextualized by the specificity of the linguistic base and the rule base that is derived from the linguistic scale, each specific to a given level. Therefore,

$$\mathcal{L}(t,n_t) = \Upsilon(t,n_t) + \Gamma(t,n_t)$$

where $\Upsilon(t, n_t)$ stands for the linguistic base at level t with the associated specificity of n_t , and $\Gamma(t, n_t)$ stands for the rule base assembled from the linguistic scale applicable at level t.

We may now specify an attribute $\omega \in \Pi, \omega > 1$ and a criterion for the linguistic scale Λ . The fuzzy rule base $\Gamma(t, n_t)$ at level t may be seen to incorporate two rule bases:

$$\Gamma(t, n_t) = \Gamma_{opt}(t, n_t) + \Gamma_{subop}(t, n_t) = \left\{ \Pi_i^{n_t} \right\},$$

where $\Gamma_{opt}(t, n_t)$ is a fuzzy the base at level t with the optimal rules that meet the condition

$$\left(\Delta_{d},\Pi_{i}^{n_{t}}\right) < \omega \times \left(\Delta_{d},\Gamma\left(t,n_{t}\right)\right),\tag{1}$$

 $\Gamma_{subop}(t, n_t)$ is a rule base of level t, containing suboptimal rules that do not meet condition (1), and Δ_d is the set of all input and output variables.

The inherent elasticity of the linguistic scale governs the transition from level t to t + 1. Starting from term 2, a certain term generated by ψ is added to each term from the left. For level t + 1, the dimension of the linguistic scale constitutes $2n_t - 1$, as shown in Figure 2.

The transition from level t to level t + 1 aims to build a more accurate model of how the hierarchical institutional complex functions. The rule base of level t + 1, *i.e.*, $\Gamma(t+1, n_{t+1}) = \Gamma(t+1, 2n_t - 1)$, is formed using $\Gamma(t, n_t)$. It includes the whole rule base $\Gamma_{opt}(t, n_t)$, while the rules from $\Gamma_{subop}(t, n_t)$ are extended using a newly-formed scale of level t + 1. Subsequently, the application of criterion (1) to these rules would identify the optimal ones among them.

The algorithm, as described, allows for deriving the required result by a proper specification of the initial granulation degree n_t and the extendability attribute ω .

²There is a literature suggesting the interrelationships between the choice of language and the functioning of an institution.

³It is, therefore, noteworthy that this tradeoff in specificity is reflected in analyses at the level of political systems as well. See Tsebelis [5] as a well-studied example in the political science literature.



4. Forming a Fuzzy Rule

We now turn to what the structure of the standard algorithm used to model a fuzzy rule base would look like when characterizing an institutional context. The context can be seen as a complex of a variety of institutions providing observations of the form:

ase

$$(r_1^{(d)}, r_2^{(d)}, \cdots, r_m^{(d)}, y^{(d)}), \ d = [1, D],$$
 (2)

where the $y^{(d)}$ and $y^{(d)}$ stand for values of the output of regulatory control and the outcome in institutional domain d.

The rules themselves take the form of a $IF \rightarrow THEN$ statement, linking the level(s) of a regulatory control output(s) and the outcome. Once the range of values that each variable can assume has approximately been established, the rule base can then be formed using the following general procedure.

First, the domains of the variables are partitioned into specific groups. For each group a membership function is defined in a manner that ensures that they overlap at the 0.5 level.

Next, the initial rule base for the institutional context can be established based vaguely on whether the outcomes inhere to a given institution or whether it may subjectively involve regulatory output from more than one institution. In the first case, each institution would be assigned a specific rule. Therefore, for each

 $(r_1^{(d)}, r_2^{(d)}, \dots, r_m^{(d)}, y^{(d)}), (d = \overline{1, D}),$ the constitution would define the degree of membership of the variable val-

ues to the corresponding fuzzy sets. After that, each observation in the domain would be related to the fuzzy sets with the maximal degree of membership for the variable values from the given institution. The resulting set of rules would comprise the initial rule base. In the second case, the constitution would proceed by generating the rule set according to feasible combinations of fuzzy premises in implications and conclusions of the rules such

that the maximal number of rules in the base is defined by $l = l_1 \times l_2 \times \cdots \times l_m \times l_y$. Here $l_1, l_2, \cdots, l_m, l_y$ indicate the numbers of membership functions used to define the input and output variables $(r_1^{(d)}, r_2^{(d)}, \cdots, r_m^{(d)}, y^{(d)})$.

Note that this approach to form the initial rule base appears reasonable where only a small number of variables and membership functions are involved.

Third, the initial rule base is likely to require optimization since it is likely to be characterized by redundancies involving inconsistencies in the rules within the rule base. Optimizations of institutional rules over time can be modeled by using information on expert insight or by examining how the institution learned and adapted to observed outcomes and data.

The ability of this approach, beyond guiding a model of institutional context, is naturally also prescriptive. For instance, one approach to reducing the size of a fuzzy rule base uses observed data that would be relevant to the institutional context in its entirety. All examples from the observed or "learning sample" are tested against each rule, and each rule is given a rank. Given these ranks, the rules with lowest ranks can be eliminated from the base. Naturally, it then makes sense to remove rules that generate different membership functions for the output variable since, in such cases, rules would be in contradiction, and retaining only the rule with the highest rank would make sense. In such a manner, the total number of the rules in the base can conceivably be reduced leaving only the most consistent of the rules that remain to form the final rule base.

5. Conclusion

Adopting a fuzzy rule base model as the workhorse for institutional analysis has certain rather promising attractions, which have only been hinted here. Besides being rule focused, the approach allows the rule base to be assessed on the merits of its optimality. The rules themselves are based on the linguistic scales of the context, and that, in turn, requires theoretical bottom-lines to be tested against observed data or subjective, expert opinion. In other words, the approach will allow for a genuinely contextual theory of institutions.

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