Institutional Grammar 2.0: A Specification for Encoding and Analyzing Institutional Design

Christopher K. Frantz
Norwegian University of Science and Technology
christopher.frantz@ntnu.no

Saba Siddiki
Syracuse University
ssiddiki@syr.edu

Abstract: Public affairs scholars have contributed rich insights on the role and outcomes of institutions in policy and administrative settings. They have offered numerous empirical studies of these topics, alongside concepts and theories that can be leveraged in their assessment. But there remains a relative dearth in attention to approaches that can be used to support rigorous assessments of institutional design itself – those that support reliable and nuanced representations of institutional structure and meaning. The Institutional Grammar (IG) is one such approach that has gained in prominence over the last decade. Existing applications validate the IG's utility toward rigorous assessments of institutional design, and highlight the IG's value in operationalizing concepts relevant in policy and administration scholarship. We build on existing IG research by presenting a revised specification IG 2.0 for encoding and analyzing institutional design that responds to representational necessities and analytical opportunities within and beyond policy and administrative domains.

Keywords: policy design, policy analysis, institutional analysis, institutional analysis and development framework, institutional grammar, institutional modeling

Abstract: Public affairs scholars have contributed rich insights on the role and outcomes of institutions in policy and administrative settings. They have offered numerous empirical studies of these topics, alongside concepts and theories that can be leveraged in their assessment. But there remains a relative dearth in attention to approaches that can be used to support rigorous assessments of institutional design itself – those that support reliable and nuanced representations of institutional structure and meaning. The Institutional Grammar (IG) is one such approach that has gained in prominence over the last decade. Existing applications validate the IG's utility toward rigorous assessments of institutional design, and highlight the IG's value in operationalizing concepts relevant in policy and administration scholarship. We build on existing IG research by presenting a revised specification IG 2.0 for encoding and analyzing institutional design that responds to representational necessities and analytical opportunities within and beyond policy and administrative domains.

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/padm.12719

Keywords: policy design, policy analysis, institutional analysis, institutional analysis and development framework, institutional grammar, institutional modeling

1. Introduction

Institutional analysis – the study of formal and informal rules, norms, and strategies that govern behavior – is of enduring interest to public policy and administration scholars. Institutional analysis has been leveraged to investigate questions central to these fields; for example, what informs individual and collective decision making in policy and administrative domains, how are policymaking arenas and administrative domains structured, and how is the production and provision of public goods and services organized? Approaching such questions from an institutional perspective draws attention to the structure and meaning of institutions that constitute, or otherwise parameterize, features of institutionally governed domains, as well as to how specifically they opportune or constrain behavior therein. Institutional analysis is thus necessarily dependent on the ability to robustly and reliably represent the structure and meaning of institutions. This paper presents innovations to an analytical approach which is increasingly used within public policy and administration studies for this objective, called the Institutional Grammar (IG).

The IG is a theoretically grounded analytical approach for assessing the syntactic structure and associated meaning of directives comprising institutions -- such as public policies, administrative regulations, and social norms -- and resultant behavioral outcomes. These directives are called "institutional statements" under the IG. Institutional statements *regulate* actions for actors within the presence or absence of particular constraints, or *constitute* or otherwise parameterize features of systems in which actors interact. Following this characterization, a revised version of the IG, as introduced in this article, considers institutional language expressed in statements of both regulative and constitutive kind. Recognizing both distinct characteristics as well as overlapping conceptions of the latter, the revised IG is

comprised of syntactic components that are variably configured to reflect statements of both regulative and constitutive form under the umbrella of an integrated syntax and associated semantics.

Over the last decade, the IG has been increasingly applied in various institutional domains, or settings governed by sets of formal and informal institutions. Research published over this period addresses the integrity of the IG syntax (Schlüter and Theesfeld 2010), highlights its applicability within computational modeling of institutional emergence and outcomes emerging from institutionally governed behavior (Smajgl et al. 2008; Frantz et al. 2015), and offers operational coding guidelines for applying the IG to study policy design (Basurto et al. 2010; Siddiki et al. 2011). But while its application showcases the IG's promise for supporting institutional analysis, it also reveals its limitations. Foremost, it highlights ontological inconsistencies of the IG syntax that challenge conceptual and operational distinction among syntactic components, and the limited ability to capture institutional configurations comprehensively, both with respect to structural depth, as well as the inattention to constitutive institutions, the relevance of which has been noted by scholars (Weible and Carter 2015).

We respond to the noted limitations with a revised IG specification, termed IG 2.0, which we contrast hereafter with the "base IG syntax". This refined specification (i) introduces modifications to the base IG syntax to resolve ontological inconsistencies observed therein, (ii) presents a novel syntactical form for constitutive institutional statements, recognizing that the base IG syntax primarily accords with regulative institutional statements, and (iii) enhances the tractability of IG coded data for broader application domains and associated computational applications (e.g., natural language processing, agent-based modeling). The refined specification orients around three levels of expressiveness, with each level of expressiveness identifying a

distinctive parsing of regulative and constitutive syntactic components common across all levels: IG Core, IG Extended, and IG Logico. The granularity with which syntactic components are parsed at each level of expressiveness has implications for how human readable coded texts are, the computational tractability of coded data, and logical consistency of parsed data. Analyses can be designed to selectively encode at different levels of expressiveness, i.e., varying levels of detail, to support the investigation of different types of research questions in correspondence to the applied analytical methods and techniques, thereby supporting the IG's theoretical and methodological versatility. To capture institutional complexity more systematically, the revised specification also accommodates identification and analysis of inter- and intra-statement relationships based on a nested institutional statement conception (Frantz et al. 2013). Altogether, the IG 2.0 facilitates accurate and comprehensive representations of institutional structure and meaning, central to the conduct of institutional analysis in policy, administrative, and other domains.

In the remainder of this paper, we offer a brief introduction to the IG, provide an elaborated rationale for the IG 2.0, and give a detailed overview of the key features of IG 2.0.

2. Introduction to the Institutional Grammar

Scholars of public affairs, and cognate fields, express an enduring interest in the institutions that govern behavior (March and Olsen 1989; North 1990; Pierson 2000; Williamson 2000). Institutions, defined here as the explicit or tacit strategies, norms, or rules that indicate to actors what they can, must, or must not do in certain situations or within specific contexts, or parameterize features of systems in which actors interact, are of the most important artifacts of societies (Crawford and Ostrom 1995; Ostrom 2005; Searle 2005). Through their implicit recognition (e.g., when reflected in social norms) or formal codification (e.g., when captured in

public policies) they establish regularities in human action that have non-trivial influence on the social and environmental contexts in which they are applied. The salience of institutions has prompted a field of study oriented on understanding the design and impacts of institutions. This research has generated rich insights about the qualities of institutions, how institutions emerge, and the individual and collective impacts they generate. However, the interpretation of scholarship generated by institutional analysts exploring these various subjects has been challenged by inconsistent definitions of institutions, a lack of clarity surrounding the scale at which institutions are being analyzed, and inconsistent approaches for characterizing their design.

The IG, presented by Sue Crawford and Elinor Ostrom in 1995, was in part motivated by the noted inconsistencies in institutional research, and the desire to contribute generalizable knowledge about what institutions are. Like many others motivated by this same objective, Crawford and Ostrom (1995) posited a definition of institutions oriented in functional characteristics; noting what institutions *do* (e.g., establish regularities in behavior). But in tackling the question of what institutions *are*, they took a different tact than other institutional scholars. This tact was distinctive in two ways. First, it urged characterization of the level of analysis at which analysts examine institutions, and relatedly, posited an "institutional statement" as the focal unit of analysis in institutional assessments. Crawford and Ostrom defined an institutional statement as a "shared linguistic constraint or opportunity that prescribes, permits, or advises actions or outcomes for actors (both individual and corporate)" (Crawford and Ostrom 1995, p. 583). Institutions are comprised of one or more institutional statements (Siddiki et al. 2019). The second distinctive aspect of Crawford and Ostrom's approach to clarifying what institutions are was to identify generalizable, constituent parts of institutional statements (i.e., components common to statements observed across institutional types and domains). Each statement

component was understood to convey distinctive forms of information, much like the different syntactic components comprising sentences in the English language do. Thus, the components of the institutional statements were characterized as syntactic components constituting an "institutional grammar."

Crawford and Ostrom identified five syntactic components that combine to form institutional statements: (i) an Attribute (A) identifies to whom an institutional statement applies; (ii) an Aim (I) is the activity linked in an institutional statement to the Attribute; (iii) a Condition (C) is the temporal, spatial, or procedural parameter that describes when, where and how the statement applies; (iv) a Deontic (D) is the prescriptive operator that indicates whether the Attribute is required, allowed, or forbidden to perform the specified Aim within noted Conditions; and (v) an Or else (O) is a payoff associated with the fulfillment of the institutional statement. Institutional statements are defined by the presence of at least some of these syntactic components; suggesting that definitionally, institutional statements have both necessary and sufficient syntactic components. At a minimum, statements must have an Attribute, Aim, and Condition. Rooted in game theoretic conceptions, statements with these component parts are characterized as strategies [Ex. "Farmers participating in farmer's market (A) open (I) stall at 9:00am (C)"]. Statements that contain these components and a Deontic, are characterized as norms [Ex. "Farmers participating in farmer's market (A) *must* (D) open (I) stall at 9:00am (C)"]. Statements that contain all five syntactic components are characterized as rules [Ex. "Farmers participating in farmer's market (A) must (D) open (I) stall at 9:00am (C) *or be restricted from selling goods* (O)"].

Extant IG scholarship addresses the logic underlying the IG syntax (Schlüter and Theesfeld 2010), suggests methodological refinements to the syntax (Siddiki et al. 2011; Frantz et

al. 2013; 2015) or clarifies operational guidelines for applying the IG (Basurto et al. 2010), uses the IG in the operationalization of concepts (Clement et al. 2015; Roditis et al. 2015), and explores the value of employing the IG in the context of computational modeling (Smajgl et al. 2008; Frantz et al. 2015). As a corpus, these articles validate the IG's utility toward gaining systematic assessments of institutional design and demonstrate its theoretical versatility (i.e., operationalization of concepts linked to various theories) and methodological versatility (i.e., ability to be paired with various methodological approaches).

Notable IG scholarship, in terms of the extent to which it has shaped the trajectory of IG research include:

- Smajgl et al. (2008): The authors used the IG in an agent-based modeling exercise to assess institutional emergence, showcasing how the IG can be levered in endogenous parameterization of rules and signaling the value of the IG in agent-based modeling more generally.
- Basurto et al. (2010): The authors used the IG to analyze policy design, offering as part of their exercise the first complete set of operational coding guidelines for such task.
- Siddiki et al. (2011): The authors introduced an additional syntactic component to the IG syntax – the Object (B) – contributing ontological improvements to the IG syntax and promoting reliability in IG coding.
- Weible and Carter (2015): The authors highlight fundamental differences between the meaning and form of regulative and constitutive institutions, and concomitant challenges associated with applying the IG syntax to constitutive institutions.
- Frantz et al. (2013; 2015): The authors introduced the concept of nested institutional statements, with the acronymal label of nADICO, enabling the representation of the

interlinkage and structural complexity in institutional statements, and providing the basis for endogenous generation of "rules in use" represented as institutional statements in agent-based institutional modeling.

Importantly, through offering distinctive contributions relating to the construction and/or application of the IG, all of this research commonly advances the ability to accurately, substantively, and comprehensively represent institutional structure and meaning, and thereby supports rigorous assessments of institutional design across diverse institutional domains.

The revised IG specification reported in this paper builds on insights of the research referenced above, and integrates select methodological refinements. In this light, reviewing the previous work, alongside empirical insights, helps motivate the underlying aims for IG 2.0 as recalled at this stage, namely (i) resolving ontological inconsistencies in concept and coding practice; (ii) fostering comprehensive and reliable coding of statements; and (iii) enhancing versatility of the IG across disciplines, methods and techniques.

Inasmuch as ontological inconsistencies in the current IG conception (detailed in Section 3.1) reflect conceptual limitations of the IG and associated syntax, there are also operational limitations that stem primarily from practice. A central operational limitation is the institutional analyst's over-commitment to retaining the *structural* integrity of institutional statements in syntactic parsing (i.e., ensuring that individual statements are captured in parsed form just as they originally appear in aggregate form in an institution under investigation), which sometimes amounts to a loss of *semantic* integrity (i.e., capturing the institutional meaning of a statement). For example, within policy documents, regulated activities and associated sanctions can be presented in different sections, or sanctions may implicitly apply across multiple statements. By looking at the structure of individual statements without attention to such can lead to

mischaracterization of encoded statements as normative, as opposed to correctly identifying those as rules in Crawford and Ostrom's statement type characterization. Similarly, separation of statement content into separate sentences can equally produce such misclassification, signaling that institutional statements do not always correspond to sentences; sentences can contain multiple institutional statements, and conversely, institutional statement content can be distributed across multiple sentences.

Referencing motivations for the second aim -- increasing reliability and comprehensiveness of coding scope -- a central limitation of existing practice is the accommodation of structural diversity of institutional statements, such as their expression in actor-centric regulative form (e.g., "Actor must perform action") or entity-centric constitutive form ("Organization consists of departments"). In the past, the absence of guidance led to reformulation of statements to match the idiomatic regulative pattern prescribed by the original IG (leading to reliability challenges), or omission of such statements from the coding process in the first place (and thereby limiting comprehensiveness of the encoding). The refined IG offers an integrated syntax, comprised of syntactic components that variably configure into a regulative and constitutive form, which addresses this concern. By logically harmonizing divergent structures under a common umbrella, the IG 2.0 further affords the opportunity to encode statements that embed both syntactic forms (see Section 4.2).

The final objective relates to affording greater versatility. Existing applications of the IG in public policy and administration research showcase its potential, and recent uptake supports this observation (Siddiki et al. 2019; Dunlop et al. 2019). However, contemporary applications focus on a high-level encoding that limits analytical opportunities enabled by computational techniques, as well as the limited consideration of structural depth and logical interpretation of

institutional statements that bear the promise of novel analytical pathways not accessible to date. A central step toward this direction, which is synergic to the previous objectives, is the shift to a semantic perspective when engaging in the coding process, as well as the provision of guidelines that allow targeted coding based on an analytically relevant level of detail, that, to varying extents, leverage structural detail and computational tractability of the encoded data.

3. Institutional Grammar 2.0

We introduce an amended version of the IG that integrates many of the refinements proposed in preceding sections. Notably, this amended version serves cross-disciplinary purposes, accommodating various levels of complexity as found in institutional statements, while revising the institutional grammar to offer a comprehensive representation of institutional domains by offering an integrated syntax that considers regulative and constitutive statements alike. To this end, a central architectural alteration is to forego the conceptualization of the IG as a single syntactic specification, but rather conceive it as a layered stack of specifications that are based on a common set of syntactic components and accommodate different analytical objectives. IG 2.0 consists of three levels of expressiveness of consequently varying levels of syntactic refinement, with higher levels subsuming features specified on the lower levels as reflected in Figure 1 -- and described in the following with initial focus on regulative statements.

Insert Figure 1 Here

IG Core reflects the basic level of expressiveness that resolves selected ontological challenges (see Section 3.1) and integrates a basic notion of nested statements to capture inter-statement linkages. Doing so, it maintains compatibility with the existing coding specification and observed practice, while taking an inclusive perspective on encoding. *IG Extended* expands this perspective and accommodates a more fine-grained encoding of specific components by systematically

introducing component-level nesting. IG Extended builds a bridge between advanced computational analyses while generating coded institutional information that is still human readable. *IG Logico* shifts the perspective from a coder-centered to a logic-centered perspective and aims at expressing the relationships and functions of individual components as well as the associated logical implications more rigidly, so as to reconstruct a general conception of institutional actors and their relationships -- expanding from individual statements as units of analysis to the institutional context at large. In this article, we provide the conceptual discussion and selected features of IG 2.0 with focus on underlying motivation and analytical affordances. For a comprehensive operationalization of all features, as well as discussion of special cases and exceptions, please refer to the supplementary Institutional Grammar 2.0 Codebook (Frantz and Siddiki 2020), alongside the resources linked from the Appendix.

3.1 IG Core

IG Core includes all components used in established coding practice (as outlined in Section 2), alongside selected refinements.

Attribute (A)

The Attribute component captures the actor responsible for a given institutional statement, either in explicit or implicit form. Additionally, in some statements, an Attribute and its property/ies can be presented together. For example, a statement may refer to “farmers,” or to “certified farmers,” or to “compliant, certified farmers.” In these examples, the noun “farmers” relays the general actor to whom the statement applies, and “compliant” and “certified” are properties of this actor. At the IG Core level, the IG 2.0 differentiates identifiers (i.e., general actor to whom statement applies that is often represented in noun form) and descriptive properties.

Object (B)

The Object component is defined as the receiver of an action (described by the Aim) and performed by the actor (described by the Attribute). Objects can be animate and inanimate entities in institutional statements, and each statement can contain multiple Objects. The current specification does not differentiate between an Object receiving an action (direct Object), and a second Object affected by this interaction, or more descriptively, the receiver of the Action-Object application. Prototypical examples include the handling of artifacts, such as "Inspector must send notification to certifier", in which the direct object (notification) is well-defined. However, the indirect Object (certifier) is generally encoded as a generic instrumental Condition - as "to certifier" can be interpreted as a procedural (or "how") constraint in the absence of other syntactic fields in which to place this institutional information. Current practice further allows for selective coding of either direct or indirect object as Object component (Brady et al. 2018). This encoding characterizes the Action-Object interaction with insufficient specificity to leverage analytical value. Indeed, it violates principles of ontological consistency, or the semantically unambiguous interpretation of content both in terms of substantive and relational kind. The IG 2.0 resolves this challenge by introducing an encoding pattern that accommodates both direct and indirect Object. Similar to the Attributes coding, for both direct and indirect objects, the IG 2.0 differentiates identifiers (e.g., written *notification*) and descriptive properties (e.g., *written* notification).

Deontic (D)

The Deontic component is unchanged in the IG 2.0, but it explicitly recognizes the continuity of the concept, as implied by the directives found in practice (e.g., may, should, must), and discussed theoretically (e.g., Frantz 2015).

Aim (I)

The Aim component in the IG 2.0 is broadly aligned with contemporary encoding practice, but refines the handling of action combinations. Where multiple separable actions exist, these are decomposed into individual statements and linked by logical operators signaling their relationship as co-occurring (AND), inclusive disjunctive (OR), or exclusive disjunctive (XOR) – described as *horizontal nesting* (Frantz et al. 2013). For example, the statement "Certifier must review and approve farmer's organic system plan annually" can be coded as "Certifier must (review and (AND) approve) farmer's organic system plan annually", with parentheses signaling the action combination embedded in the aim component. Decomposed into atomic form, these statements read "Certifier must review farmer's organic system plan annually" AND "Certifier must approve farmer's organic system plan annually."

Context (C)

The refinement of the Conditions component, now referred to as Context, is a central aspect of syntactic refinements over the original IG. To date, the Conditions component offers a rich catchment of phrases related to action context in the widest sense. Conditions, originally defined as "the set of variables [articulated in words or phrases in institutional statements] that define when, where, and how an institutional statement applies" (Crawford and Ostrom 1995, p. 585), are insufficiently clear about the content captured as part of their assignment, since this characterization conflates contextual descriptors that activate or make reference to situations in which the Aim of the statement applies in the first place (and/or lead to altered Attribute/Object characterizations), and descriptors that constrain or qualify an aim during execution (i.e., once activated). To illustrate the argument, let us draw on the following example: "At 8am in the morning, all employees must be physically present." This basic example offers us two contextual

descriptors ("At 8am …", "physically"), generally categorized as *Conditions* in the original IG. Whereas the first descriptor delineates as to when a particular instruction applies, and more specifically offers a temporal description, the second characterizes and further qualifies the action content of the instruction.

Both characterizations can be of similar metaphysical kind (e.g., "*At 8am*, …" and "report *annually*" both capture temporal aspects), and hence share intrinsic properties of substantive nature (Ellis 2001; 2002). However, the variable positioning of both characterizations with respect to their essential relationships to other components and/or the action situation more generally highlights the observed inconsistency. As visualized in Figure 2, conditions can selectively reflect the activation of the statement as a whole, or, alternatively, they may merely qualify the activity embedded in the statement.

Insert Figure 2 Here

Although efforts to decompose this component exist, the conflated treatment, we suggest, promotes an ontologically inconsistent characterization of context in institutional statements, as it prevents a sufficiently precise positioning of specific institutional statements within an action situation based on the ambiguous meaning of specific components.

With the aim of (i) improving clarity and reliability of encoded policy, while at the same time (ii) affording novel analytical objectives, we thus propose a distinctive separation of Conditions into *Activation Conditions* and *Execution Constraints*, respectively. This differentiation follows the rationale that Activation Conditions describe conditions under which a statement is activated as a whole. Operationally, actors may enter a particular situation in which a given institutional statement applies (i.e., instantiation), or initiate new Attribute or Object specifications; for example, changes in Attribute roles, or introduction of new objects that can

receive statement actions. Execution Constraints, in contrast, capture behavioral specifications of an enacted institutional statement within a situation; i.e., qualify the action of a statement and thus guide its execution, or Attribute, or object specifications to which the statement action is fundamentally tied. A detailed characterization of heuristics for the differentiation of both concepts is offered at a later stage (see Figure 5). To avoid introducing terminological ambiguity on component level, we further relabel the former Conditions component as Statement *Context*, expressing both circumstances that the institutional statement is embedded in, and the constraints imposed on actions specifically.

The syntactic organization of components as introduced up to this stage (ABDIC) - with the optional nature of Object and Deontic components and hence possible variants ABDIC, ABIC, ADIC, AIC - , reflect what we refer to as *atomic institutional statements*, or more specifically, *atomic regulative institutional statements*. Those statements neither afford component-level combinations/horizontal nesting (e.g., multiple aims, etc.) nor vertical nesting (i.e., or else statements).

Or else (O)

The Or else component under the IG 2.0 incorporates the notion of *vertical statement nesting* as developed in the context of Nested ADICO, or nADICO (Frantz et al. 2013), in which the consequence for non-compliance with regulative content in the leading *monitored statement* is expressed as a complete institutional statement (*consequential statement*), in regulative-punitive (or regulative-incentivizing) form. However, consequential statements can further take constitutive forms, an aspect discussed in Section 4.2. To exemplify and discuss the application of the refined *Or else* as well as associated implications, let us consider the following example: “Certified organic farmers must not apply synthetic chemicals to crops at any time once organic

certification is conferred, or else certifier will revoke certification from farmer." Coding this statement according to traditional coding instructions, we arrive at: "Certified organic farmers (A) must not (D) apply (I) synthetic chemicals (B) to crops at any time once certification is conferred (C), or else certifier will revoke certification from farmer (O)." Using the refined coding specification, including differentiated treatment of syntactic elements and vertical nesting, the coding is as follows: "Certified (A_{prop1}) organic (A_{prop2}) farmers (A) must not (D) apply (I) synthetic chemicals (B_{dir}) to crops (B_{ind}) at any time (C_{ex}) once organic certification is conferred (C_{ac}), or else certifier (A) will (D) revoke (I) certification (B_{dir}) from farmer (B_{ind})". In this statement, components are annotated with the ABDICO syntax, with specific characterizations involving the annotation of direct and indirect objects as B_{dir} and B_{ind}, respectively, activation conditions and execution constraints as C_{ac} and C_{ex}, and finally indexed property annotations as A_{prop1}, A_{prop2}, etc. Abstractly, the coded statement can be captured in the syntactic form ADIBC[ADIBC] (where squared brackets indicate the vertically-nested consequential statement). The following extended version of this example statement that prompts vertical and horizontal nesting is the following: "Certified organic farmers must not apply synthetic chemicals to crops at any time once organic certification is conferred, or else certifier will administer official notice of noncompliance and revoke or suspend certification of farmer." Capturing vertical and horizontal nesting, this statement is coded as shown in Figure 3.

Insert Figure 3 Here

In addition to explicating the atomic responsibilities of the certifier role (administer, suspend, revoke), the systematic decomposition affords an unambiguous recognition of required action (administering official notice of non-compliance) and discretionary action (*either*

suspending *or* revoking), including the contextually implied precedence of compulsory actions (notify) and discretionary action alternatives (suspend, revoke).

It is important to note that contemporary coding practice, in fact, implicitly recognizes the need for the decomposition of complex statements under the specific condition that statements involve multiple Attributes and actions (Brady et al. 2018), but not for cases in which either Attributes or Aims (or other components) are multiple. IG 2.0 makes this decomposition explicit and intentional for all cases of component duplication (e.g., Attributes, Objects, Actions), and furthermore attaches logical operators to individual statements so as to maintain the logical relationships among decomposed statements (with details discussed in the IG 2.0 Codebook).

3.2 IG Extended

IG Extended is an extended IG Core specification that affects the level of coding granularity by moving from a breadth-centric coding (capturing all components) to a depth-centered coding (capturing individual components at detail). Central refinements to IG Core introduced in IG Extended include: (i) Hierarchical classification of Attributes and Object properties; (ii) Context taxonomy annotations; and (iii) Component-level nesting of institutional statements.

The mapping of complex statements to the existing institutional statement patterns can often only be realized by coarse-grained encoding or require considerable restructuring to accommodate the complexity and stylistic variation found in human language. This can specifically involve a more complex conception of Objects and their relationships in the Attributes and Objects components of the IG. To alleviate this, IG Core introduces the differentiation into direct and indirect Objects during coding, as well the distinction between the

respective object descriptor and object properties. It, however, does not capture richer structural relationships between Objects, Objects and properties, as well as amongst properties themselves. Leveraging this information explicitly exposes structural details of the institutional setting relevant to capture institutional configurations comprehensively. To exemplify this, we can consider the following example: “When rebuttal is unsuccessful or correction of the noncompliance by certified organic farmer is not completed within the prescribed time period, the Program Manager shall send a written notification of proposed suspension or revocation of certification to certified organic farmer.” The program manager sends a “written notification of proposed suspension or revocation of certification” - a sub-statement that, following IG Core instructions, would simply be coded as a direct Object, alongside property characterizations, embedding considerable complexity without further decomposition.

Reviewing this statement, we find that we are fundamentally dealing with four concepts of relevance: *notification*, *suspension*, *revocation*, and *certification*. While the notification is immediately identified as a direct Object, the challenge relates to the semantic decomposition of the remaining nouns. To address the decomposition, Objects can be differentiated into the actual Objects and their properties; their descriptors, as well as further, lateral Objects, a structure we characterize as Object-Property Hierarchy (note that this principle applies to various components in the IG, including Attributes). For the discussed statement, this translates into the “notification” as the Object, with the essential properties “written”, “suspension”, “revocation” and “certification”. The property “written” is directly associated with the notification itself, whereas the “suspension”, “revocation” and “certification” stand out in that they are not in a descriptive relationship with the notification.

Instead, these properties can firstly exist independently of the direct Object (i.e., a suspension, revocation or certification's existence does not rely on the notification) -- they are independent natural kinds and can in principle be Objects in their own right (e.g., referred to in another statement), and can furthermore maintain dependencies amongst each other in the form of an implicit functional hierarchy. Suspensions and revocations are functionally dependent on certifications; without the existence of certifications, the regulative acts of suspension or revocation are not meaningful. Recognizing their shared role as *children* of the certification node, we identify their logical relationship, which, in this example, is explicitly given as an *and/or relationship* (inclusive disjunction). Following the principles of this hierarchical organization, properties of entities (here: suspension and revocation as children of certification) can themselves maintain functionally dependent properties (such as being "proposed" suspensions or revocations, respectively), affording comprehensive decomposition of Object-Property relationships. Figure 4 highlights this principle abstractly (Object-Property Hierarchy Principles) - including the conceptualization of Objects as institutional statements (which we will explore later in this section) - and applies it to the explored example.

Insert Figure 4 Here

Instructive guidelines that accompany the conceptual discussion provided here are offered in the IG 2.0 Codebook (Frantz and Siddiki 2020). A specific noteworthy consideration discussed therein is the invocation of *conceptual reification* (Langacker 2008), the transformation of concepts expressed in substantive form (e.g., "inspection") to verb form (e.g., "inspect") in order to reconstruct idiomatic statements that correspond to the syntactic structure of institutional statements.

Returning to the sub-statement of concern, and applying the proposed component-level decomposition, we can now express:

"..., the Program Manager (A) shall (D) send (I) a written ($B_{dir,\ prop1}$) notification (B_{dir}) of proposed ($B_{a,1,prop1;a,2,prop1}$) suspension ($B_{a,1}$) or revocation ($B_{a,2}$) of certification(B_a) to the certified farmer (B_{ind})."

In this encoding, $B_{dir,prop1}$ signifies a property "written" of the direct Object (B_{dir}), whereas the functionally independent Object "accreditation" is annotated as B_a, along with its dependent Objects "suspension" and "revocation" ($B_{a,1}$ and $B_{a,2}$ respectively), both of which share the leaf property of being "proposed" ($B_{a,1,prop1;\ a,2,prop1}$). *prop1* identifies "proposed" as the first of potentially multiple properties to $B_{a,1}$ and $B_{a,2}$. As shown in the subscript annotation for the Object property "proposed", overlapping associations are separated by semicolons. Where an object has a single property, the index suffix on the property (e.g., prop1, prop2) is optional, but here retained for clarity.

As briefly alluded to above, in addition to the encoding of the implicit functional hierarchy as discussed to this point, the IG 2.0 supports *component-level nesting* of Objects by embedding complete institutional statements, an aspect we will motivate and operationalize later in this section.

The decomposition of the Attribute component for complex property characterizations follows the same principles as the Object hierarchy discussed here. Central variation is the differentiation into simple attributes (in equivalent to the property "written" for the example highlighted above) and complex attributes that reflect a comprehensive decomposition into related objects and associated properties.

Context Taxonomy - To offer an unambiguous characterization, and to leverage rich semantics embedded in the Context component, the IG 2.0 includes a set of taxonomies applying

to various components, all of which are listed and discussed in the IG 2.0 Codebook. The central of those, the *Context Taxonomy*, is highlighted at this stage. The proposed taxonomy provides a set of categories that capture types of context frequently encountered in policy statements, e.g., temporal, spatial, procedural, and domainal.

While primarily relying on the empirically observed occurrence in coding practice as well as in annotated corpora (see e.g., Schneider et al. 2016; 2018), it is not assumed to be exhaustive but to provide a basis for accommodating further (sub)categories where empirically observed or analytically necessary, as exemplified here for the spatial, temporal and domainal dimensions. Combining the Context characterization described above and the differentiated Context component in IG 2.0, Figure 5 provides an overview of the operationalized heuristics for the identification of Activation Conditions and Execution Constraints, and exemplifies their use with the proposed Context Taxonomy.

Insert Figure 5 Here

Complex conditional/constraining statements - While the proposed dimensions and associated categories provide the basis to capture the contextual descriptors of a given institutional act, conditional/constraining statements often carry an intrinsic complexity different from other components. They can resemble institutional statement structure themselves and can, as observed in previous examples, appear as logical combinations of multiple (activation) conditions or (execution) constraints. Borrowing the following example, we can observe such complexity: “The Program Manager may initiate suspension or revocation proceedings against a certified operation: (1) When the Program Manager has reason to believe that a certified operation has violated or is not in compliance with the Act or regulations in this part; or (2) When a certifying agent or a State organic program's governing State official fails to take

appropriate action to enforce the Act or regulations in this part." While the institutional act - the initiation of suspension or revocation proceedings - can be easily coded using the proposed specification, this specific statement has two conditions of considerable complexity:

"… When the Program Manager has reason to believe that a certified operation has violated or is not in compliance with the Act or regulations in this part; **or ...**

… When a certifying agent or a State organic program's governing State official fails to take appropriate action to enforce the Act or regulations in this part."

Upon closer inspection, those can effectively be coded using the institutional statement structure themselves, alongside further modifications. This motivates the final IG 2.0 feature reviewed in context of IG Extended: complex conditional/constraint statements. Reviewing the first condition, and applying the current coding pattern, we can observe multiple challenges: (i) nested action specifications embedded in mental constructs, in this case beliefs (here: "to believe that a certified operation has …")*;* and (ii) component-level logical combinations (here: "has violated *or* is not in compliance" and "Act *or* regulations in this part*"*).

The nested action specification is challenging to resolve, since it contains a duplicate action specification with reference to different Attributes, including "Program manager (A) has reason to believe (I)" and "certified operation (A) has violated (I) the Act (B_{dir})" - essentially two statements of strong interdependence, since one statement represents the substantive content of another - here the content of the belief. Addressing this (and recalling the specification of Objects as institutional statements as shown in Figure 4), we model the embedded belief as a nested Object, reflecting the following structure (with curly braces - { and } - signifying the nested nature of any component, the Object in this case): "Program manager (A) has reason to believe (I) {that a certified operation (A) has violated (I) the Act ($B_{dir,ref}$)} (B_{dir})". Reducing the representation to the syntactic structure, we arrive at AIB{AIBC}C - where the first B (B{…}) is

substituted by the nested statement; components are listed in order of occurrence in the original statement (and implicit Context). While restricted to the representation of a direct Object, the same can equally apply to an indirect Object, leveraging another aspect of component-level nesting for Objects. This approach is general in that it allows for arbitrary levels of nesting, e.g., expressing beliefs about beliefs, while further retaining the ability to represent statement combinations.

Applying these principles to Attributes (as indicated in the context of the Object-Property Hierarchy shown in Figure 4), modifying the statement above as "Program managers who believe that certified operations violate the Act", we can accurately reflect this complexity with a complex Attribute descriptor consisting of an institutional statement: "Program managers (A) who believe (A_{prop}) {that a certified operation (A) has violated (I) the Act ($B_{dir,ref}$)} ($A_{prop,prop}$)", where the first (and in this case only) Attribute property A_{prop} is the program manager's belief with a nested property $A_{prop,prop}$ reflecting the belief content. Note that the annotation *ref* (with further elaboration in the IG 2.0 Codebook) reflects another feature of IG 2.0, the coding of references to other statements (e.g., individual statements, sections, documents, etc.).

The second aspect - component-level logical combinations - is captured by decomposing the compound statements into atomic institutional statements connected by logical operators. Given the use of two combinations (1. violated *or* is not in compliance; 2. with the Act *or* regulations in this part), we can decompose this into four *or*-combined statements reflected in Figure 6.

Insert Figure 6 Here

With those two principles, i.e., the nested action specification, and the decomposition of component-level logical combinations, we are able to capture complex nested structures

embedded in institutional statements, which, in this specific case, represent a compound Activation Condition statement. With the analogous decomposition on the second conditional statement we can now comprehensively annotate the statement as captured in Figure 7 (with conditional statements indented so as to clearly reflect the embedded logical precedence amongst atomic statements and combinations thereof; the annotation *pur* suggests a context characterization of type *Purpose* as introduced in the Context Taxonomy).

Insert Figure 7 Here

Reviewing this complete example, we can observe how the decomposition drives a more comprehensive, albeit more complex, coding. In this case, the component structure can be extracted as *(ABDIC or ABDIC),* with component-level nesting of the Context component, which encapsulates complex institutional statements in the form *C{(AIB{AIB} or AIB{AIB} or AIB{AIB} or AIB{AIB}) or (AIBC or AIBC or AIBC or AIBC)}*, some elements of which themselves apply component-level nesting of Objects (here the first compound conditional statement). In doing so, IG Extended coding reveals additional structural clarity that is obscured in the more coarse-grained coding schemes of the base IG, or IG Core. Affording refined analytical opportunities, IG Extended reflects a step towards computational tractability and potential decomposition of highly structured institutional arrangements by explicating the underlying *institutional tree structures* afforded by systematic application of nesting principles within and across different statement components. On the flipside, this encoding certainly imposes more responsibility and cognitive load on the coder, an aspect that can be alleviated with clear coding prescriptions, but also tool support, e.g., to facilitate the decomposition of compound statements into atomic statements as shown for the highlighted example.

3.3 IG Logico

IG Logico shifts the perspective from a pragmatic statement-centric viewpoint to an institutional perspective that affords advanced analytical capabilities by superimposing a semantic perspective on the coded institutional arrangements. Doing so, it broadly complements IG Extended encoding with a characterization of roles of involved actors, the institutional functions the actions play, and affording cross-references amongst institutional statements, along with the resolution of remaining logical ambiguity. IG Logico does so without compromise on cognitive load and at the expense of general accessibility to coders, but in return provides an interface for reasoning over policies and institutions more generally as well as supporting advanced computational models that capture the institutional semantics of the involved actions at greater detail. Central refinements in IG Logico - selectively discussed in the following (omitted ones are captured in the IG 2.0 Codebook and in forthcoming work) - include:

- Syntactic and semantic specification of IG
- Scoped statement references
- Logical relationships of component properties
- Extended semantic annotations
- Second-order embedding of components
- Institutional function annotations
- Transformation rules

The IG 2.0 allows for tangible assessment and operationalization of both the representation and formalization of institutional statement language. Since this is central to the analytical perspective on IG 2.0, both specifications of the high-level syntax and semantics of IG 2.0 are referenced in the Appendix of this article.

Foregoing the discussion of second-order embedding of components and role annotations – that is the detection of objects, for example, in other statement components and the attachment of role labels to actors, we aim at showcasing specific analytical potential of IG Logico by discussing *institutional function annotations* and *transformation rules*.

Institutional Function Annotations. A feature that highlights the analytical opportunities arising from the refined coding for IG Logico are institutional function annotations, and here more specifically, *regulative function annotations*. Institutional functions are characterizations of operational activities expressed in terms of institutional semantics as relevant from an analytical perspective. Their purpose is thus to draw the analytical links between the expressed actions and their corresponding effects in an institutional sense (e.g., in the form of institutional acts) as interpreted through discipline-specific analytical lenses. If seen from the perspective of regulatory compliance, for example, specific behavioral details are of lesser concern than their meaning or effects in the context of a given institutional setting, e.g., representing compliance, violation, enforcement, etc. Institutional functions as an umbrella includes both conceptions of regulative functions – as discussed in this context – and constitutive functions – discussed in the following section. The value of this concept is to map operations as expressed in institutional statements to an analytical level relevant to the analyst, as well as to leverage an unambiguous characterization of the function an action signals in a given context. The value of an unambiguous characterization of actions becomes more apparent in action expressions that afford semantic transformations to reflect domain-specific meaning. Taking an excerpt from an earlier example, "… When a certifying agent (A) fails to take (I) appropriate action (B_{dir}) to enforce the regulations in this part ($C_{ex,pur,ref}$) …", the statement expresses a condition of non-compliance, i.e., the failure to take appropriate action, in the form of inaction. While apparent to the human coder, the inaction can be made accessible for analytical purposes. A pathway to afford this is to provide customized semantic annotations of components in order to signal regulative functions associated with the given action (with a regulative function taxonomy listed in the IG 2.0 Codebook). Figure 8 shows the complete illustrative example featuring nested

institutional statement combinations as activation conditions as well as regulative function annotations.

Insert Figure 8 Here

Transformation Rules. To leverage analytical opportunities from statement coding, IG 2.0 includes a set of transformation rules that afford flexible adaptation of statement structure, e.g., to infer implied regulated activity, or third-party obligations. Exemplifying one transformation rule (with the remaining ones listed in the IG 2.0 Codebook and forthcoming work), we build on the previously annotated statement and extrapolate all implied regulated activity for all role perspectives referenced in the annotated statement (e.g., Program Manager, certifying agent, etc.), i.e., we reconstruct variants of the statement from the perspective of each of those roles. The transformation steps are as follows:

- Within all atomic conditional statements, identify all atomic embedded statements
- For each atomic statement identified in the previous step,
    - Construct a separate leading monitored statement from the atomic statement,
    - Invert the statement
        - by introducing a corresponding (or modifying an existing) Deontic component (e.g., violate → must not violate; cooperate → must not cooperate and vice versa), or
        - by negating the specified activity (or where annotated, the institutional function),
    - Append the unmodified original statement as a consequential statement, i.e., as 'Or else' component.

Operationalizing this using the aforementioned example, we arrive at the statement shown in Figure 9 for the nested first conditional statement (with the actor perspective for which the statement is reconstructed – here: certified operation - held in bold font, and linguistic additions held in italicized brackets).

Insert Figure 9 Here

Following these steps, Figure 10 showcases the regulative instruction for the second conditional statement that relates to the “certifying agent”.

Insert Figure 10 Here

The final statement derived from the third conditional statement extracts the obligations associated with the “State organic program’s governing State official” as visualized in Figure 11.

Insert Figure 11 Here

Reviewing those examples, we can observe how the annotation with institutional functions and standardized logical transformation leverages two aspects. Firstly, it enables the reconstruction of an actor relationship network (in this case tripartite) from a single statement, but furthermore fosters the explicit representation of the largely implied obligations attached to all involved actors, an aspect common in regulatory documents. The example provided here illustrates this with respect to the expectation that certified operations have to comply with the Act - an aspect that is implied and unproblematic from a pragmatic perspective and legal interpretation, but only by transformation made accessible for explicit logical treatment. The role-centered extrapolation of statements, as showcased by this specific transformation rule, further responds to IG 2.0’s objective to abstract from linguistic aspects, such as biases carried by stylistic preferences or policy writing practice (e.g., expression of policy from specific actor’s perspective).

Extracting such embedded tacit information in a standardized algorithmic manner enables the logical evaluation, be it by reasoning or through behavioral institutional models, a feat that would otherwise exclusively rely on manual interpretation on the part of a modeler or analyst.

Following this overview of regulative institutional statements in IG 2.0, in the following section, we turn to a discussion of constitutive statements and associated syntax.

4. Constitutive Institutional Statements & Hybrid Institutional Statements

4.1 Constitutive Institutional Statements

Complementing the introduction of levels of expressiveness from the regulative perspective, a second innovation in IG 2.0 is the introduction of an explicit consideration of constitutive institutional statements. Constitutive statements configure and parameterize features of the institutional system. Constitutive statements define, modify, or otherwise ascribe attributes or characteristics to individual entities, where entities can be actors, objects, artifacts, organizational structures as well as roles and actions as relevant in a specific institutional setting (see e.g., Biagioli 2009). This specification or characterization of entities further includes endowment of authority (e.g., specification of institutional/declarative power) and other forms of status. In addition to the emphasis on regulated entities, constitutive statements can act self-reflectively by imposing constraints on their own applicability, and thus entertain a meta-constitutive function in that they may not only focus on the entities that are subject to a given policy, but further define, parameterize and contextualize the policy (source) itself. The latter generally involves the specification of initiation and termination of a given policy, as well as its relation to other policies (e.g., substitution, amendment, etc.). Naturally, the distinction between regulative and constitutive statements can be challenging, given that the definition of a role, may naturally imply a set of attached behavioral constraints. Moreover, as observed in extant literature (e.g., Searle 1969) and discussed in the conclusion of this section, constitutive statements can often be reconstructed in regulative terms in the first place (Hindriks 2009), but more importantly, the constitution of entities in a given institutional setting can have consequences for the institutional setting that may not be stated or regulated explicitly (Cherry 1973).

Recognizing the theoretical debate on the relationship of constitutive and regulative statements, empirically the analyst is nevertheless challenged to encode statements that have a distinctive constitutive definitional form that diverts from the regulative form. Averting potential reliability challenges, such statements are often ignored in prevailing coding practice. Addressing this limitation of the IG and affording comprehensive encoding of policy, IG 2.0 includes a syntax capturing both constitutive and regulative statements, including potential combinations thereof.

In this section, we outline encoding principles for constitutive statements. Given the novel consideration of constitutive statements as part of the IG, the initial focus is the introduction of fundamental components upon which the syntactic structure of constitutive statements builds. Deviating from the traditional general characterization of constitutive statements in the syntactic form "X is/counts as Y in context Z" as proposed by Searle (1969), the constitutive syntax proposed as part of the IG 2.0 seeks a comprehensive reflection of constitutive statement structure as *observed in practice*. With this objective in mind, we introduce the following syntactic components of constitutive institutional statements. The *Constituted Entity* reflects the entity that is defined, modified or otherwise characterized (constituted) as part of the institutional statement – the definiendum, and corresponding to the "Y" in Searle's conception. The *Constituting Properties*, in contrast, captures the characteristics to be associated with the Constituted Entity – reflecting the definiens in an institutional statement, loosely corresponding to the "X" in the general syntax. The component that characterizes the linkage between Constituted Entity and Constituting Properties is the *Constitutive Function*. The functional relationship of Constituted Entity and Constituting Properties is not uniform, since it can involve the definition, modification, of the entity, but, for

example, further reflect the endowment of authority, power and other forms of status. As with regulative statements, we find a differentiated characterization of statement *Context* in terms of activation condition, conditions under which a given statement applies, and execution constraints that offer qualification for the Constitutive Function specifically, or entity characterizations more generally. A noteworthy deviation from the regulative structure is the Modal component that seeks a general characterization of regulated activities or constitutive functions. While the regulative Deontic links a regulated activity with a responsible actor, or duty bearer, and reflects elements of deontic logic, the constitutive Modal makes reference to modal logic more generally, capturing the ability to express *necessity/requirement* or mere *possibility* (as parallels to *obligation* and *permission* in deontic logic) without immediate association with responsible actor. In practice, this reflects the role of constitutive statements to capture institutional settings more generally (e.g., in terms of entities, roles, and actions that are required to exist), where the implementation of associated duties is generally left to associated regulative statements. The following examples highlights this use: "This regulation *shall* come into effect on …". While this example states that a regulation will come into force (i.e., is required to be in force) by a certain date, it does not explicate how this comes about and potential associated responsibilities.

Finally, as found in the regulative case, we likewise consider the existence of an *Or else* component in the form of nested institutional statements for constitutive statements. Beyond the specification of regulative-punitive or -incentivizing consequences introduced in the context of regulative statements, Or else components can further have reflective function. They can, for example, render a specific institutional statement invalid as a consequence of non-fulfillment of the institutional content specified as part of the monitored constitutive statement, and thereby affect systemic aspects of the institutional configuration more generally – without necessarily

specifying an explicit sanction. The following example – devoid of any explicit syntactic treatment – illustrates such case: "In student recruitment plans, diversity must mean diversity in race, religion, sexual orientation and gender, or else [the plans are invalid]." (where the squared brackets signal a vertically-nested statement). Combined with the *Modal* characterization ("must" signals a requirement), the *Or else* carries the important role of expressing *existential* consequences (here the plan's invalidity), or triggering other activities that are not necessarily incentivizing of punitive in kind. Integrating constitutive statement characteristics, the refined *Or else* captures various forms of consequences (e.g., social, existential, physical or other forms of systemic consequences) that follow the non-fulfillment of the leading institutional statement.

With these components as basis, we propose the representation of constitutive institutional statements in a syntactic form akin to the ABDICO syntax for regulative statements, captured in the acronym *PMFECO*, composed of the *Constituting Properties* (P), *Modal* (M), *Constitutive Function* (F), *Constituted Entity* (E), alongside *Context* (C) and *Or else* (O) components. Out of these components, Constitutive Function, Constituted Entity and Context (FEC) are necessary to form a constitutive statement, whereas all remaining components are sufficient.

With the specification of these fundamental components in mind, we can turn to the contextualization with the levels of expressiveness as introduced in IG 2.0.

IG Core

Mirroring the discussion in the context of regulative statements, for constitutive statements IG Core builds on the use of the basic components, alongside the conception of statement-level nesting, i.e., the combination of *atomic constitutive institutional statements* comprised of the PMFEC syntax (or any permissible variant thereof) as motivated above. As

with regulative statements, we explicitly recognize component properties for the Constituting Properties and Constituted Entity components (similar to Attributes and Object components for regulative statements) to capture the nuanced and detailed characterization of the substantive content these components carry. Before turning to deeper structural encoding under IG Extended, we complement this broad characterization with an example illustrating candidate coding of constitutive statements (coded akin to the inline annotation used in the regulative examples presented before): "From Jan 1 onward, (C_{ac}), proceeds (E) reported in monthly reporting requirements (E_{prop}) shall (M) mean (F) proceeds (P) from individual financial obligations (P_{prop})".

IG Extended

As with regulative statements, IG Extended captures structural details of institutional statements. This specifically involves the consideration of the Object-Property Hierarchy (see Section 3.2) to reflect the hierarchical structure of objects embedded in institutional statements, as highlighted for regulative statements. We illustrate its use in the context of decomposition patterns commonly found in the context of constitutive statements specifically. Taking the example of organizational entities, "The Committee (E) shall (M) consist of (F) a (President (P_a), [AND] Secretary (P_b), and [AND] qualified ($P_{c,prop}$) Treasurer (P_c))(P), appointed by the public (P_{prop})", we observe component-level combinations for constituted properties ("President", "Secretary", "Treasurer") that characterize the makeup of the constituted entity ("Committee"). Introducing this decomposition, structural elements are unambiguously identified alongside applicable logical connectors. To this end, the individual constituent properties can possess individual properties ("*qualified* Treasurer") as well as shared properties ("appointed by the public"), mirroring the annotation scheme introduced in the context of the Object-Property

Hierarchy. Specific operational aspects of the refinements as introduced on IG Extended level for constitutive statements are discussed in the IG 2.0 Codebook (Frantz and Siddiki 2020).

IG Logico

Central innovations relating to constitutive statements on IG Logico involve the systematic annotation of constitutive functions as the second specialization of institutional functions (the first being the regulative functions discussed in the context of regulative statements in Section 3.3). As indicated during the introduction of the constitutive syntax, constitutive functions carry a central semantic role in institutional configurations by characterizing the relationship between constituting properties (where existing) and constituted entity, or identifying the effect or purpose of the constituted entity in the institutional setting. Combined with the rather diverse forms of "constitution" such statements can express, a richer characterization specifically of the institutional function is important to capture the complementary role of constitutive statements (e.g., creation of entity vs. modification) and entities more generally in the context of an institutional setting. While not uniform in their function, we can observe a set of patterns that describe the relationship of constituted entity and constituting properties (if existing) and capture the declarative role these functions hold with respect to the institutional setting. To this end, we firstly recognize the two-fold nature of constituted entities in terms of entities as embedded in an institutional or policy setting, and secondly, the policy itself. Constituted entities of the first type can either be defined (e.g., definition of a role), as well as modified. In addition, we find constitutive functions that capture organizational or structural relationships, such as hierarchical structures (e.g., subordination) or other forms of compositions (such as the example highlighted above). We further find functions associated with the introduction (establishment) into and removal (termination) of given entities

from an institutional setting. As indicated before, a central feature specific to constitutive functions in an institutional setting is to capture the specification of institutional or declarative power and other forms of status. In contrast to the entity-centric definitional emphasis of constitutive functions, here the focus lies on the characterization of entities' relational and configurational embedding in an institutional setting. Moreover, the introduction of constitutive functions addresses the lacking ability to capture any representation of institutional power – a central shortcoming of institutional statements in the original institutional grammar in as far as its ability to capture institutional structure comprehensively is concerned. Figure 12 provides an overview of the different constitutive functions recognized at this stage (with detailed characterizations captured in the IG 2.0 Codebook).

Insert Figure 12 Here

While comparatively limited with respect to the level of detail, this overview builds on the discussion offered in the context of regulative statements, and provides an insight into the central refinements offered as part of IG 2.0. Before concluding the discussion of IG 2.0, we reconcile the characterization of statements that carry both regulative and constitutive components.

4.2 Hybrid Institutional Statements

The distinction between regulative and constitutive statements has invited for debate (see e.g., Hindriks 2009; Morin 2013), such as the implied reference to constituted entities in most regulative statements. Inasmuch as we have accommodated the encoding of constitutive statements based on syntactic components, we are left with the challenge to capture cases in which statements explicitly contain regulative *and* constitutive components (as opposed to merely referencing entities constituted antecedently), albeit at brevity in this context. Using the

illustrative example in Figure 13, we can observe that the statement embeds both structural features of regulative statements, as well as components of the introduced constitutive syntax, with the leading statement being of regulative nature, complemented by the object characterization in constitutive terms – reflecting the implied constitution of entities as part of regulative statements as alluded to by Hindriks (2009). The introduction of the constitutive syntax affords the explicit characterization of the structural interdependency of regulative and constitutive statements, which we refer to as *hybrid institutional statements*. We characterize specific statements based on the order of statement type occurrence as either *constitutive-regulative* or *regulative-constitutive hybrids* (such as the one exemplified).

Insert Figure 13 Here

As a specialization of hybrid institutional statements, and without further exemplification at this stage, we further identify occurrences of statements that afford overlapping annotation as *both* constitutive and regulative statements, characterized as *polymorphic institutional statements*. Such characterization highlights the ambiguity and limitations of linguistic representation for specific circumstances, but further resolves the accommodation of specific analytical objectives that may define the preference for their regulative or constitutive representation. All forms of hybrid institutional statements referenced here are described in detail in the IG 2.0 Codebook (Frantz and Siddiki 2020) and in forthcoming work.

5. Summary of Refinements and Concluding Remarks

In this article, we describe a substantial set of refinements under the umbrella IG 2.0, both to signify a progression of the IG specification, but at the same time, a conceptual departure. While the existing IG provides a general structure to understand institutional statements systematically, it is limited in its ability to capture institutional domains

comprehensively, harmonize disciplinary traditions and necessities, let alone fully attend to project-specific analytical objectives. Addressing this, the IG 2.0 iteratively refines the status quo by suggesting a review of fundamental principles of the IG, with specific focus on resolving ontological inconsistencies by favoring a semantic over syntactic perspective when refining component specifications. Capturing institutional configurations more comprehensively, IG 2.0 further increases coding reliability by accommodating expression patterns found in practice. At the same time, IG 2.0 enhances analytical value by offering selective coding on specific levels of expressiveness aligned with the analyst's objectives and methodological toolbox, such as accommodating component-level statistical analyses as commonly applied in the context of the original IG (IG Core), richer structural representations supporting the development of behavioral models (IG Extended), or a logical treatment of encoded policy (IG Logico). The revisions introduced here are inclusive: We largely retain compatibility with previous coding practice, but we specifically recognize and consequently accommodate the need to open up the IG to novel application arenas as enabled by improved computational tractability of the IG 2.0.

Recollecting essential features of IG 2.0 for both regulative and the constitutive institutional statement types without further reiteration at this stage, Figure 14 provides an integrated overview of the syntactic structure and associated features by levels of expressiveness.

Insert Figure 14 Here

A limitation specific to the presentation in this article is the brief treatment of the range of features IG 2.0 incorporates. Highlighting the essential features, entrenched theoretical and operational treatment at greater depth is left to forthcoming work.

We conclude this paper by arguing, as others have, that the IG is a promising approach for characterizing institutional design. In doing so, we further argue that reliable and robust

characterizations of institutional design, including institutional structure and meaning, is fundamental to institutional analysis more broadly, which policy and administration scholars have consistently relied on to broach questions central to these fields. However, because the IG is an approach that is relatively nascent, we urge the user community to challenge its theoretical and operational foundations posed here and elsewhere. Such challenges are necessary for encouraging scientific progress. We also posit the need for the user community to generate further insights about the analytical value and possibilities of leveraging the IG to understand institutional design; specifically offering guidance about how to aggregate the micro-institutional data generated through IG applications to produce meaningful insights about behavioral, systemic, and institutional outcomes.

References

Biagioli, C. (2009): Modelli Funzionali delle Leggi: Verso Testi Legislativi Autoesplicativi. European Press Academic Publishing, Firenze.

Brady, U., Basurto, X., Bennett, A., Carter, D.P., Hanlon, J., Heikkila, T., Lien, A., Chonaiew, S., Olivier, T., Schlager, E., Siddiki, S., & Weible, C.M. (2018). Institutional Analysis of Rules-in-Form Coding Guidelines. Center for Behavior, Institutions, and the Environment Working Paper Series, #CBIE-2018-006. Tempe, Arizona.

Basurto, X., Kingsley, G., McQueen, K., Smith, M., & Weible, C.M. (2010). A systematic approach to institutional analysis: Applying Crawford and Ostrom's Grammar. Political Research Quarterly 63, 523-553. DOI: 10.1177/1065912909334430

Cherry, C. (1973). Regulative and Constitutive Rules. The Philosophical Quarterly, Vol. 23, No. 93 (Oct., 1973), pp. 301-315

Crawford, S.E.S., & Ostrom, E. (1995). A grammar of institutions. American Political Science Review 89, 582-600. DOI: https://doi.org/10.2307/2082975

Crawford, S.E.S., & Ostrom, E. (2005). A grammar of institutions. In E. Ostrom (Author), *Understanding Institutional Diversity* (137-174). Princeton, NJ: Princeton University Press.

Dunlop, C. A., Kamkhaji, J. C. & Radaelli, C. M. (2019). A sleeping giant awakes? The rise of the Institutional Grammar Tool (IGT) in policy research, Journal of Chinese Governance, 4:2, 163-180, DOI: 10.1080/23812346.2019.1575502

Ellis, B. (2001). *Scientific Essentialism*. Cambridge, UK: Cambridge University Press.

Ellis, B. (2002). *The Philosophy of Nature*. Montreal, CA: McGill-Queen's University Press.

Frantz, C., Purvis, M.K., Nowostawski, M., & Savarimuthu, B.T.R. (2013) nADICO: A Nested Grammar of Institutions. In Boella G., Elkind E., Savarimuthu B.T.R., Dignum F., Purvis M.K. (eds) PRIMA 2013: Principles and Practice of Multi-Agent Systems. Lecture Notes in Computer Science, vol 8291. Springer, Berlin, Heidelberg, DOI: 10.1007/978-3-642-44927-7_31

Frantz, C. K. (2015): *Agent-Based Institutional Modelling: Novel Techniques for Deriving Structure from Behaviour*, PhD thesis, University of Otago, 2015, Available under: http://hdl.handle.net/10523/5906

Frantz, C. K., Purvis, M. K., Savarimuthu, B. T. R., & Nowostawski, M. (2015): Modelling Dynamic Normative Understanding in Agent Societies. Scalable Computing: Practice and Experience, vol. 16, no. 4, pp. 355-378, DOI: 10.12694/scpe.v16i4.1128

Frantz, C. K. & Siddiki, S. N. (2020). Institutional Grammar 2.0 Codebook, Available under: https://arxiv.org/abs/2008.08937

Heikkila, T., & Weible, C.M. (2018). A semiautomated approach to analyzing polycentricity. Environmental Policy and Governance, 28, 308-318. DOI: 10.1002/eet.1817

Hindriks, F. (2009). Constitutive Rules, Language, and Ontology. Erkenntnis 71, 253–275. DOI: 10.1007/s10670-009-9178-6

Langacker, R. W. (2008). Cognitive Grammar: A Basic Introduction. New York: Oxford University Press.

March, J.G., & Olsen, J.P. (1989). Rediscovering institutions. New York, NY: Simon and Schuster.

Morin, O. (2013) Three Ways of Misunderstanding the Power of Rules. In: Schmitz M., Kobow B., Schmid H. (eds) The Background of Social Reality. Studies in the Philosophy of Sociality, vol 1. Springer, Dordrecht. DOI: 10.1007/978-94-007-5600-7_11

North, D. (1990). Institutions, institutional change, and economic performance. Cambridge, UK: Cambridge University Press.

Ostrom, E. (2005). Understanding institutional diversity. Princeton, NJ: Princeton University Press.

Pierson, P. (2000). Increasing returns, path dependence, and the study of politics. American Political Science Review, 94, 251-267. DOI: 10.2307/2586011

Powell, W.W., & DiMaggio, P.J. (1991). The new institutionalism in organizational analysis. Chicago, IL: University of Chicago Press.

Schlüter, A., & Theesfeld, I. (2010). The grammar of institutions: The challenge of distinguishing between strategies, norms, and rules. Rationality and Society, 22, 445-475. DOI: 10.1177/1043463110377299

Schneider, N., Hwang, J. D., Srikumar, V., Green, M., Suresh, A., Conger, K., O'Gorman, T., & Palmer, M. (2016). A corpus of preposition supersenses. In Proceedings of the 10th Linguistic Annotation Workshop held in conjunction with ACL 2016 (LAW-X 2016) (99-109). DOI: 10.18653/v1/W16-1712.

Schneider, N., Hwang, J. D., Srikumar, V., Prange, J., Blodgett, A., Moeller, S. R., Stern, A., Bitan, A., & Abend, O. (2018). Comprehensive supersense disambiguation of English prepositions and possessives. Proceedings of the 56th Annual Meeting of the Association for Computational Linguistics, Melbourne, Australia, July 15–20, 2018

Searle, J. R. (1969): Speech Acts: An Essay in the Philosophy of Language. Cambridge University Press, Cambridge.

Searle, J. R. (2005). What is an institution? Journal of Institutional Economics 1, 1-22. DOI: 10.1017/S1744137405000020

Siddiki, S. (2014). Assessing policy design and interpretation: An institutions-based analysis in the context of aquaculture in Florida and Virginia, United States. Review of Policy Research, 31, 281-303. DOI: https://doi.org/10.1111/ropr.12075

Siddiki, S., Heikkila, T., Weible, C.M., Pacheco-Vega, R., Carter, D., Curley, C., DeSlatte, A., & Bennett, A. (2019). Institutional analysis with the institutional grammar. Policy Studies Journal. DOI: 10.1111/psj.12361

Siddiki, S., Weible, C.M., Basurto, X., & Calanni, J. (2011). Dissecting policy designs: An application of the institutional grammar tool. Policy Studies Journal. DOI: 10.1111/j.1541-0072.2010.00397.x

Smajgl, A., Izquierdo, L.R., & Huigen, M. (2008). Modeling endogenous rule exchanges in an institutional context: The ADICO sequence. Advances in Complex Systems 11, 199-215. DOI: 10.1142/S021952590800157X

Weible, C.M., & Carter, D.P. (2015). The composition of policy change: Comparing Colorado's 1977 and 2006 Smoking Bans. Policy Sciences 48, 207-231. DOI: 10.1007/s11077-015-9217-x

Williamson, O. E. (2000). The new institutional economics: Taking stock, looking ahead. Journal of Economic Literature 38, 595-613.

Figures

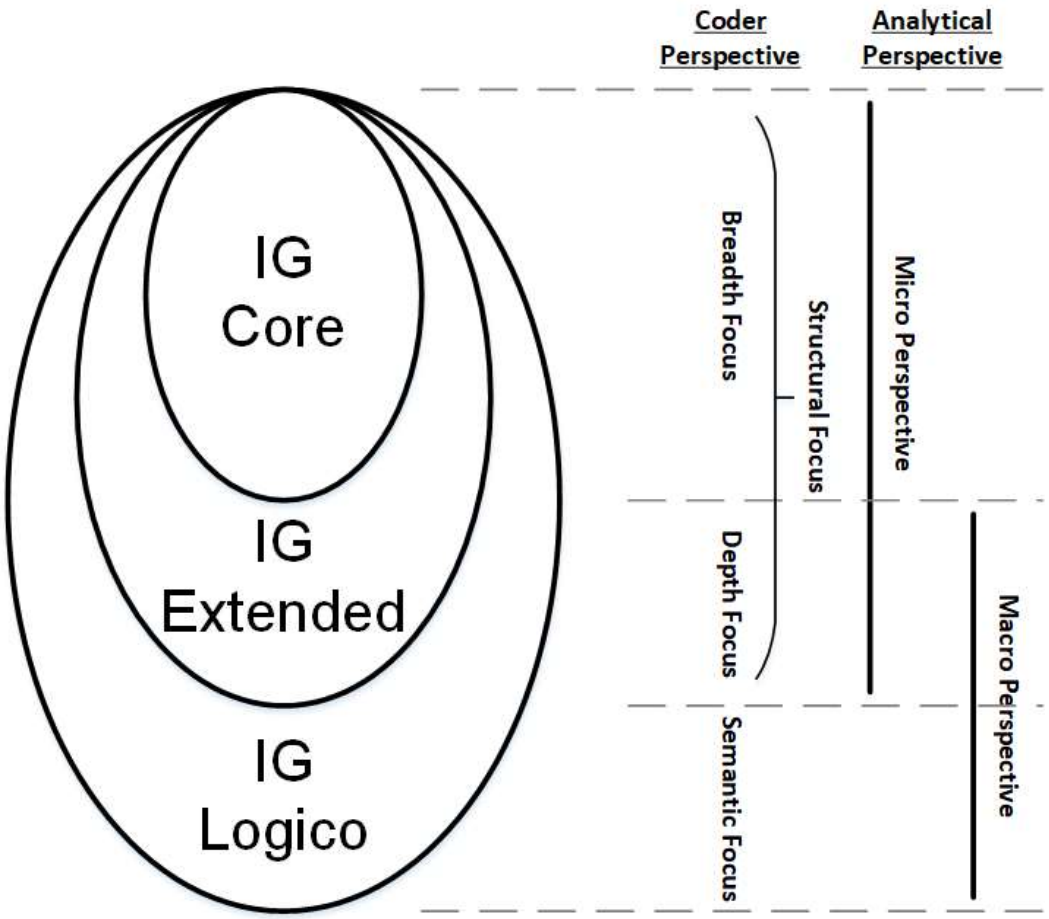

Figure 1. Conceptual Levels of the Institutional Grammar 2.0

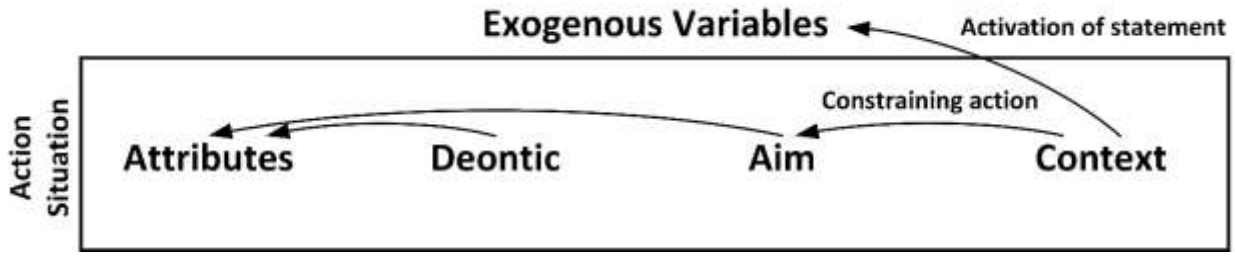

Figure 2. Positioning of Activation Conditions and Execution Constraints relative to the Action Situation

Certified (A_{prop}) organic (A_{prop}) farmers (A) must not (D) apply (I) synthetic chemicals (B_{dir}) to crops (B_{ind}) at any time (C_{ex}) once organic certification is conferred (C_{ac}), **or else**

[

- Certifier (A) will (D) administer (I) official (B_{prop}) notice of noncompliance (B_{dir}),
  AND
- (Certifier* (A) will* (D) revoke (I) certification of farmer* (B_{dir}),
  XOR**
- Certifier* (A) will* (D) suspend (I) certification of farmer* (B_{dir}))***.

]****

* The component value is inferred from the leading monitored statement.

** The characterization as 'either or' highlights the IG's objective to resolve ambiguity found in human language, specifically the context-dependent interpretation of logical relationships. This specific choice (XOR) rests on the broader understanding of the policy: in the context of the referenced organic farming regulation, suspensions and revocations are exclusive measures.

*** Parentheses signal distinctive sanction alternatives (suspension, revocation) in addition to the prescribed notice of non-compliance (which is administered irrespective of associated consequence).

**** Square brackets signal vertical nesting, where the nested statements express combinations of consequences (horizontal nesting) that follow the non-compliance with the activity regulated in the leading monitored statement.

Figure 3. Horizontal and Vertical Nesting in Institutional Statements

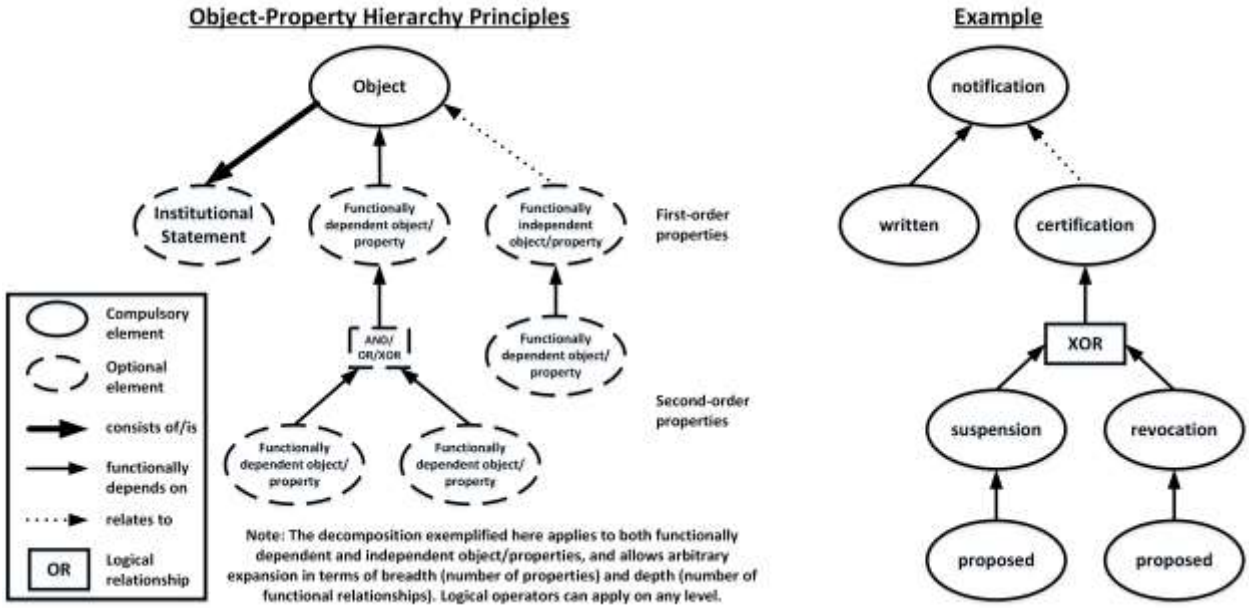

Figure 4. Object-Property Hierarchy

Differentiation of Activation Conditions and Execution Constraints

Activation Conditions describe the entry into a new action situation, which includes the specification of circumstances, such as environmental variables, but also novel of modified relationships between attributes, objects and actions.

Execution Constraints are necessary descriptors to complement a rule specification. While the statement may make reference to specific circumstances that characterize the regulated activities, execution constraints to not provide any information as to when, where, or otherwise specified, the institutional statement comes into force.

Heuristics for the Differentiation

Activation Conditions: To satisfy the conditions for characterization as activation conditions, the identified context clause in question must *satisfy at least one of the following conditions* related to attributes, objects, or circumstances:

- ***Attributes: The clause instantiates a) a change in attributes linked to a statement's activity or b) a change in attribute role.***
  - Example: Between the hours of 6pm and 6am on Mondays, members of neighborhood watch residing in blocks 7-10 will assume night patrol activities. (change in attribute role within specified time frame)
- ***Objects: The clause instantiates a change of the object(s) linked to the statement's activity.***
  - Example: Starting Dec. 15th, inspectors must exclusively use revised inspection form. (novel object use)
- ***Environmental circumstances: The clause instantiates a discrete setting (constrained temporally, spatially, or otherwise as shown below) in which the non-conditional clause is the attribute links in an altered way to statement activity and receiver of the activity (i.e., direct object).***
  - Example: Upon receiving final notice of non-compliance, farmers shall cease sale of any product bearing the USDA organic farming label. (instantiation of novel attribute-action link in discrete temporal setting)

Execution Constraints: Execution constraints are identified based on a single heuristic:

- ***Assuming that the context clause complements the action description, and in the selective removal of other potential context descriptors, can the statement be construed to apply under all circumstances?***
  - Example: Parents must drop their kids at school between 7:30 and 8:00am.
    In this example, given that absence of other context clauses, the statement as a whole applies at all time (no indication with respect to initiation or termination of the rule is provided); the temporal constraint complements the content of the rule – the context in which «dropping off» has to occur - and thus complements the action description.

Examples for activation conditions and execution constraints for all taxonomy types are provided below:

Context Taxonomy and Associated Examples for Activation Condition and Execution Constraints

	Type of Context	Activation Condition → activate statement	Execution Constraint → qualifies action in execution
Substantive Context	Temporal		
	Point in time	Starting June 15th, inspector should use updated fish health checklist.	Students must submit report on 15th December.
	Time frame	Between the hours from 10:00pm and 6:00am, neighborhood residents participating in "Neighborhood Watch" must assume patrol duties.	Parents must drop their kids at school between 7:30 and 8:00am.
	Spatial		
	Location	When entering marina, person must reduce boat speed to 5 kph.	Person must dock boat in licensed marina.
	Direction	Farmer must carry special permit when transporting fish from state A to state B.	Tow trucks must transport illegally parked vehicles from street to auto impound.
	Domainal		
	Activity realm	During decision-making, each member has the right to one vote.	Drivers must not stop irrespective of others' driving.
	Topical realm	For drinking water, the responsible authority may perform inspections at its discretion.	Professor shall rely on administrative office for questions related to plagiarism.
Procedural Context	Order	Upon completion of the certification process, a farmer may advertise as organic.	Department shall review tenure files following the interview of the candidate.
	Method		
	Means	If greeting by handshake, individuals should mind hygiene.	Sick individuals should avoid greeting by handshake.
	Instrument	If a person tests for Covid-19 using rapid test, the individual may request for reduced quarantine period.	Person shall determine their quarantine period based on type of Covid-19 test.
Aspirational Context	Purpose	If inspected unannounced for compliance assessment, farmer must provide inspector with all requested information immediately.	Certifiers may perform random checks to ensure compliance.
Situational Context	Circumstance		
	State	When the traffic light is red, drivers must stop.	Patients may receive vaccination while seated.
	Event	When the traffic light turns from red to green, drivers must resume driving.	Joggers with pace-makers shall remain attentive to heartbeat when transitioning from walking to running.

Notes:

- Context categories can overlap for the purpose of annotation, i.e., a specific context characterization can both be identified as temporal and situational. Categories can furthermore vary in generality; specifically State and Event characterizations are more general than other categories.
- The underlined statement components signal the exemplified context type; they do not necessarily identify complete conditional/constraining statements.
- A characterization for all context types exemplified here is provided as part of the IG 2.0 Codebook (Frantz and Siddiki, 2020).

Figure 5. Activation Conditions and Execution Constraints Definitions, Differentiation Heuristics, as well as Exemplification in Context Taxonomy

... When the Program Manager (A) has reason to believe (I) that a {certified operation (A) has violated (I) the Act ($B_{dir,ref}$)} (B_{dir})

OR

... When the Program Manager (A) has reason to believe (I) that a {certified operation (A) has violated (I) regulations in this part ($B_{dir,ref}$)} (B_{dir})

OR

... When the Program Manager (A) has reason to believe (I) that a {certified operation (A) is not in compliance (I) with the Act ($B_{dir,ref}$)} (B_{dir})

OR

... When the Program Manager (A) has reason to believe (I) that a {certified operation (A) is not in compliance (I) with regulations in this part ($B_{dir,ref}$)} (B_{dir})

An alternative and more concise encoding shifts the statement combination into the embedded Object expression:

... When the Program Manager (A) has reason to believe (I) that a {
(certified operation (A) has violated (I) the Act ($B_{dir,ref}$)) (B_{dir})
OR
(certified operation (A) has violated (I) regulations in this part ($B_{dir,ref}$)) (B_{dir})
OR
(certified operation (A) is not in compliance (I) with the Act ($B_{dir,ref}$)) (B_{dir})
OR
(certified operation (A) is not in compliance (I) with regulations in this part ($B_{dir,ref}$)) (B_{dir})}

Figure 6. Component-Level Nesting Example

(The Program Manager (A) may (D) initiate (I) suspension proceedings (B_{dir}) against a certified operation (B_{ind})

XOR

The Program Manager (A) may (D) initiate (I) revocation proceedings (B_{dir}) against a certified operation (B_{ind}))

({When the Program Manager (A) has reason to believe (I) that a {certified operation (A) has violated (I) the Act ($B_{dir,ref}$)} (B_{dir})

OR

When the Program Manager (A) has reason to believe (I) that a {certified operation (A) has violated (I) regulations in this part ($B_{dir,ref}$)} (B_{dir})

OR

When the Program Manager (A) has reason to believe (I) that a {certified operation (A) is not in compliance (I) with the Act ($B_{dir,ref}$)} (B_{dir})

OR

When the Program Manager (A) has reason to believe (I) that a {certified operation (A) is not in compliance (I) with regulations in this part ($B_{dir,ref}$)} (B_{dir})} (C_{ac})

OR

{When a certifying agent (A) fails to take (I) appropriate action (B_{dir}) to enforce the Act ($C_{ex,pur,ref}$)

OR

When a State organic program's governing State official (A) fails to take (I) appropriate action (B_{dir}) to enforce the Act ($C_{ex,pur,ref}$)

OR

When a certifying agent (A) fails to take (I) appropriate action (B_{dir}) to enforce the regulations in this part ($C_{ex,pur,ref}$)

OR

When a State organic program's governing State official (A) fails to (I) take appropriate action (B_{dir}) to enforce the regulations in this part ($C_{ex,pur,ref}$)} (C_{ac}))

Figure 7. Comprehensive Component-level Nesting Example

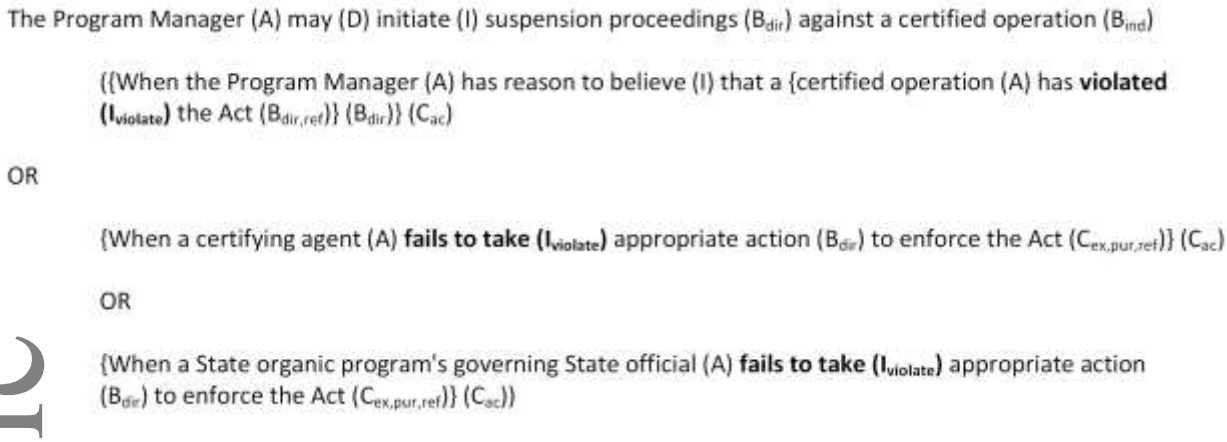

Figure 8. Regulative Functions Annotation Example

[A] **certified operation** (A) must not (D) violate ($I_{cooperate}$) the Act ($B_{dir,ref}$),

OR ELSE

the Program Manager (A) may (D) initiate (I) suspension proceedings (B_{dir}) against a certified operation (B_{ind})

({When the Program Manager (A) has reason to believe (I) that a {certified operation (A) has violated ($I_{violate}$) the Act ($B_{dir,ref}$)} (B_{dir})} (C_{ac})

OR

{When a certifying agent (A) fails to take ($I_{violate}$) appropriate action (B_{dir}) to enforce the Act ($C_{ex,pur,ref}$)} (C_{ac})

OR

{When a State organic program's governing State official (A) fails to take ($I_{violate}$) appropriate action (B_{dir}) to enforce the Act ($C_{ex,pur,ref}$)} (C_{ac}))

Figure 9. Transformed First Conditional Statement

[A] **certifying agent** (A) must not (D) fail to take ($I_{cooperate}$) appropriate action (B_{dir}) to enforce the Act ($C_{ex,pur,ref}$)

OR ELSE

the Program Manager (A) may (D) initiate (I) suspension proceedings (B_{dir}) against a certified operation (B_{ind})

({When the Program Manager (A) has reason to believe (I) that a {certified operation (A) has violated ($I_{violate}$) the Act ($B_{dir,ref}$)} (B_{dir})} (C_{ac})

OR

{When a certifying agent (A) fails to take ($I_{violate}$) appropriate action (B_{dir}) to enforce the Act ($C_{ex,pur,ref}$)} (C_{ac})

OR

{When a State organic program's governing State official (A) fails to take ($I_{violate}$) appropriate action (B_{dir}) to enforce the Act ($C_{ex,pur,ref}$)} (C_{ac}))

Figure 10. Transformed Second Conditional Statement

[A] **State organic program's governing State official** (A) must not (D) fail to take ($I_{cooperate}$) appropriate action (B_{dir}) to enforce the Act ($C_{ex,pur,ref}$)

OR ELSE

the Program Manager (A) may (D) initiate (I) suspension proceedings (B_{dir}) against a certified operation (B_{ind})

({When the Program Manager (A) has reason to believe (I) that a {certified operation (A) has violated ($I_{violate}$) the Act ($B_{dir,ref}$)} (B_{dir})} (C_{ac})

OR

{When a certifying agent (A) fails to take ($I_{violate}$) appropriate action (B_{dir}) to enforce the Act ($C_{ex,pur,ref}$)} (C_{ac})

OR

{When a State organic program's governing State official (A) fails to take ($I_{violate}$) appropriate action (B_{dir}) to enforce the Act ($C_{ex,pur,ref}$)} (C_{ac}))

Figure 11. Transformed Third Conditional Statement

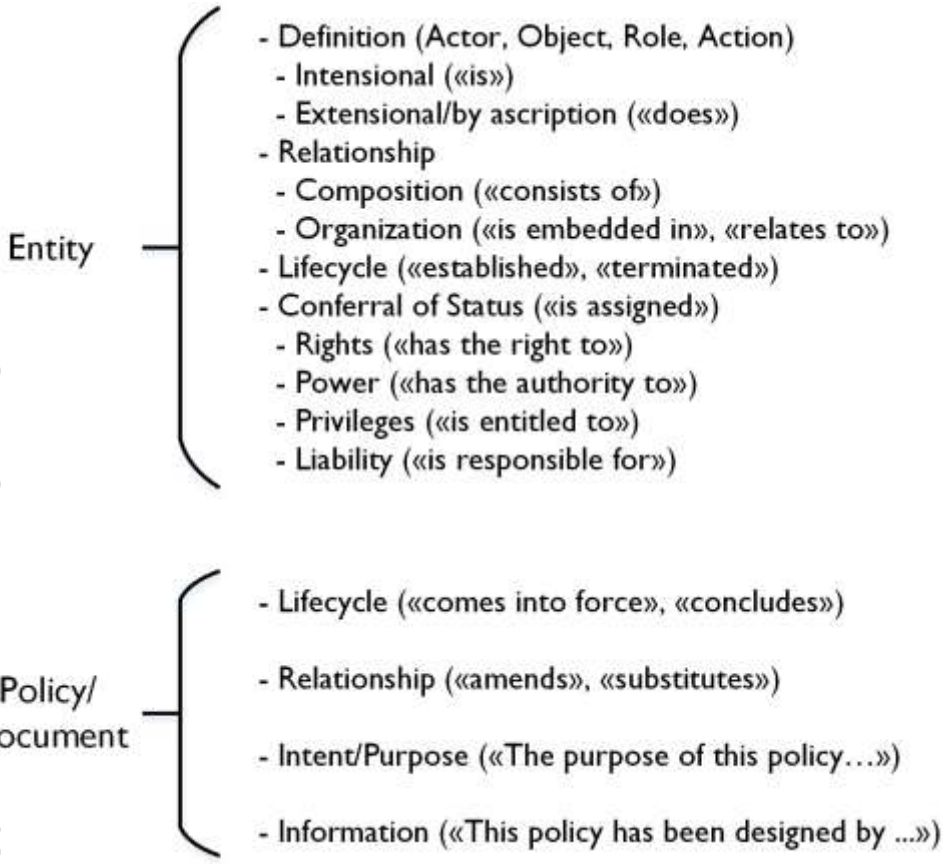

Figure 12. Constitutive Functions Taxonomy

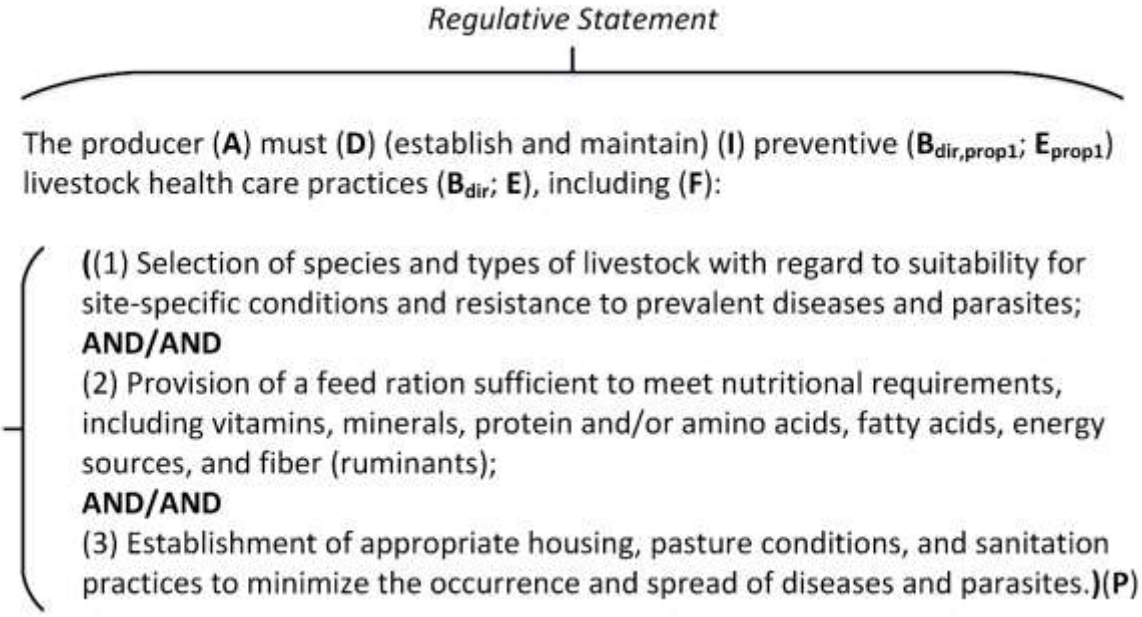

Figure 13. Regulative-Constitutive Hybrid Statement Example

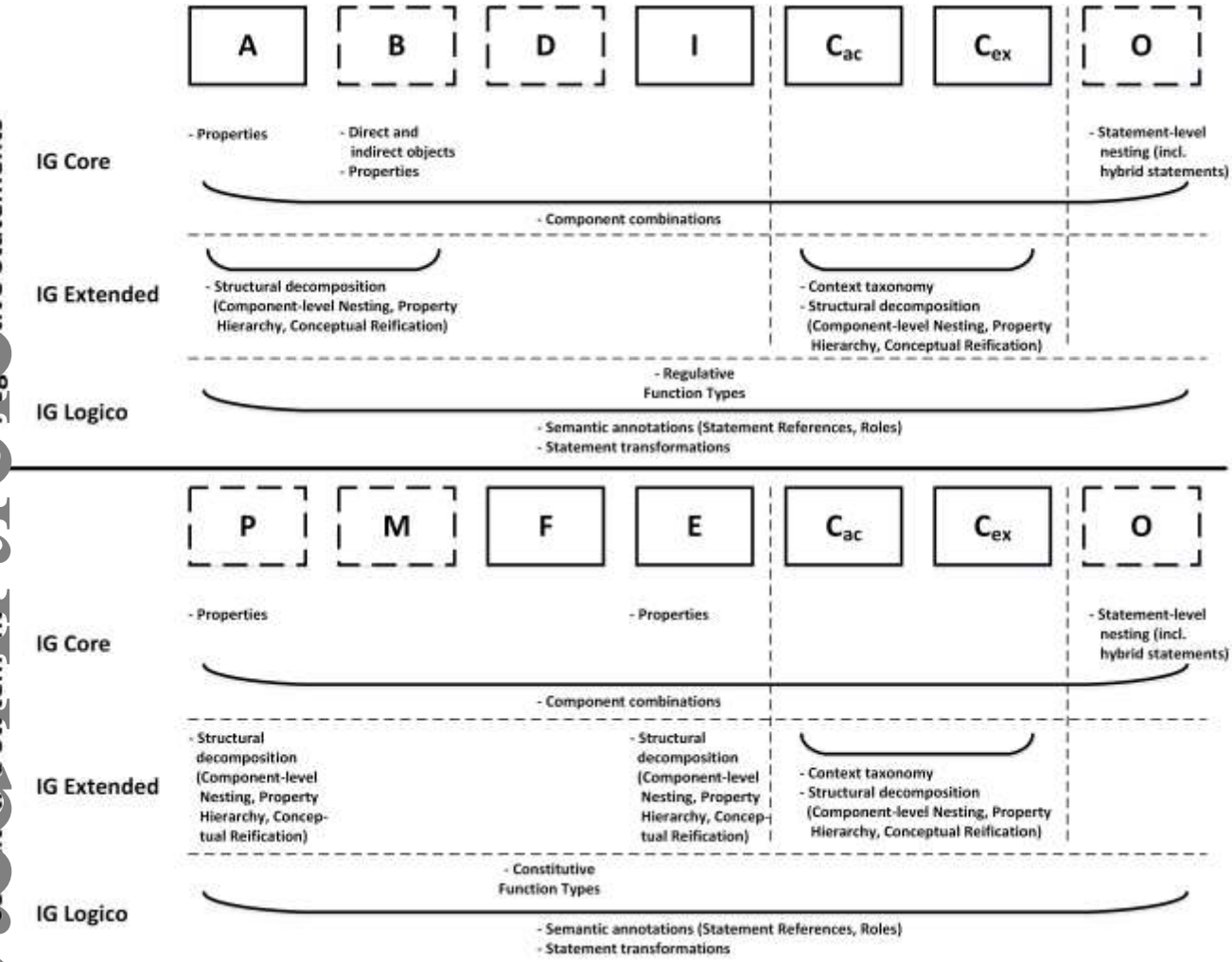

Figure 14. Regulative & Constitutive Statement Structure across Levels of Expressiveness

Appendix

Resources referenced throughout this article, including IG 2.0 Syntax and Semantics as well as a link to the IG 2.0 Codebook, can be found under the following URL: https://github.com/InstitutionalGrammar/IG-2.0-Resources