5. Compliance, Regtech, and smart legal ecosystems: a methodology for legal governance validation

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I INTRODUCTION

This chapter presents a methodology in three steps to empirically validate legal governance models, i.e. to validate the results of conditions and the interrelationship among the conditions selected to generate legal ecosystems. The concept legal ecosystem as discussed below refers to the totality of actors operating in a governance and compliance space. This is produced in the convergence of the so-called Internet of Things (IoT), the Web of (Linked) Open Data (LOD), and Industry 4.0 (I4.0) and 5.0 (I5.0).[1]

This three-step methodology aims to achieve the *empirical validation* of legal governance regulatory models. These steps are presented in three diagrams: (1) a scheme drawing the rule and meta-rule of law (Figure 5.1); (2) a meta-model for legal governance (Figure 5.2); and (3) a causal validation scheme for legal compliance (Figure 5.3).

These diagrams present the relevant concepts as (1) a general scheme with three dimensions and four clusters; (2) a meta-model encompassing legal compliance through design (LCtD) and ecological validity; and (3) the construction of an empirical validation model of causal chains. The ultimate objective of the methodology is to inform the building and testing of smart legal ecosystems for the Web 4.0 (the Web of Multi-agent Systems, MAS) and Web 5.0 (the Web embedding ethical values and legal norms). Industry 4.0 refers to smart manufacturing, covering a wide range of production and distribution processes. Industry 5.0, in addition, responds to the human social effects and consequences of adopting smart manufacturing on the IoT, including compliance with legal rules and ethical values, thus, linking automation and the effective use of cyber-physical systems to the human dimension.[2] Our methodology is meant to link and integrate these technologies and processes to ensure that they can operate in accordance with the relevant legal rules, policy principles, and ethical values.

[1] This chapter elaborates on a previous version presented as a position paper at the Research Workshop on Workshop on Artificial Intelligence for Legal Complex Systems (AICOL) at JURIX2022, *see* http://www.aicol.eu/.

[2] *See* Xun Xu, Yuqian Lu, Birgit Vogel-Heuser, and Lihui Wang, Industry 4.0 and Industry 5.0 – Inception, conception and perception, *Journal of Manufacturing Systems* (2021) 61: 530–5 (2021); Wei Xian, Kan Yu, Fengling Han, Le Fang, Dehua He, and Qing-Long Han, Advanced Manufacturing in Industry 5.0: A Survey of Key Enabling Technologies and Future Trends, *IEEE Transactions on Industrial Informatics* (2023).

This chapter mainly provides a conceptualization of *smart legal ecosystems*, following our previous work on the *middle-out* and *inside-out* approaches[3] and Human-Robot-Interaction (HRI).[4] It is noted that this methodological approach is general and flexible. It can therefore also be applied in relation to, and located in between, regulatory implementation models focusing on private and/or on public law. It can be easily applied in fields in which distributed (or federated) architectures and monitored semi-automated asymmetric multi-level governance are needed, such as cybersecurity, health, financing, and banking. Our approach embraces a conceptual and metricized gradual perspective, considering different types of compliance responses ranging from over-compliance to strict, literal, partial compliance as well as non-compliance.[5]

Our research programme is aimed at solving legal governance challenges in the emerging context of *hybrid*[6] or *symbiotic*, or *artificial social intelligence*[7] where humans and artificial agents cooperate to produce emergent second-order phenomena 'that involve groups of agents who reason and decide, specifically, about actions – theirs or others' – that may affect the social environment where they interact with other agents'.[8] We aim to develop solutions drawing on legal theory (jurisprudence), computer science, and Artificial Intelligence (AI) principles and perspectives.

The remainder of the chapter is structured as follows. Section II introduces the subject and key concepts. Section III is divided into three subsections that positions the three-step methodology for legal governance and smart legal ecosystems evaluation. Section IV is focused on the notion of smart legal ecosystem, comparing it with Elinor Ostrom's notion

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[3] Pompeu Casanovas, Louis de Koker, and Mustafa Hashmi, Law, Socio-Legal Governance, the Internet of Things, and Industry 4.0: A Middle-Out/Inside-Out Approach, *J. Multidisciplinary Scientific Journal* (MDPI) (2022) 5: 64–91, available at: https://www.mdpi.com/2571-8800/5/1/5.

[4] Pompeu Casanovas, Building a Smart Legal Ecosystem for Industry 5.0, in Woodrow Barfield, Yueh-Hsuan Weng, and Ugo Pagallo (eds.), *Cambridge Handbook on Law, Policy, and Regulations for Human-Robot Interaction*, Cambridge University Press, 2024 (in press).

[5] *See* Louis de Koker and Pompeu Casanovas, 'De-risking', De-banking and Denials of Bank Services: An Over-Compliance Dilemma?, in Doron Goldbarsht and Louis de Koker (eds.), *Financial Crime, Law and Governance: Navigating Challenges in Different Contexts*, Cham, Springer, 2024; Ho-Pun Lam, Mustafa Hashmi, and Akhil Kumar. Towards a Formal Framework for Partial Compliance of Business Processes, in Victor Rodríguez-Doncel (ed.), *International Workshop on AI Approaches to the Complexity of Legal Systems*, AICOL2020 XI-XII, LNAI 13048, Cham, Springer, 2020, pp. 90–105.

[6] Zeynep Akata, Dan Balliet, Maarten De Rijke, Frank Dignum, Virginia Dignum, Guszti Eiben, Antske Fokkens et al., A Research Agenda for Hybrid Intelligence: Augmenting Human Intellect with Collaborative, Adaptive, Responsible, and Explainable Artificial Intelligence, *Computer* (2020) 53, 8: 18–28.

[7] Pablo Noriega, Julian Padget, Harko Verhagen, and Mark D'Inverno, The Challenge of Artificial Socio-Cognitive Systems (2014). Available at https://digital.csic.es/bitstream/10261/132343/1/COIN2014_TP.pdf.

[8] Pablo Noriega, Jordi Sabater-Mir, Harko Verhagen, Julian Padget, and Mark d'Inverno, Identifying Affordances for Modelling Second-Order Emergent Phenomena with the WIT Framework, International Conference on Autonomous Agents and Multiagent Systems (AMMAS17), LNCS 10613, Cham: Springer, 2017, pp. 208–27.

of social-ecological systems, and providing examples from smart manufacturing. Section V draws some conclusions and describes future work.

II COMPLIANCE, THE INTERNET, AND INDUSTRY 5.0

A Key Concepts

This chapter applies a range of concepts that are helpful to explain upfront. The concepts are complex, and this brief discussion is aimed at clarifying and differentiating the concepts rather than comprehensively and exhaustively defining them.

1 Legal governance

By *legal governance* we understand the set of processes that generate a sustainable regulatory ecosystem reflecting fundamental legal concepts of a modern democracy.[9] We conceive it in this socio-technological context as an explanatory and validatory notion, primarily informed by a social and cognitive science approach, to support the implementation of the rule of law in hybrid environments in which Human-Machine-Interaction (HMI) and HRI constitute symbiotic contexts and scenarios.

2 Legal ecosystem

A *legal ecosystem* can be defined as a complex and dynamic system that includes multiple levels of governance, ranging from local to national and international, and involving a wide range of actors, including lawmakers, judges, lawyers, law enforcement officials, civil society organizations, companies, corporations, and ordinary consumers and citizens.[10] The ecosystem approach is not a mainstream approach in legal, social, or computational analysis theories. However, the idea of rights as social expectations to be organized and managed has been crucial for the political notion of *linked democracy ecosystems*, based on Elinor Ostrom's design principles for the effective management of common pool resource institutions or systems (CPRs).[11] Notably, Ostrom's late developments of dynamic social-ecological systems

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[9] *See* Marta Poblet, Pompeu Casanovas, and Víctor Rodríguez-Doncel, *Linked Democracy. Foundations, Methodologies and Applications*, Cham, Springer Nature, Law Briefs 750, 2019. Available at: https://www.springer.com/gp/book/9783030133627.

[10] *See* the references in notes 3 and 4. *See* also Mustafa Hashmi, Pompeu Casanovas, and Louis de Koker, Legal Compliance through Design: Preliminary Results of a Literature Survey, TERECOM@JURIX (2018): 59–74. Available at: http://ceur-ws.org/Vol-2309/06.pdf.

[11] Cf. Poblet et al., *Linked Democracy* (2019), p. 82 ff. The well-known and much discussed Ostrom's eight principles are: (1) Clearly defined boundaries; (2) congruence between appropriation and provision rules and local conditions; (3) collective-choice arrangements; (4) monitoring; (5) graduated sanctions; (6) conflict-resolution mechanisms; (7) minimal recognition of rights to organize; (8) for large social systems, nested enterprises (appropriation, provision, enforcement, conflict resolution, and governance activities organized in multiple layers of nested enterprises). Cf. Elinor Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge University Press, 1990, p. 90. For a critical review of the eight principles, cf. Michael Cox, Gwen Arnold, and Sergio Villamayor Tomás, A Review of Design Principles for

(SESs) also includes an updated version of a multi-level, nested framework for analysing outcomes achieved in SESs.[12] (See Section IV.D.)

3 Smart legal ecosystem

A *smart legal ecosystem* (SLE) is (partially) embedded into cyber-physical systems (CPSs) that function in an intelligent environment encompassing the features of the IoT, I4.0 and I5.0 (especially ethics and law), to achieve legal compliance in real time.[13] (See Section IV.E.)

4 Compliance

The Merriam-Webster Dictionary provides three different meanings of *compliance*: (1) 'the act or process of complying to a desire, demand, proposal, or regimen or to coercion'; (2) 'conformity in fulfilling official requirements'; (3) 'the ability of an object to yield elastically when a force is applied'.[14] Although the second meaning captures the desired result of our work, the behavioural nuances of the first and third meanings are also useful for our purposes. From a computational approach, *compliance*, in a broad sense, can be understood as fulfilling or aligning with normative constraints. It is worthwhile noticing that there are different types and grades of compliance,[15] depending on the regulatory source, the type of norms at stake, and the type of authority issuing the norms. For instance, strict compliance can be expected in case of enforceable norms. On the contrary, in the implementation of soft law and software technical standards, compliance and risk managers may adopt a more flexible stance,[16] unless non-compliance may hold serious reputational or other consequences.

Community-Based Natural Resource Management, *Ecology and Society* (2010) 15, 4. Available at: https://www.jstor.org/stable/26268233.

[12] Ostrom provides a multilevel holistic view to decompose the complexity of SESs. She shows the relationships 'among first-level core subsystems of an SES that affect each other as well as linked social, economic, and political settings and related ecosystems'. Core subsystems are: (1) *resource systems* (e.g., parks encompassing forested areas, wildlife, and water systems); (2) *resource units* (e.g., trees, shrubs…); (3) *governance systems* (e.g., the government and other organizations to manage the park with specific rules); and (4) *users* (individuals who use the park for multiple purposes). 'Each core subsystem is made up of multiple second-level variables (e.g., size of a resource system, mobility of a resource unit, level of governance, users' knowledge of the resource system), which are further composed of deeper-level variables.' Cf. Elinor Ostrom, A General Framework for Analyzing Sustainability of Social-Ecological Systems, *Science* (2009) 325 (5939): 419–22, p. 420.

[13] Cf. Pompeu Casanovas, Building a Smart Legal Ecosystem for Industry 5.0 (2024).

[14] *See* https://www.merriam-webster.com/dictionary/compliance. English Dictionaries usually refer to the behavioural and institutional dimensions of the notion. The definition offered by the *Collins Dictionary*, e.g., refers broadly to the expectations driven by social bonds and institutions: 'Compliance with something, for example a law, treaty, or agreement means doing what you are required or expected to do.' Available at: https://www.collinsdictionary.com/dictionary/english/legal-compliance#google_vignette.

[15] Louis de Koker and Pompeu Casanovas, 'De-risking', De-banking and Denials of Bank Services: An Over-Compliance Dilemma? (2024).

[16] Cf. 'Software engineering standards determine practices that "compliant" software processes shall follow. Standards generally define practices in terms of constraints that must hold for documents. The document types identified by standards include typical development products, such as

5 Business compliance

In a strict sense for technologists, *business compliance* points to a previously selected set of requirements for industry and business and industry processes, as set, for instance, by ISO/IEC 2700, the international gold standard for information security management, among many others.[17] More generally, for the industry and corporate organizations, it means business policies, procedures, and processes that accord with the relevant laws, regulations, standards, best practices, or similar requirements. Business compliance therefore includes legal compliance by the business but extends to compliance with rules and norms that are not strictly legal in nature. In a broader sense, it refers to the behaviour of a human or artificial agent in conformity (in the case of human behaviour) or alignment (in the case of artificial agents) with a set of provisions, norms, rules, or principles (including values) that can, but may not necessarily, be codified or systematized in a code, regulatory model, or normative system.

6 Legal compliance

By *legal compliance* we broadly mean the whole process of being in conformance with the requirements set out both in traditional legal instruments (mainly hard law, i.e. the laws adopted by Parliaments and judgments of Courts), and other kinds of instruments that have a regulatory effect without being binding in law (soft law, such as standards, codes of conduct, regulatory and industry guidelines, and also codes of ethics).

From a business perspective legal compliance is therefore a sub-set of business compliance but legal compliance ranges also broader as individuals and non-business entities must also act in conformance with the law.

While business compliance, as mentioned before, aligns external requirements with corporates' internal policies and procedures, legal compliance denotes the conformity of legal subjects (with a variety of roles as citizens, consumers, corporations, companies, agencies, administration etc.) with the law.

Compliance management, is often encountered in the business context. It refers to the management of compliance obligations, i.e., the designing, implementing, revising, and monitoring of the execution of processes to ensure staff and business processes comply with industry and security standards, as well as corporate and regulatory policies and codes of ethics, primarily reflecting the hard and soft law with which the business must comply.

As we will see later, the entrenchment of a cognitive understanding with abstract patterns to produce a standardized sustainable behaviour is one of the main issues for the emergence of sustainable smart legal ecosystems. This raises the challenge of explaining the relationships between rules and regulations. Moreover, both from a business management and a legal point of view, the technical concept of *regulatory compliance* – a theoretical term referring to the conformity with a regulatory model – also raises the problem of the relationships between

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user requirements, and also process-oriented documents, such as progress reviews and management' (p. 836). Wolfgang Emmerich, Anthony Finkelstein, Carlo Montangero, Stefano Antonelli, Stephen Armitage, and Richard Stevens, Managing Standards Compliance, *IEEE Transactions on Software Engineering* (1999) 25 (6): 836–51.

[17] According to ISO/IEC 27002: 'The organization must identify and document its obligations to external authorities and other third parties in relation to information security, including intellectual property, [business] records, privacy/personally identifiable information and cryptography.'

rules and norms.[18] (See Sections II.B.2 and III.B.1.) Note that 'regulatory compliance' is often viewed by business as synonymous with legal compliance but the theoretical term is afforded the meaning as understood by technologists.

7 Rule and meta-rule of law

Traditionally, the *rule of law* conceptualizes the principle that tyranny and totalitarian forms of government of a social body are undesirable. In the legal tradition, this expression is defined as the set of practices, norms, rules, and principles that allow the functioning of the market and social bonds – the civil society – while securing justice. Thus, from a *procedural* point of view, the rule of law purports to restrict the arbitrary exercise of power, i.e., to avoid tyranny and dictatorship, as a political form. This poses the issue of legitimacy as a necessary (non-sufficient) condition. In a more *substantive* version, the rule of law refers to principles embracing fundamental rights. Both aspects will be assumed in this chapter. When these principles are formally represented into some kind of logic, set of algorithms and/or computer languages, we will refer to it as the *meta-rule of law*. Other related approaches consider legal instruments in the light of *meta-regulation*, i.e. 'the rules that govern how individual policies are developed and reviewed', for example, among others, impact assessment, stakeholder consultation, and evaluation.[19] This latter multi-levelled perspective entails validation processes, which is one of the main elements of our approach. (See Sections III.A and III.C.)

8 RegTech and LawTech

RegTech, *SupTech*, *LawTech*, *FinTech*, *GovTech* ..., are broad ostensive concepts recently introduced – mainly by marketers – into technology practice and then into regulatory instruments with no standardized meaning or consistent usage.[20] For instance, in Europe, according to many recent provisions and working documents of the EU Commission about the building of European Digital Market (EDM) and Common Data Spaces (CDSs), *GovTech* refers to technology at the service of public administration; *RegTech* to technology at the service of regulation and compliance; and *LegalTech* or *LawTech* to technology at the service of law (EU Strategy for Data, 2020).[21] In this chapter, we will broadly use *RegTech* in regard to legal web services on the Web of Data (WoD) and the IoT.

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[18] 'The general idea [of previous works] is to determine whether the constraints (i.e., norms) imposed by some regulatory framework (ranging from statutory acts, to regulations, to industry standards, to best practices and internal policies) are met by some systems. Regardless how good and feasible these approaches may be, to the best of our knowledge, the majority of the approaches neglect the aspect of whether the method they propose offers a faithful representation of the norms and it is suitable to reason appropriately with the norm.' Mustafa Hashmi, Guido Governatori, and Moe Thandar Wynn, Normative Requirements for Regulatory Compliance: An Abstract Formal Framework, *Information Systems Frontiers* (2016) 18: 429–55, p. 430.

[19] Kathrin Lauber and Eleanor Brooks, Why Meta-Regulation Matters for Public Health: The Case of the EU Better Regulation Agenda, *Globalization and Health* (2023) 19 (70), https://globalizationandhealth.biomedcentral.com/articles/10.1186/s12992-023-00971-4.

[20] Louis de Koker, Nicholas Morris, and Sue Jaffer, Regulating Financial Services in an Era of Technological Disruption, *Law in Context* (2020) 36 (2): 90–112, p. 92, https://journals.latrobe.edu.au/index.php/law-in-context/article/view/98.

[21] For instance, '*RegTech* can enable more cost-effective, highly-automated reporting by helping reporting entities provide data more accurately and rapidly. *SupTech* can assist supervisory authori-

B The Validation Turn

1 Situated cognition

The methodology that we are proposing enhances *situated* cognition, technology, and regulations, implementing some principles of cognitive and social sciences, neuroscience, and deontic philosophy, partially based on the pioneering work carried out by Edmund Husserl and his influence on Karl Bühler, Eric Voegelin, and Alfred Schütz.[22] These interwar developments constitute a specific trend within the phenomenological tradition, linking hyletic (sensitive) knowledge with the emergence of environments in specific (pragmatic) contexts. Expression is 'a parable of action', according to Johann Jakob Engel and Karl Bühler.[23] They could develop and discuss it on personal bases, without excluding Hans Kelsen and other neo-Kantian normative theorists from this discussion.[24] In the next generation, social and computer scientists applied and developed these cognitive notions – relationships, interactions, environments – in a range of fields including computer science,[25] linguistics,[26] anthropology,[27] and sociology.[28]

However, although we are taking an *expressive* path (see Section IV.A), we acknowledge that the relevant variables depend on the selected level of abstraction for building and applying the regulatory design. Thus, we can combine this contextual approach with the inferential rule modelling which can also be implemented as a component of the regulatory model. This combination does not prevent us from considering norms from outside the narrow context as well. On the contrary, humans (and robots) do not solely interpret the content of norms. They *play* with them, i.e. they figure out what they entail, they create and recreate their types and instantiations in many ways.

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ties by allowing faster processing and more accurate and sophisticated analyses of the reported data to support their decisions. The right technology will also be needed to implement and maintain key elements of the future reporting system such as the common data dictionary and the supervisory data space.' *See* the Communication from the Commission to the EU Parliament, *Strategy on supervisory data in EU financial services*, Brussels, 15.12.2021 COM(2021) 798 final, p. 13. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0798.

[22] Cf. Alfred Schütz, Husserl and His Influence on Me, *Collected Papers V. Phenomenology and the Social Sciences*, Lester Embree (ed.), Dordrecht: Springer, 2011, pp. 1–4.

[23] Janette Friedrich, Le concept d'expression chez Karl Bühler, *Intellectica. Revue de l'Association pour la Recherche Cognitive* (2012) 57 (1): 199–217.

[24] Alfred Schütz, Letters of Schutz to Felix Kaufmann, Eric Voegelin, and with Aron Gurswitsch, *Collected Papers V. Phenomenology and the Social Sciences*, Lester Embree (ed.), Dordrecht: Springer, 2011.

[25] Lucy Suchman, *Plans and Situated Actions: The Problem of Human-Machine Communication*. New York: Cambridge University Press, 1987.

[26] Gilles Fauconnier, *Mental Spaces: Aspects of Meaning Construction in Natural Language,* MIT University Press, 1994.

[27] Aaron V. Cicourel, Three Models of Discourse Analysis: The Role of Social Structure, *Discourse Processes* (1980) 3 (2): 101–31.

[28] According to Cicourel, e.g., 'The general point is that the communication we attribute to discourse and any paralinguistic and nonverbal activities is part of a complex, multi-level, not always integrated setting. Multiple sources of information are always operative and so our analysis of discourse must necessarily simplify or reify many aspects of social interaction as well as what we are calling discourse.' Ibid. p. 101.

As Amedeo G. Conte would say,[29] they are situated in an interactive dynamic *nomotropic* space in which norms and rules can be understood from a behavioural point of view, and this behaviour can divert from just complying or violating the rules.[30] It can recreate, reformulate, or even rewrite them as entities, as language, or as mere objects. *Acting-in-function-of rules* is not acting according to their content but considering the possibility of reshaping, reusing, or ignoring them in accordance with a plurality of interests, including *a contrario* interpretations of their explicit meaning. Conte furnishes several examples, based on the classical tradition of Max Weber, François de la Rochefoucauld, and Karl Bühler – the thief's, the hypocrite's, and phantasma's (*praxis am phantasma*)[31] *nomotropism*.[32] He adds that of the conscientious objector (e.g. burning the conscription letter as an expressive public answer). We find a similar perspective in the Common Law tradition (Oliver W. Holmes),[33] and, most interestingly, in the early developments of MAS and artificial societies. From a behavioural perspective, agents can also cheat and lie. Autonomous goal-directed behaviour as the root of all social phenomena has been one of the guiding main objectives of Cristiano Castelfranchi's work at micro and macro levels.[34]

2 Rules and regulations

This section builds on the last subsection. From our perspective, it is relevant to recognize and distinguish different dimensions in the relationship between *rules* and *regulations*. The first

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[29] Amedeo G. Conte, Nomotropismo: agire in funzione di regole, *Sociologia del diritto* (2000) 1: 1–26.

[30] 'I have named "nomotropism" [*Nomotropismus, Nomotropism, Nomotropisme, Nomotropizm*] *acting in-function-of rules*.' Amedeo G. Conte, *Sociologia filosofica del diritto*, Torino: G. Giappichelli Editore, 2011, p. 47. About its origins and the conceptual uses of the concept, see by the same author, *Adelaster. Il nome del vero*, Nomologi, v. 6. Milano: Edizione Universitarie di Lettere, Economia, Diritto, 2016, p. 87 ff.

[31] Bühler also called it *deixis am phantasma*, i.e. 'shifting the indexical ground or origo away from the participants' actual space of perception to an imagined space within which the speaker can orient the interlocutors' attention to physically absent entities'. Anja Stukenbrock, Pointing to an 'Empty' Space: Deixis am Phantasma in face-to-face interaction, *Journal of Pragmatics* (2014) 74: 70–93. *Deixis am phantasma* refers to the imaginary space in which the interlocutors can place the discourse to which they refer. According to Bühler, it has a role of discursive representation, like anaphora and *demonstratio ad oculos* (ocular demonstration). It has been translated by 'imagination-oriented deixis'. Cf. Karl Bühler, *The Theory of Language: The Representational Function of Language (Sprachtheorie)*, Translated by Donald Fraser Goodwin. Amsterdam: John Benjamin's Publishing Company, 1934/1990, p. 137 ff.

[32] *See* Amedeo G. Conte (2016), *Adelaster. Il nome del vero*, pp. 88 ff., and 194–5. It may be 'nomotropism' without compliance. 'Nomotropism and compliance to a rule are not equivalent' (ibid.).

[33] Justice Holmes' famous *dictum*: 'If you want to know the law and nothing else you must look at it as a bad man, who cares only for the material consequences which such knowledge enables him to predict, not as a good one, who finds his reasons for conduct, whether inside the law or outside of it, in the vaguer sanctions of conscience.' Oliver W. Holmes, Path of the Law, *Boston Law School Magazine* (1897) 1, (4): 1–3.

[34] Cristiano Castelfranchi, The Micro-Macro Constitution of Power, *ProtoSociology* (2003) 18: 208–65.

group of dimensions opens an abstract 'space', 'place', or '*topos*' (according to the dialectic and rhetoric tradition from the Middle Ages) at different levels of abstraction in which senses, concepts, and categories play a cognitive role. The second ones can be understood as *behavioural patterns*, directly pointing to an interactive social space.

G.A. Conte has proposed the scheme shown in Table 5.1 to discuss the interrelation between rule and regularity. This analysis supports the identification of some differences and similarities between *following* a rule, *complying* with a rule, *carrying out* a regularity, *fulfilling* some conditions, *satisfying* some requirements, and *generating* smart legal ecosystems (as shared, interactive, common behaviour).

Table 5.1 Conte's two paradigms and four Idealtypen for a philosophy of rules

–	**Rule**	**Regularity**
Deontic	Deontic rule	Deontic regularity
Non-deontic	Non-deontic rule	Non-deontic regularity

Source: Amedeo G. Conte, *Adelaster. Il nome del vero* (2016), p. 188.

This taxonomy assumes that there is a kind of continuum between rule and regularity, i.e. the answer to the question *What is the relationship between following a rule and continuing in a regularity?*[35] [carrying out a regularity] cannot be discrete or absolute, as assumed by neo-Kantian legal theories (*Sein* vs. *Sollen*). On the contrary, this continuum should be analysed from an empirical (phenomenological) perspective.[36] It is worth noting that either in this kind of approach, which is not assuming methodological individualism, or in Ostrom's taxonomy of rules that we will examine later (Section IV.B), which actually does it, deontic markers or operators (prohibition, obligation, permission) only work for a sub-set of linguistic sentences carrying on a regulatory function. According to Conte, a sentence can even have a *syntactic* deontic meaning without properly being a prescription, i.e. without having a *semantic* one.[37]

As we will see, we are not bounded by a deontic approach solely, but the *validation turn* we are proposing is able to cope with non-deontic rules, contingency, and legal validity at the same time, i.e. with different kinds of linguistic expressions and behavioural patterns alike from a *pragmatic* point of view.

[35] Conte's original question (in Italian) is: *Quale è il rapporto tra seguire una regola e proseguire una regolarità?* Amedeo G. Conte, *Adelaster. Il nome del vero* (2016), p. 189.

[36] Conte's answer assumes an *eidetic* phenomenological perspective: there is a *continuum* but not identity between regularities, which are identical to themselves, and rules, which are not.

[37] For example, in sentences such as 'the bishop must impart confirmation' or 'a will must have two witnesses', *must* is not expressing an obligation but a necessary (not sufficient) condition to get a valid confirmation or a valid will, i.e. in fact, what is expressed is an *anankastic* proposition. Amedeo G. Conte, *Adelaster. Il nome del vero* (2016), p. 189.

III A THREE-STEP METHODOLOGICAL APPROACH FOR LEGAL GOVERNANCE VALIDATION

This section outlines our methodology, identifying its main components and presenting them in ordered sequences. Nevertheless, a full development and theoretical discussion will not yet be offered. Our intention is to provide a brief first summary.

A First Step: A Meta-Rule of Law Scheme

Figure 5.1 provides a general schematic representation of the rule of law and its counterpart, the *meta-rule of law*, i.e. the embedded protections of the *substantive* rule of law – related to human and constitutional rights – in computer systems through formal languages. It highlights the difference between regulations that were conceived to rule human social behaviour, and the new digital dimension in which rules, principles, and instruments are embedded into formal languages and computational codes to be digitally generated, interpreted, and implemented. Natural, semiforma, and formal languages have different properties. As shown by the *ergativity*[38] of polysynthetic (not Indo-European) languages, there is no universal grammar covering all aspects of expressive verbal morphology.[39] Hence, plurality and difference start at the more basic level.

In our use, like in ancient Greek, *meta* means 'after', 'beyond', 'transcending', but not 'about' (they are not rules *about* rules, but *through* rules). It is a way to describe the way in which legal ecosystems (or socio-legal ecosystems), according to their main elements, can be built.

The cycle of the meta-rule of law is plotted in Figure 5.1. It shows the use of two axes (vertical: binding power, horizontal: social dialogue), three dimensions (social, legal, and computational), four clusters (hard law, policies, soft law, and ethics), and four cornerstones (multi-stakeholder governance, anchoring institutions, the binomial trust/security, and institutional strengthening) to produce regulatory effects. All these elements are components of the regulatory system lifecycle, i.e. *elements of legal governance*. The semi-automation of legal governance is the next step, i.e. the creation of a regulatory interspace, bringing together all relevant stakeholders (including rulers, industry, and citizens), and the AI and legal instruments at their disposal.

Hard law refers to binding legal rules arising from statutes, regulations, and case law; i.e. to the outcomes of legitimated and official bodies with a specific jurisdiction. *Soft law* includes rules arising from non-binding regulatory instruments based on dialogue and social and political agreements. These instruments are not formally enforceable and have very little or no binding force but are regularly used in international relationships and international law (codes, standards, recommendations, opinions, white books, expert advice …). Industrial

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[38] Ergativity refers to the 'tendency of a language to pair the subject, or agent, of an intransitive verb with the object, or patient, of a transitive verb', https://www.britannica.com/topic/ergativity. This cannot be considered a universal property of natural languages.

[39] Rachel Nordlinger and Evan Kidd, Uncovering Ergative Use in Murrinhpatha: Evidence from Experimental Data, *Australian Journal of Linguistics* (2023) 43 (1): 69–86.

Standards and technical protocols can also be broadly qualified under this category.[40] *Policies* are specific management standards or frameworks adopted to achieve specific goals in public or private organizations, i.e. broadly, to solve a set of organizational, economic, corporate, political, administrative, or government problems. Corporate policies (such as COSO[41] and COBIT[42]) have responded to a number of corporate and IT and data governance models, and more recently, to analytics and data governance models and architectures[43] (both for the market and for public administration).[44] Finally, *Ethics* involve the principles and values taken into account by hard law, soft law, and policies. They are usually embedded or mentioned in

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[40] See https://commission.europa.eu/law/law-making-process/planning-and-proposing-law/better-regulation/better-regulation-guidelines-and-toolbox_en. We could assert that, in this sense, soft law is becoming a component of the legislative process as well. EU Directives and Regulations, for instance, are built stemming from public consultation, expert knowledge, and impact studies.

[41] The *COmmittee of Sponsoring Organizations of the Treadway Commission* (COSO) is a joint initiative of the five private sector organizations of the financial sector. Among them, the American Accounting Association and the American Institute of CPAs. COSO was organized in 1985 to sponsor the National Commission on Fraudulent Financial Reporting, an independent private-sector initiative that studied the causal factors that can lead to fraudulent financial reporting. It also developed recommendations for public companies and their independent auditors, for the SEC and other regulators, and for educational institutions. COSO's *Internal Control – Integrated Framework*, and the *ERM Framework*, focuses specifically on four key components of an internal control system: (1) ethical environment – as a feature of the control environment component; (2) scope of risk management – as an element of the risk assessment component; (3) extent of internal audit activities – as a feature of the monitoring component; and (4) the quality of Accounting Control Procedures (ACPQ) – as an outcome variable of the control activities component. Cf. http://www.coso.org/.

[42] The *Control OBjectives for Information and related Technology* (COBIT) is a set of best practices, rules, and principles for IT governance created by the *Information Systems Audit and Control Association* (ISACA), and the *IT Governance Institute* (ITGI). COBIT consists of a set of generic processes for the management of IT. The framework defines each process together with process inputs and outputs, key process-activities, process objectives, performance measures, and a maturity model. The core of the model aligns business goals with IT processes (framework, process descriptions, control objectives, management guidelines, and maturity models). Cf. http://www.isaca.org/COBIT/.

[43] For a more detailed explanation, including *The Open Group Architecture Framework* (TOGAF) applications to public administration, see Legal Linked Data Ecosystems and the Rule of Law, chapter 5 of Poblet et al. *Linked Democracy* (2019) p. 87 ff.

[44] According to GARTNER, 'data governance is the specification of decision rights and an accountability framework to ensure the appropriate behavior in the valuation, creation, consumption and control of data and analytics'. GARTNER latest analyses constitute a warning about the exhaustion of models. 'Data and analytics governance continues to be a significant challenge for many organizations. Despite years of effort, and multiple failed efforts, the best practices targeted by many organizations remain outdated. Hype in data and analytics (D&A) around data products is rampant. Unfortunately, more and more data products, programs and projects are failing due to ineffective governance, tied to the lack of alignment to real business needs.' *See* Predicts 2024: Data and Analytics Governance Requires a Reset, 20 December 2023 – ID G00801644.

a broad way in other types of regulations, for example into the EU GDPR or into the so-called Artificial Intelligence Act.[45]

However, contemporary ethics consists of an articulated body of principles for regulation – fairness, equity, proportionality, transparency … – grounded on open theoretical stands that must be leveraged and discussed any time that they are applied to situations, scenarios, or conflictual cases. This is the reason for placing Ethics at the core of the meta-model of legal governance (see next section). This contention does not entail that law encompasses ethics on all occasions. Ethics constitutes an independent and autonomous theoretical field. What it entails is that for ethical principles to be operational, different levels of abstraction – high, medium, and low – must be distinguished. The meso-level is what allows us to choose and define the values that can be adapted to a particular context and micro-situation. But, on the other hand, legal formulations can ignore ethical principles, and sometimes do. Our position is that for an ecosystem to be considered 'legal', i.e. to be *legitimate* as well as *legal*, the transparency of ethical principles must be specifically clarified.[46]

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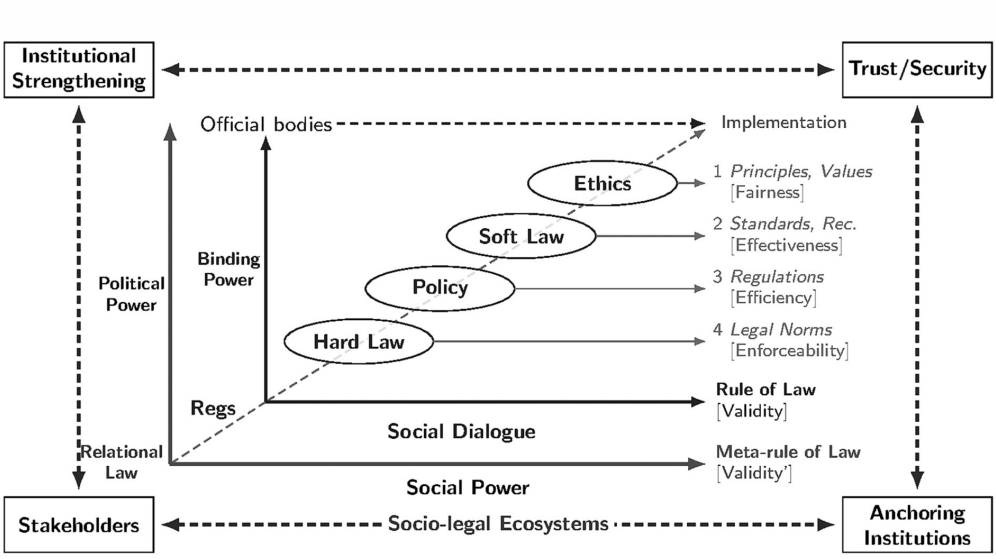
[45] Cf. Brussels, 21.4.2021 COM(2021) 206 final 2021/0106 (COD) Proposal for a *Regulation of the European Parliament and of The Council Laying Down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act) and Amending Certain Union Legislative Acts*, Brussels, 21.4.2021 COM(2021) 206 final 2021/0106 (COD). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52021PC0206. The final text, not yet published, was approved by the EU Parliament on 13 March 2024 with several amendments with respect to the original draft. Cf. *P9_TA(2024)0138 Artificial Intelligence Act European Parliament legislative resolution of 13 March 2024 on the proposal for a regulation of the European Parliament and of the Council on laying down harmonised rules on Artificial Intelligence (Artificial Intelligence Act) and amending certain Union Legislative Acts (COM(2021)0206 – C9-0146/2021 – 2021/0106(COD))* Cf. as well, (1) the High-Level Expert Group on AI (HLEG), *Ethics Guidelines for Trustworthy AI* (2019); (2) HLEG, *Assessment List for Trustworthy Artificial Intelligence (ALTAI) for self-assessment*, 2020; (3) the European Parliament resolution of 20 October 2020 on a framework of ethical aspects of artificial intelligence, robotics and related technologies, 2020/2012(INL).

[46] We use the classical concept of *congruence* to assess the compliance with ethical principles. Depending on the context and processes to be regulated, this may give rise to difficult questions as it may eventually depend on the discretionary interpretation of AI providers, as the EU AIA proposal specified: 'The precise technical solutions to achieve compliance with those requirements may be provided by standards or by other technical specifications or otherwise be developed in accordance with general engineering or scientific knowledge *at the discretion of the provider of the AI system*' (our emphasis) AIA Proposal, Explanatory memorandum, 5.2.3., p. 13, *in fine*. The final text approved by the EU Parliament stresses the role of 'regulatory sandboxes' officially set to control discretionary interpretations. Cf. on the origins and development of regulatory sandboxes and innovation hubs, Louis de Koker, Nicholas Morris, and Sue Jaffer, Regulating Financial Services in an Era of Technological Disruption, *Law in Context* (2019) 36 (2): 90–112. 'To respond to new financial innovation, regulators have been establishing innovation hubs and regulatory sandboxes. Innovation hubs enable them to engage innovators more effectively. Sandboxes allow the products to be tested in a controlled environment and enable regulators to consider whether existing laws are appropriate to regulate such products and, if not, what measures may be required' (p. 90). Cf. on regulatory sandboxes as instruments of legal governance, Ugo Pagallo, Paola Aurucci, Pompeu Casanovas, Raja Chatila, Patrice Chazerand, Virginia Dignum, Christoph Luetge, Robert Madelin, Burkhard Schafer, and Peggy Valcke, AI4People – *On Good AI Governance: 14 Priority Actions,*

Building a legal ecosystem for a specific platform, information workflow, or application starts with the conceptual model that must be designed, using a selection of relevant components from this scheme (Figure 5.1).



Source: Pompeu Casanovas, Louis de Koker, and Mustafa Hashmi, Law, Socio-Legal Governance, the Internet of Things, and Industry 4.0: A Middle-Out/Inside-Out Approach, *J. Multidisciplinary Scientific Journal* (MDPI) (2022) 5: 64–91, available at: https://www.mdpi.com/2571-8800/5/1/5.

Figure 5.1 Scheme for the meta-rule of law

It should be noted that, from the empirical approach that we are taking here, 'validity' (as a synonym of 'legality') is a second-order property that emerges only when a threshold for *enforceability, efficiency*, *effectiveness*, and *fairness* has been established and applied. Thus, it is not held as a property of single norms, but it should be applied to the whole regulatory model as a system.[47] When embedded in a logic language, we can predicate validity as a formal property related to consistency and coherency (*validity*), but it does not drag 'validity' with it in the same way that 'truth' does in descriptive logic reasoning. Our contention is that to make it 'legal', at the empirical level (i.e. at the *existential* or *ontic* level, not at the deontic one) more requirements are needed related to a more complex compliance process; and as we will state in

a S.M.A.R.T. Model of Governance, and a Regulatory Toolbox (November 6, 2019), available at SSRN: https://ssrn.com/abstract=3486508.

[47] Conte criticizes the unicity of the notion and contends that the term 'norm' refers at the same time to at least five different things: a deontic enunciation, a deontic proposition, a deontic statement, a deontic state of affairs, a deontic *noema.* We can observe that these 'deontic entities' are actually working in contexts that are deemed to be also different. *See* Amedeo G. Conte, Norme: cinq référents, *Phenomenology and Mind* (2017) 13: 22–8.

the next sections, *validation* processes cannot be equated with legal *validity* (as a second-order property or as a means of achieving consistency on the regulatory model).[48]

B Second Step: A Meta-Model for Legal Governance

1 Legal Compliance through Design (LCtD)

The second step comprises LCtD.[49] Legal compliance cannot be hard-coded but can be partially automated. LCtD encompasses legal interpretation and decision-making, bridging the path from the four clusters previously identified (the sources of law) to legal governance. The model situates Ethics at an intermediary position because it also applies directly to AI devices, platforms, modules, and applications, independently of jurisdictional and sovereignty principles and restrictions. LCtD leads to the emergence of *ecological validity* (a tuple of positive, empirical, composite, and formal validity).[50] The meta-model drawn in Figure 5.2 plots the whole process.

Especially *accountability* – the concept of being responsible and able to give satisfactory reasons for actions taken – and *explainability* – entailing that computer and AI models and their effects can be described in plain language to make sense for a human being – can be coupled to implement smart legal ecosystems (among other ethical principles).[51] The notion and levels of *autonomy* – the capacity to carry out independent decisions – is crucial, as it is a shared ability of both humans and AI systems that needs to be specified at any level of the generated ecosystems that are produced within hybrid HRI.

The way of embedding ethics and law into the system is not adopting a bottom-up or a top-down approach. The relationship between the choice and interpretation of ethical principles and legal provisions should be integrated into a *middle-out* and *inside-out approach*; i.e. focusing on the information flow of the modules in the platform and stemming from the execution of their functional tasks.[52] Hence, legal governance is generated through a con-

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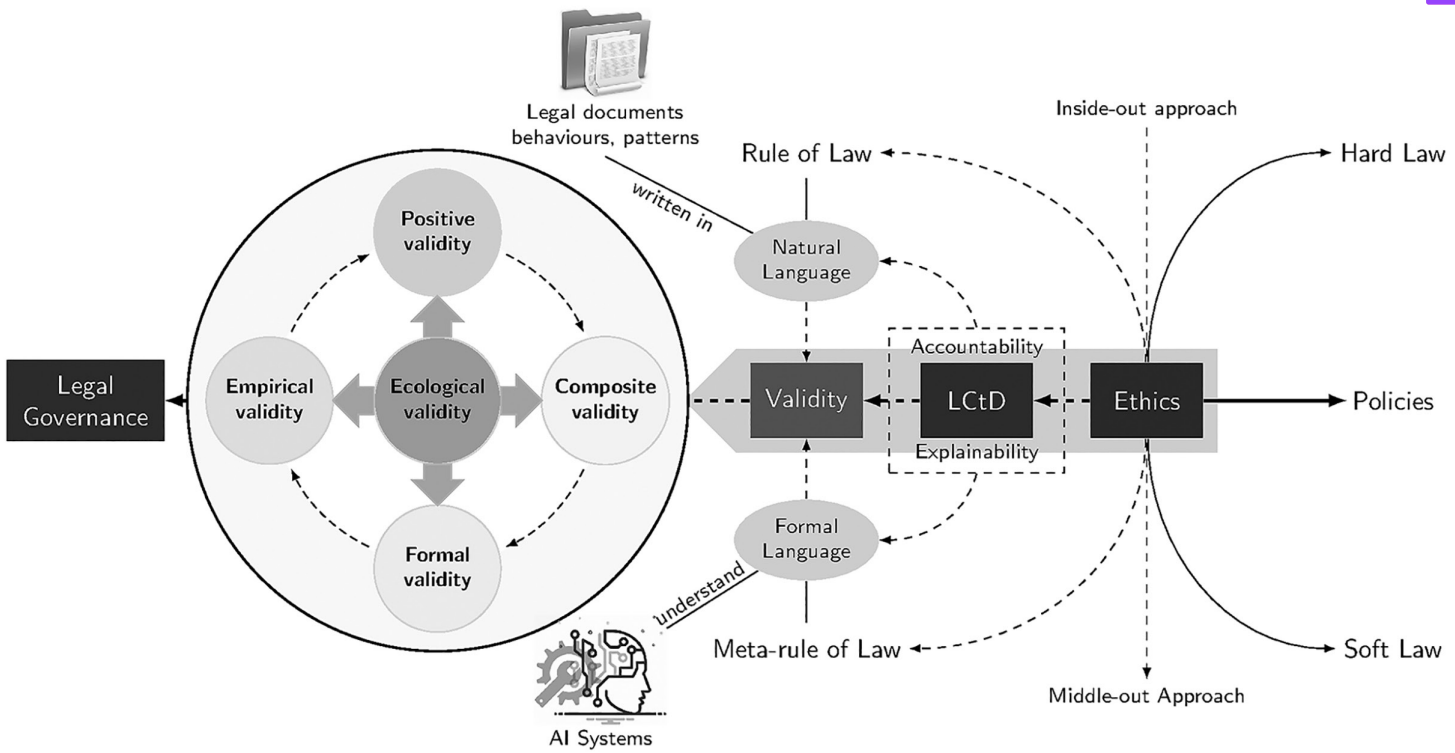
[48] We should differentiate *consistency* at the syntactic level; *coherency*, at the semantic level, and *cohesion*, at the pragmatic one.

[49] See Hashmi et al. Legal Compliance through Design (2018).

[50] *Positive* validity draws on the interpretation of inclusive legal positivism: positive law can also include ethical values and constitutional fundamental rights to be assessed. *Empirical* validity is equivalent to effectivity: the degree of compliance can be measured, and it will hold beyond a certain threshold that should be decided in the implementation of the regulatory model. *Composite* validity is the statistical outcome obtained as a result of the application of a composed validity indicator. *Formal* validity refers to the logical consistency and semantic cohesion of the model. To be sustainable, a legal ecosystem must draw on *ecological* validity as a product of these four components. Cf. Andrea Ciambra and Pompeu Casanovas, Drafting a Composite Indicator of Validity for Regulatory Models and Legal Systems, in *International Workshop on AI Approaches to the Complexity of Legal Systems*, AICOL2013, LNAI 8929, Berlin, Heidelberg: Springer Berlin Heidelberg, 2013, pp. 69–81.

[51] About the coupling of accountability and explainability, see Luciano Floridi, Josh Cowls, Thomas C. King, and Mariarosaria Taddeo, How to Design AI for Social Good: Seven Essential Factors, *Science and Engineering Ethics* (2020) 26: 1771–96. They refer to this coupling as *explicability*, and identify five core ethical principles for AI design: *beneficence*, *nonmaleficence*, *justice*, *autonomy*, and *explicability.*

[52] See U. Pagallo, P. Casanovas, and R. Madelin, The Middle-out Approach: Assessing Models of Legal Governance in Data Protection and Artificial Intelligence, in *Theory and Practice of*



Source: Pompeu Casanovas, Mustafa Hashmi, Louis de Koker, and Ho-Pun Lam (2024), A Three Steps Methodological Approach to Legal Governance Validation, https://www.arxiv.org/pdf/2407.20691.

Figure 5.2 Meta-model of legal governance

trolled process, encompassing both human and AI. Smart legal ecosystems emerge from this symbiotic interaction.

It should be noted that the elements of the three dimensions relevant in this context (social, legal, and technological) matter from a technical perspective, as they must be computed in real time. *Validation* occurs in the technological dimension, between the social and the legal dimensions, as a separate process but uniting and linking the two former dimensions. The meta-model of legal governance envisages therefore legal compliance validation processes that occur in real time and in parallel. Thus, the legal ecological validity is generated by means of a Compliance through Design (CtD) process at the time that a first technological validation is also produced. This can be possible because what is effectively generated is a hybrid HMI sustainable legal ecosystem, and not solely a system of norms holding abstract properties.

We deem this *duality* – legal validity and compliance validation – as key in our methodological approach, for it is able to harness the whole lifecycle of legal governance.

2 The OPTIMAI example

Socio-technical systems, the coordination of MAS, and CPS rely on continuous informational flows at three different layers – the perception, network, and application layers. From a theoretical point of view, this third technological dimension adds more complexity to the notions of *normative and empirical validity* that have been separated into two separate fields by many legal and socio-legal theorists (from Max Weber to Robert Alexy[53] and Jürgen Habermas[54]). In contrast, we are focusing on the validation process in an empirical chain, requiring approaches that are not reflected in the current leading theories of socio-legal or legal validity. A practical example may be helpful.

A 'smart factory' refers to the vertical integration of various components to implement a flexible and reconfigurable manufacturing system. OPTIMAI is an I4.0 EU project to create a Decision Support Framework for the EU industry.[55] The OPTIMAI framework consists of a self-organized multi-agent system assisted with big data-based feedback and coordination. As described by its designers, the model includes an intelligent negotiation mechanism for agents to cooperate with each other. Its architecture has been introduced in a functional way as:

> the OPTIMAI project architecture for zero-defect manufacturing (ZDM) is applicable to a variety of industrial verticals. To *realise a standards-based approach*, we elaborate on the parallels drawn between the presented architectural framework and two leading reference architectures underpinning the 'factories of the future' vision (RAMI 4.0 and IIRA). System specifications for ZDM are

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Legislation. Taylor & Francis, Published online: 18 Sep 2019, J-Gate, Scopus, Hein On-Line. Open Access: https://www.tandfonline.com/doi/full/10.1080/20508840.2019.1664543.

[53] Cf. e.g. Robert Alexy, On the Concept and the Nature of Law, *Ratio juris* (2008) 21 (3): 281–99. 'The basis of non-positivism as defended here is the thesis that the single most essential feature of law is its dual nature. The thesis of the dual nature of law presupposes that there exist necessary properties of law belonging to its factual or real dimension, as well as necessary properties belonging to its ideal or critical dimension. Coercion is an essential feature found on the factual side, whereas the claim to correctness is constitutive of the ideal dimension.' p. 292.

[54] Jürgen Habermas, *Between Facts and Norms: Contributions to a Discourse Theory of Law and Democracy,* English version: John Wiley & Sons, 1992/2015.

[55] See https://optimai.eu/. *Optimising Manufacturing Processes through Artificial Intelligence and Virtualization*.

> hence defined according to the perspectives of the two architectural models, allowing us to examine cutting-edge technologies for ZDM (such as blockchain, AI and AR) as both an I4.0 solution, as well as an Industrial IoT system.[56]

It should be noted that standards are applied through architecture and modular building, embedding them as functional requirements of the entire system, and keeping humans in the loop. From the perspective of a control engineer, the smart factory has been described as a dual closed-loop system: 'One loop consists of physical resources and cloud, while the second loop consists of supervisory control terminals and cloud.'[57]

Our point is that there is a third normative loop, going along with the online processing and generating the SLE that assumes a nested ecological validity of its regulatory components.[58] The meta-model of Figure 5.2 must be anchored into specific regulatory models, starting with the selection of the legal instruments plotted in Figure 5.1. To make it happen nothing prevents us to use all kind of already existing generative AI tools and Large Language Models (LLMs) to explore them if we proceed in a controlled manner.[59] In the same way and preliminary, we can use the patterns for legal compliance-checking proposed by Francesconi and Governatori.[60] Yet, at the implementation level, their semantic distinction between *provisions* and *norms* could be expanded by incorporating the pragmatic dimension that is needed to generate and validate legal ecosystems.

The validation of the smart regulatory ecosystem should be data- or event-driven. The accuracy of the validation is dependent on the quality of the dataflow provided to feed the system. However, at the micro-level, more variables should be considered to make it happen in a sustainable way. We will come back to this process later, as a great deal of work has been already done in Ostrom's political science tradition. Exogenous conditions to build and legally validate institutions stemming from human (and human-machine) interactions – i.e. conditions grounded on *social behaviour, behavioural patterns* – matter, and must be identified and operated as well.

C Third Step: A Compliance Causal Model

To enable an *empirical approach* to legal sources, norms, and smart legal ecosystems, we will construct their causal chains (including computer and human behaviour). This is the third step.

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[56] George Margetis, Konstantinos C. Apostolakis, Nikolaos Dimitriou, Dimitrios Tzovaras, and Constantine Stephanidis, Aligning Emerging Technologies onto I4. 0 Principles: Towards a Novel Architecture for Zero-Defect Manufacturing, *2022 IEEE 27th International Conference on Emerging Technologies and Factory Automation* (ETFA), *IEEE Xplore* (2022), pp. 1–8.

[57] Shiyong Wang, Jiafu Wan, Daqiang Zhang, Di Li, and Chunhua Zhang, Towards Smart Factory for Industry 4.0: A Self-Organized Multi-Agent System with Big Data-Based Feedback and Coordination, *Computer Networks* (2016) 10: 158–1.

[58] For a more detailed account, see Pompeu Casanovas, Building a Smart Legal Ecosystem for Industry 5.0 (2024).

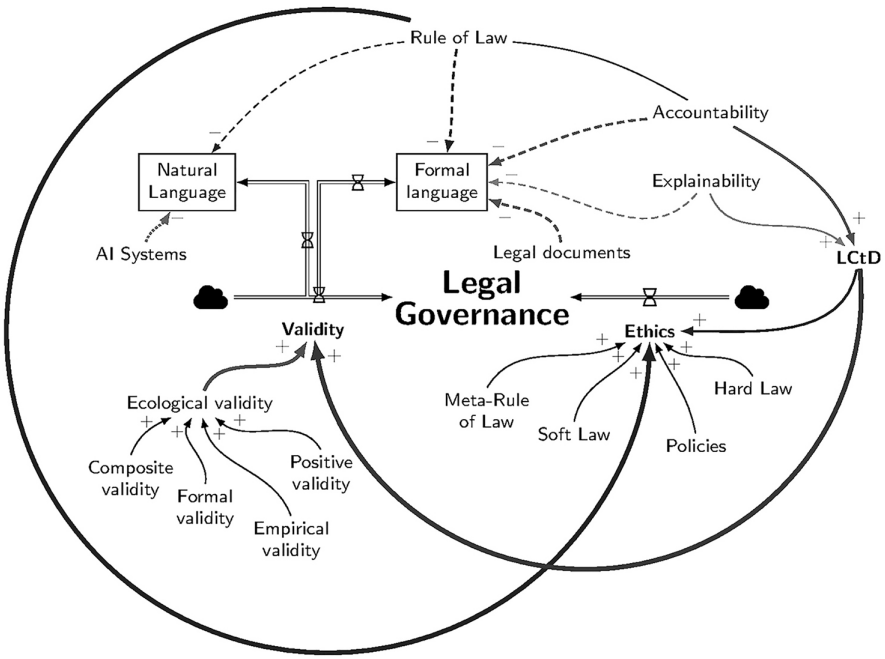
[59] Cf. John J. Nay, Law Informs Code: A Legal Informatics Approach to Aligning Artificial Intelligence with Humans, *Nw. J. Tech. & Intell. Prop*. (2022) 20: 309–92.

[60] Cf. Enrico Francesconi and Guido Governatori, Patterns for Legal Compliance Checking in a Decidable Framework of Linked Open Data, *Artificial Intelligence and Law* (2023) 31(3): 445–64.

This involves constructing the causal-loop models[61] *identifying* the parameters and constraints (internal, external, auxiliary), *defining* the degree of relationship (strong vs weak), *learning* about inter/intra-dependence at various levels of granularity between various components of the ecosystem impacting the validity (positive vs inhibitory effects), and *modelling* deeper (three-tier) levels of complexity of interaction in the legal governance model.

The model is being tested, refined, and optimized in three different OPTIMAI 4.0 scenarios: (1) *quality checking* (multimodal sensor network allowing for smart and secure data collection on production lines); (2) *augmented reality* (context-aware environment using augmented reality (AR) glasses to optimize production chains); and (3) *digital twins* (digital technology allowing the virtualization of the production process). These scenarios inform three use cases corresponding to three separate OPTIMAI 4.0 pilots.

The legal validation process, i.e. the generation of a sustainable legal ecosystem which can be deemed legal, can be performed by (1) applying and detailing the scheme of Figure 5.1; (2) implementing the meta-model dynamic process of Figure 5.2; and (3) testing legal compliance through the causal model of Figure 5.3. The final outcome will be the OPTIMAI regulatory model.



Source: Pompeu Casanovas, Mustafa Hashmi, Louis de Koker, and Ho-Pun Lam (2024), A Three Steps Methodological Approach to Legal Governance Validation, https://www.arxiv.org/pdf/2407.20691.

Figure 5.3 Legal governance meta-model: a causal legal validation scheme

[61] Magoroh Maruyama, The Second Cybernetics: Deviation-Amplifying Mutual Causal Processes, *American Scientist* (1963) 51 (2): 164–79. http://www.jstor.org/stable/27838689.

IV SMART LEGAL ECOSYSTEMS

A Three Preliminary Remarks

Three preliminary remarks to this methodological shift may be helpful, before we address institutions and ecosystems. First, the implementation of generative AI – for example Generative Pre-trained Transformer (GPT) – is gaining traction in the field of I5.0, and several potential applications have been already considered in the literature, for example predictive maintenance, quality control, CoBots, and personalized products and services.[62] However, the authors have also warned against the biases and misinterpretations that can accompany its implementation if it is not controlled from the beginning. These concerns are even more evident in the ethical and legal field, as transformers and LLMs generate their results according to their training data, and the rule of law consists of a culturally and institutionally dependent toolkit of legal instruments. Using ChatGPT (OpenAI) or even Claude (Constitutional AI) to analyse large data to feed regulatory systems can reproduce such institutional biases. Despite concerns, we nevertheless think that our three-step methodology can make use of generative AI and LLMs provided that that semantic injection is adopted and monitored fine tuning prompting is used to minimize risks.[63]

Second, in the law and the Semantic Web field, there have recently been interesting developments linking semantic rules to ontology building. Francesconi and Governatori[64] propose an automatic legal compliance checking framework describing legal rules using Semantic Web standards. Wu et al.[65] introduced a new approach to learn typed rule in knowledge graph. Zasada et al.,[66] on the other hand, evaluated the difficulties of modelling compliance rule languages to respond to regulatory requirements. As already said (Section III.C), our three-step methodology to evaluate smart legal ecosystems can also incorporate these types of solutions based on the optimized expressiveness and decidability of OWL 2 (with the introduction of three decidable languages for specific tasks such as OWL2-EL, OWL 2-QL, and OWL 2-RL).[67]

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[62] Cf. Wei Xian et al., A Survey of Key Enabling Technologies and Future Trends (2023).

[63] Pompeu Casanovas, Mustafa Hashmi, and Marta Poblet, Generative AI and the Rule of Law, *Proceedings of Artificial Intelligence Governance Ethics and Law (AIGEL*), Reviewed, Selected Papers. 2 November – 19 December 2022, Barcelona, Spain, https://ceur-ws.org/Vol-3531/.

[64] Francesconi and Governatori, Patterns for Legal Compliance (2023).

[65] Hong Wu, Zhe Wang, Kewen Wang, and Yi-Dong Shen, Learning Typed Rules over Knowledge Graphs, *Proceedings of the 19th International Conference on Principles of Knowledge Representation and Reasoning*, 2022, pp. 494–503.

[66] Andrea Zasada, Mustafa Hashmi, Michael Fellmann, and David Knuplesch, Evaluation of Compliance Rule Languages for Modelling Regulatory Compliance Requirements, *Software* (2023) 2 (1): 71–120.

[67] Francesconi and Governatori, Patterns for Legal Compliance Checking (2023). The W3C Web Ontology Language (OWL) is a Semantic Web language designed to digitally represent knowledge about things, groups of things, and relations between things. 'The OWL 2 Web Ontology Language, informally OWL 2, is an ontology language for the Semantic Web with formally defined meaning. OWL 2 ontologies provide classes, properties, individuals, and data values and are stored as Semantic Web documents. OWL 2 ontologies can be used along with information written in RDF, and OWL 2 ontologies themselves are primarily exchanged as RDF documents.' Cf. https://www.w3.org/TR/owl2-primer/.

Third, for at least 50 years there has been a sharp divide among legal theorists regarding the nature of norms, in particular regarding what Carlos Alchourrón and Eugenio Bulygin had called the *hyletic*[68] and the *expressive* notions of norms, formulated in a variety of ways.[69] The first one assumes that norms have an independent semantic content, which can be represented into logical recursive rules,[70] while the second relates to the notions of interaction, context, and intention. From an ontological approach, the former assumes norms as independent entities – 'a norm is an abstract, pure conceptual entity'. The latter, on the other hand holds that norms are language-dependent – 'norms are the result of the prescriptive use of language'. This broad-ranging dichotomy has also been applied to discuss the well-known and influential institutional view proposed by John Searle,[71] according to which the difference between constitutive and regulatory rules – a *hyletic* one, contrary to what it may seem – would be able to account for all regulatory systems.[72] From a certain point of view, smart legal ecosystems assume the expressive, i.e. pragmatic, function of norms when dealing with actors and agents for integrative purposes. However, this is not excluding the formal system representation. We deem this is a necessary approach as well at the design level. Thus, it is our contention that the consistency and coherence of regulatory models can be seen as a key component to foster cohesiveness at the implementation level. Contradictions and inconsistencies can give rise to unexpected effects and applications of the regulatory system.

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[68] From Greek *hylē*: wood, matter. The Merriam-Webster Dictionary, following Aristotle, offers a concise definition: 'whatever receives form or determination from outside itself', especially 'matter in its primordial, unorganized state'.

[69] C. Alchourrón and Eugenio Bulygin, The Expressive Conception of Norms, in *New Essays in Deontic Logic*, Risto Hilpinen, ed. Dordrecht: Reidel, 1981, pp. 95–124.

[70] 'For the *hyletic conception* norms are proposition-like entities, i.e. meanings of certain expressions, called normative sentences. A normative sentence is the linguistic expression of a norm and a norm is said to be the meaning of a normative sentence in much the same way in which a proposition is regarded as the meaning (sense) of a descriptive sentence. But normative sentences, unlike descriptive sentences, have *prescriptive meaning:* that something ought, ought not, or may be the case (or be done).' Ibid. p. 96.

[71] Cf. John R. Searle, *The Construction of Social Reality*, New York: The Free Press, 1995; John R. Searle, What is an Institution?, *Journal of Institutional Economics* (2005) 1 (1): 1–22; John R. Searle, *Making the Social World: The Structure of Human Civilization*, Oxford: Oxford University Press, 2010.

[72] See the thorough discussion on this topic in the papers gathered in Paolo Di Lucia and Edoardo Fittipaldi (eds.) *Revisiting Searle on Deriving 'ought'* from '*is*', Cham: Springer Nature, 2021 (with Searle's participation).

B The ADICO Institutional Syntax

In philosophy and political science, institutions have been a permanent focus of analysis for more than 70 years. There are general definitions, which, so to speak, establish a delimited abstract semantic space,[73] and more comprehensive ones that allow a wider open game of 'building blocks' within and outside of them at the micro-level.[74]

In 1995, Sue E.S. Crawford and Elinor Ostrom introduced what they called an 'institutional grammar' to theorize enduring regularities of human action structured by (1) *rules*; (2) *norms*; and (3) *shared strategies*.[75] They differentiated the *institutions-as-equilibria*[76] *institutions-as-norms*,[77] and *institutions-as-rules*[78] approaches. The first one stems from the

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[73] According to philosopher John R. Searle, institutional roles and their defining deontic properties are institutional facts created by collectively accepted constitutive rules. Status-functions with deontic powers are yielded by collectively accepted *constitutive rules* with the structure 'X counts as Y in context Z'. 'What is an institution? An institution is any collectively accepted system of rules (procedures, practices) that enable us to create institutional facts.' Searle, What is an Institution? (2005), p. 21.

[74] 'Broadly defined, institutions are the prescriptions that humans use to organize all forms of repetitive and structured interactions including those within families, neighborhoods, markets, firms, sports leagues, churches, private associations, and governments at all scales. Individuals interacting within rule-structured situations face choices regarding the actions and strategies they take, leading to consequences for themselves and for others.' Elinor Ostrom, *Understanding Institutional Diversity*, Princeton University Press, 2005, p. 3.

[75] Sue E.S. Crawford and Elinor Ostrom, A Grammar of Institutions, *American Political Science Review* (1995) 89 (3): 582–600.

[76] Institutions would be defined as regular behaviour patterns sustained by mutual expectations about the actions that others will take. Cf. Friedrich A. von Hayek, The Use of Knowledge in Society, *American Economic Review* (1945) 35: 519–30; Karl Menger, *Problems in Economics and Sociology*. Urbana: University of Illinois Press, 1963.

[77] According to Crawford and Ostrom, A Grammar of Institutions (1995), *institutions-as-norms* go beyond immediate means-ends relationships to analyse the shared beliefs of a group about normative obligations. Patterns of interaction are based on the shared perceptions among a group of proper and improper behaviour in particular situations. Cf. David K. Lewis, *Convention: A Philosophical Study*, Cambridge, MA: Harvard University Press, 1969; Edna Ullmann-Margalit, *The Emergence of Norms*. Oxford: Clarendon, 1977.

[78] The *institutions-as-rules* approach encompasses the political science institutional analysis tradition sustained by Douglass North and Elinor Ostrom herself. Cf. Douglass North, *Institutions, Institutional Change, and Economic Performance*, New York: Cambridge University Press, 1990; Elinor Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action*, New York: Cambridge University Press, 1990. But, interestingly, it also draws on the tradition of American legal realism; hence, on the way how compliant behaviour with social and legal rules is produced. It contends that many observed patterns of interaction are based on a common understanding that actions that are not following rules, i.e. that those that ignore or violate their prescribed content are likely to be sanctioned (in many ways, including ostracism). 'To understand regularized patterns of interaction affected by rules, one needs to examine the actions and outcomes that rules allow, require, or forbid and the mechanisms that exist to enforce those rules.' Crawford and Ostrom, A Grammar of Institutions (1995), p. 583. Cf. Wesley Newcomb Hohfeld, *Fundamental Legal Conceptions as Applied in Judicial Reasoning: And Other Legal Essays*, Yale

stability that can arise from mutually understood actor preferences and optimizing behaviour from a rational choice perspective, assuming that a particular equilibrium is produced from the actors' motivation, while the two latter focused on the linguistic constraints (spoken, written, or tacitly understood prescriptions or advice) that influence these mutually understood actor preferences.[79] Hence, institutions are understood as stable patterns of behaviour stemming from a cognitive approach.

Crawford and Ostrom resume and refine these three approaches within a fourth one, in which norms, rules, and strategies are considered as components:

> We use the broad term *institutional statement* to encompass all three concepts. Institutional statement refers to a shared linguistic constraint or opportunity that prescribes, permits, or advises actions or outcomes for actors (both individual and corporate). Institutional statements are spoken, written, or tacitly understood in a form intelligible to actors in an empirical setting.[80]

They then present the *ADICO syntax, a grammar of rules*, to explain 'the cumulative manner in which institutional statements affect individuals' expectations about the actions of others and the consequences of their own actions'.[81] We summarize Crawford and Ostrom's methodological proposal in Table 5.2. The reader will immediately notice that the terminology they use does not match the usual meaning accorded to rules and norms in jurisprudence.

According to the authors:

> All shared strategies can be written as [ATTRIBUTES] [AIM] [CONDITIONS] (AIC); all norms can be written as [ATTRIBUTES] [DEONTIC] [AIM] [CONDITIONS] (ADIC); and all rules can be written as: [ATTRIBUTES] [DEONTIC] [AIM] [CONDITIONS] [OR ELSE] (ADICO). The syntax is cumulative: norms contain all of the components of a shared strategy plus a DEONTIC; rules contain all the components of a norm plus an OR ELSE.[82]

Three additional observations to put this institutional methodology into practice: (1) Government, state, or official backing is not a necessary condition for an institutional statement to be a rule (self-organized or private communities can develop their own rules); (2) the linguistic statements that form the institutional basis for shared expectations that influence observed regularities in behaviour should be empirically described; (3) the whole instrumental ADICO structure is a component of the broader sociological ecology built by Elinor Ostrom to encompass actions, contexts, and evaluations called the *Institutional Analysis and Development* (IAD) network.[83] Figure 5.4 shows Ostrom's IAD meta-model.

University Press, 1923. John R. Commons, *Legal Foundations of Capitalism*, Madison: University of Wisconsin Press, 1968.

79 Crawford and Ostrom, A Grammar of Institutions (1995), p. 582.

80 Ibid (emphasis added).

81 Ibid. p. 596.

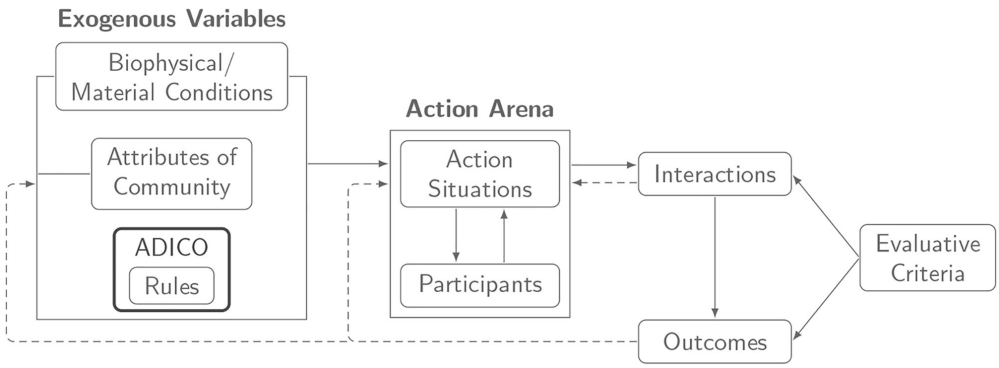
82 Ibid. p. 582.

83 Ostrom, *Understanding Institutional Diversity* (2005), chapter 6.

Table 5.2 ADICO syntax components

Acr.	Component	Definition	Rule	Norm	Shared strat.
A	ATTRIBUTE	A holder for any value of a participant-level variable that distinguishes to whom the institutional statement applies (gender, age, labour, experience …). They can operate at *individual-level* or *organizational-level* (collective). *Who* does this statement refer to?	A	A	A
D	DEONTIC	A holder for three modal verbs or functors: *May* (permission), *must*, must not (obligation), *should*, should not (prohibition).	D	D	–
I	AIM	A holder for those variables which define when, where, how, and to what extent an AIM is permitted, obligatory, or forbidden A holder that describes particular actions or outcomes to which the deontic is assigned. *What* is the statement about?	I	I	I
C	CONDITION	A holder for those variables which define when, where, how, and to what extent an AIM is permitted, obligatory, or forbidden. *Under what conditions* must the AIM occur?	C	C	C
O	OR ELSE	A holder for those variables which define the sanctions to be imposed for not following a rule. Institutional consequences of actors' behaviour.	O	–	–

Source: Sue E.S. Crawford and Elinor Ostrom, 'A Grammar of Institutions', *American Political Science Review* 89, no. 3 (1995): 582–600, p. 584, our drawing.



Source: Adapted from Elinor Ostrom (2005). *Understanding Institutional Diversity*, Princeton University Press, p. 15.

Figure 5.4 ADICO as a IAD component

The IAD framework introduces a new typology of rules, following the four common uses of the term 'rules' in everyday language, first identified by Max Black,[84] according to their scope: *instructions*, *precepts*, *principles* and *regulations*.[85] In Ostrom's usage, rules can combine several elements of these formulations:

> Rules can be thought of as the set of instructions for creating an action situation in a particular environment. In some ways, rules have an analogous role to that of genes. Genes combine to build a phenotype. Rules combine to build the structure of an action situation. The property rights that participants hold in diverse settings are a result of the underlying set of rules-in-use.[86]

The ADICO component is built in a way that can be described as cumulative, evolutive, transitional, and as such it can be nested or embedded into different regulatory models. Its usability draws on its functional flexibility, in which regularities can bring about rules, or the other way around, rules can *emerge* from regularities. Therefore, a social behaviour can be tacit or explicit, expected or non-attended, conscious or instinctive. There is no fixed categorial scale. A social behaviour can first be unnoticed by the agents, become a shared strategy, and end up as a social norm or even as a rule when its content is sanctioned. There are many examples mentioned by Crawford and Ostrom taken from everyday life, for instance: 'The person who places a phone call calls back when the call gets disconnected.'

It is precisely this wide range of possibilities, the fluid or 'liquid' nature of behavioural patterns coupled with analytical precision, that has caught the attention of many research communities interested in the implementation and practical side of regulatory models. Among them, computer and AI scientists modelling institutions.

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[84] Max Black, *Models and Metaphors: Studies in Language and Philosophy*. Ithaca, NY: Cornell University Press, 1962.

[85] Black differentiates four senses of what a rule is or consists of: (1) The term 'rule' denotes an *instruction* when it is used as an effective strategy how to solve a problem, e.g. 'Do not plant tomatoes until after the next frost'; in this sense, it can be said that the rule is effective or ineffective, confirmed or supported by experience, tested or untested; (2) when 'rule' denotes a *precept*, the term is being used as a maxim for prudential or moral behaviour; for instance a prudential rule would be: 'It is always sound to pay one's debts promptly'; (3) when 'rule' denotes a *principle* (or a *general truth*) we can make a statement related with a certain state of affairs and provide evidence for or against it, like in 'Years like 1952 that are divisible by 4 are leap years'; and (4) when used in a 'regulation' sense, *rules* refer to something laid down by an authority (judge, magistrate, board of directors…), e.g. 'The dealer at bridge must bid first'. In this sense, according to Black, *Models and Metaphors* (1962) p. 109, 'it is permissible to speak of the rule in question as being announced, put into effect, enforced (energetically, strictly, laxly, invariably, occasionally), disobeyed, broken, rescinded, changed, revoked, reinstated. And it makes sense also to ask such questions as: "When was the rule put into force?" "How long since the rule was reinstated?" "Is this the first time it has been a penalty for breaking this rule?" and other questions involving reference to *times*.' Cf. Black, *Models and Metaphors* (1962), pp. 109 ff.; Ostrom, *Understanding Institutional Diversity* (2005), pp. 16 ff.

[86] Ostrom, *Understanding Institutional Diversity* (2005), pp. 16 ff.

C Related Work: Computer Science and AI

ADICO (within IAD) has been explored from a computational approach following different trends in the sciences of design. Institutional Grammar 2.0 (IG 2.0) has extended the original syntactic dimension towards a semantic approach in public administration and e-government.[87] Ostrom's questions are quite close to our own: 'How is regulation content structured? More specifically, how is regulatory language pertaining to actors and activities organized? Furthermore, is regulatory language, and the directives of which it is comprised, conveyed consistently and coherently?'[88] Research focuses on 'ascertaining patterns in regulatory text that can be assessed in relation to regulatory antecedents and outcomes'.[89] It basically incorporates Semantic Web and Natural Language Processing technologies into Ostrom's drivers.

Researchers on Normative Multi-agent Systems (norMAS) have also paid close attention to ADICO and IAD. Ghorbani et al. (2012)[90] focus on *shared strategies*,[91] turning them more granular. They understand them as social *collective expectations*, developed in a number of situations that allow more specific concepts for describing the behaviour of artificial agents. The authors stress the *transient* character of shared strategies 'that puts them between actual standard norms or social conventions, and fully unregulated behaviour, both in the collective and the individual perspectives'.[92]

They distinguish between: (1) *factual regularities* (e.g. 'Dutch eat at 5:30 pm'); (2) *common* strategies (most individuals do *s*); (3) *shared* strategies (most individuals believe that most individuals do *s*); (4) *collective* strategies (most individuals believe that most individuals believe most individuals do *s*); (5) *joint* strategies (where everyone in the group intends that they do the expected thing); (6) *internalized norms* (in which individuals are progressively aware of the norms: the more the norm is internalized, the less decision is required); (7) *tacit* social conventions (in which individuals are not fully aware of the norms); (8) *shared plans* (there is no need for an agent to have intentions towards the act of another agent, but they can coordinate in performing the action); and (9) *collective* plans (there is a commitment to the joint activity).

Finally, they offer a formalization of Ostrom's *institutional statements* to get a semantic description of rules, norms, and shared strategies based on temporal, modal, and epistemic

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87 Cf. Christopher K. Frantz and Saba Siddiki, Institutional Grammar 2.0: A Specification for Encoding and Analyzing Institutional Design, *Public Administration* (2021) 99 (2): 222–47. By the same authors, (eds.) *Institutional Grammar*, Cham: Springer International Publishing, 2022.

88 Saba Siddiki and Christopher K. Frantz, Understanding Regulation using the Institutional Grammar 2.0, *Regulation & Governance*, (2023), doi:10.1111/rego.12546, p. 2.

89 Ibid.

90 Amineh Ghorbani, Huib Aldewereld, Virginia Dignum, and Pablo Noriega, Shared Strategies in Artificial Agent Societies, Simao Sichman and H. Aldewereld (eds.), COIN 2012, LNAI 7756, 2013, pp. 71–86.

91 'A Shared strategy is an institutional statement where there are no sanctions or deontic type, and represents general expectations about the aggregate behaviour of others.' Ibid. p. 75.

92 Ibid. p. 77.

(KD45) logic – logic $L_{T\,BP}$ – from which they can produce some refinements on Crawford and Ostrom's original formalization.[93]

In the last 15 years there have been some alternative proposals in MAS as well. For example, nADICO introduced a notion of nesting monitored and consequential ('Or else') statements, and a refined differentiation between norms and rules.[94]

However, to our knowledge, the most elaborated tool to date for modelling artificial agents drawing on ADICO and IAD is the model presented as *Action Situated Language* (ASL).[95] ASL is a fully machine-readable computational model to examine the impact that any of the variables outlined in the IAD framework has on the resulting social interactions. In addition to attributes and physical boundaries, ASL syntax uses four types of rules for artificial agents: (1) *Boundary rules*: which agents are allowed to enter the action situation; (2) *position rules*: what roles do the participants take on; (3) *choice rules*: what actions are available to the various roles under the current conditions; and (4) *control rules*: what are the effects of those actions.[96] Along with several more components (initial and terminal conditions, facts…): (1) ASL 'completely encapsulate human-made regulations'; (2) 'has its semantics automatically generated as a formal game model by a computational engine […] that repeatedly interpret the rules in place'; (3) 'includes a mechanism to solve conflicts between contradicting rules, that allows new rules with higher priority to override older rules with lower priority'; and (4) 'has its semantics grounded as an extensive-form game (EFG) with a restricted use of imperfect information', augmented with a set of literals that correspond to states of the system.

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[93] For instance, they introduce a new operator for the semantic definition of 'most' to formalize 'most from group R believe that most of group R do I'.

[94] Christopher Frantz, Martin K. Purvis, Mariusz Nowostawski, and Bastin Tony Roy Savarimuthu, nADICO: A Nested Grammar of Institutions, in PRIMA 2013, *Principles and Practice of Multi-Agent Systems*, LNCS 8291, Berlin, Heidelbergh: Springer, 2013, pp. 429–436.

[95] Cf. Nieves Montes, Nardine Osman, and Carles Sierra, A Computational Model of Ostrom's Institutional Analysis and Development Framework, *Artificial Intelligence* (2022) 311 (2022): 103756. They introduce their work as follows: 'In order to write rule configurations in a systematic manner, we present our novel *Action Situation Language* (ASL). This is a machine-readable logical language (implemented in Prolog) whose syntax is highly tailored to the exogenous variables outlined in the IAD framework. ASL is complemented by a game engine that takes as input a valid action situation description and automatically generates its semantics as an extensive-form game (EFG). EFGs are abstract and very general models, prevalent in the microeconomics field, that can be instantiated to represent a wide variety of social interactions among an arbitrary number of agents. Although environmental and community attributes also play a role in generating the EFG semantics, we are particularly interested in the impact that rules have on the resulting formal model. In fact, an essential component of the game engine is a *rule interpreter*, whose function is to query the rule base, process their implications and solve conflicts between contradicting rules. … In fact, the two main innovations we present (ASL plus its game engine) bridge the gap between the normative multi-agent systems (norMAS) and game theory fields.' (p. 4).

[96] Montes et al., A Computational Model of Ostrom's Institutional Analysis and Development Framework (2022), p. 6.

D Legal Ecosystems

As we have shown, ADICO and IAD have had a huge impact on the building of regulatory models based on information and AI technologies. They have also been fleshed out in blockchain, cryptocurrencies systems, and smart contracts[97] as they are flexible enough to be adapted as a practical framework. Especially the idea of understanding regulatory models as *sustainable polycentric decentralized SESs*, to use Ostrom's terminology, is not limited to the self-regulated governance of common-pool resources (such as fisheries, water, or land), but has had multiple applications in community building, including smart cities.[98]

However, if we compare Ostrom's developments with our own work in legal compliance, there are some basic differences that should be noted. IAD can be understood as a social *meta-model* but not as a *legal* one. Given the plurality of different situations and contexts, Ostrom has always been very prudent in presenting it as a general policy method.[99] We should follow her advice as well. There is no sure-fire method. Legal systems have their own characteristics and the many jurisdictions and plurality of norms at stake in the building of any SLE entail that the construction of an ecosystem depends on the selection of exogenous variables *and* the legal instruments that operate in a given context. Law, legal behaviour, and professional practices have their own languages and, so to speak, *institutional descriptions*. Ostrom was fully aware of their complexity: 'The simplifying assumption is frequently made in analytical theories that individuals in an action situation will take only those actions that are lawful given the rules that apply.'[100]

We have developed a methodology in three steps to cope with legal languages and instruments. *How could we produce a way to validate when a regulatory model and the smart ecosystem it generates are 'truly' legal?* This is the difficult research question, stemming from the previous assumption that we must consider not only one but many linguistic and non-linguistic sources (see Figure 5.1). I.e., our problem arises not from the classification of social actions

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[97] Christopher K. Frantz and Mariusz Nowostawski, From Institutions to Code: Towards Automated Generation of Smart Contracts, in *2016 IEEE 1st International Workshops on Foundations and Applications of Self* Systems (FAS* W)*, IEEE, 2016, pp. 210–15; Palina Tolmach, Yi Li, Shang-Wei Lin, Yang Liu, and Zengxiang Li, A Survey of Smart Contract Formal Specification and Verification, *ACM Computing Surveys (CSUR)* (2021) 54 (7): 1–38; Yuan Huang, Queping Kong, Nan Jia, Xiangping Chen, and Zibin Zheng, Intelligence-Driven Optimization of Smart Contracts, in Zibin Zheng, Hong-Ning Dai, and Jiajing Wu (eds.) *Blockchain Intelligence: Methods, Applications and Challenges*, Cham: Springer, 2021, pp. 73–93.

[98] Cf. Mahtab Aghamiri, Amineh Ghorbani, Jolien Ubacht, Igor Nikolic, and Paulein Herder, Enabling Citizen Participation in Sustainable Collective Action in Smart Cities: The Case of Buiksloter-ham, in *XVI Biennial IASC Conference: Practicing the Commons*, 2017, pp. 1–27.

[99] 'No one can undertake a complete analysis of all of the potential rules that they might use and analytically determine which set of rules will be optimal for the outcomes they value in a particular ecological, economic, social, and political setting. One must recognize that policies involving rule changes must be viewed as experiments.' Ostrom, *Understanding Institutional Diversity* (2005), p. 255.

[100] Ibid. p. 21. 'In settings where a heavy investment is *not* made in monitoring the ongoing actions of participants, however, considerable difference between predicted and actual behavior can occur as a result of the lack of congruence between a model of lawful behavior and the illegal actions that individuals frequently take in such situations.'

from which an ecosystem can emerge, but from the fact that there are legal provisions that qualify the behaviour of human and artificial agents *alike*.

The notion 'legal ecosystem' has already been used in academy and business in a broader way. For instance, it constitutes a regular mode to understand and refer to the transformations, language, functions, and practices experienced by the legal profession in the digital age for the members of the *Liquid Legal Institute* (LLI), a German association created in 2018.[101] LLI pays close attention to the creation of legal web services and platforms. In fact, this is the new landscape lawyers have to face in Web and Industry 4.0 and 5.0. This is a situation already anticipated by Richard Susskind's seminal works. We usually refer to it as the 'double implosion of the legal profession'.[102]

There have been some criticisms as well by economists looking at the 'business ecosystem' field linked to innovation networks.[103] Nevertheless, the use of the notion, either in its networking connection sense[104] or in its more technical sense,[105] is growing among researchers interested in regulatory models.

In a platform-driven economy, markets have expanded, and companies and corporations have changed their business models towards what Michael G. Jacobides and Ioannis Lianos have called *ecosystem firms* (with some of them becoming *ecosystem orchestrators*):

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[101] The purpose of the LLI, as set down in its articles of association, is to 'research and promote new ways of thinking as well as new technologies and other innovations in the "legal ecosystem" (i.e., the so-called legal transformation)'. Cf. Jens Wagner, Foreword: En Route to a Common Legal Platform, in Kai Jacob, Dierk Schindler, Roger Strathausen (eds.) *Liquid Legal. Towards a Common Legal Platform*, Cham: Springer, 2020, p. xvi.

[102] Cf. Pompeu Casanovas, Inteligencia Artificial y Derecho: la doble implosión de las profesiones y servicios jurídicos en la era digital [Spanish], in Martín Serrano and Olivia Velarde (eds.), *Mirando hacia el futuro. Cambios sociohistóricos vinculados a la virtualización*. Madrid: Centro de Investigaciones Sociológicas (CIS), pp. 83–114. A summary [English] in: 'The Double Implosion in the Legal Professions and a New Integrated Data Regulation Space', *La clave de BAES*, 17 January 2024, https://www.baeslegalcripto.eu/legalcripto/en/the-double-implosion-in-the-legal-professions-and-a-new-integrated-data-regulation-space-by-pompeu-casanovas/.

[103] 'Everything becomes or is qualified as an ecosystem without any real justification or analysis. However, the business ecosystem is an inter-organizational network that obeys certain rules, which is not the case with the current "legal or legal ecosystem", as it is generally presented in the general or specialized press.' Nabyla Daidj, New Practices in the Digital Economy: Towards the Uberization of Law?, in Antoine Masson and Gavin Robinson (eds.). *Mapping Legal Innovation: Trends and Perspectives*, Cham: Springer, 2021, pp. 139–57, p. 145.

[104] See Dorothy J. Glancy, Autonomous and Automated and Connected Cars – Oh My! First Generation Autonomous Cars in the Legal Ecosystem, *Minnesota Journal of Law, Science and Technology* (2015) 16 (2): 619–92; Lucien Rapp, Maria Topka, and Lucas Mallowan, Which Jurisdiction for Private In-Space Assembled Autonomous Platforms?, *Space Policy* (2021) 56: 101413; Christian Matt, Florian Eichel, Manuel Bieri, and Daniel Pfäffli, Towards a Multicentric Quality Framework for Legal Information Portals: An Application to the DACH Region, *Government Information Quarterly* (2023) 40: 101840.

[105] See Bernd Blobel, Pekka Ruotsalainen, Mathias Brochhausen, Edson Prestes, and Michael A. Houghtaling, Designing and Managing Advanced, Intelligent and Ethical Health and Social Care Ecosystems, *Journal of Personalized Medicine* (2023) 13 (8): 1209.

> On top of all these changes, we also saw deregulation, as regulators worldwide changed their attitudes toward new business models and considered that experimentation is good, spurred on by the concerns over rent-seeking from entrenched incumbents. Regulators in every area from energy to financial services became more open to new ideas constructing 'regulatory sandboxes' to facilitate safe innovation, as technology-aided transformation became socially accepted and politically desirable. Thus, it became easier to experiment, adjust, and invent new ways of organizing, often transcending the boundaries of established industries.[106]

The authors comment on the liminal boundaries of industry, and the absence of theory for ecosystems. They also make sharp observations about the asymmetry of the players and the break of competition laws. The challenges of this need for regulation lie in the reconstruction of theory and instrumental tools, as 'our analytical toolkit is ill suited to address the nature of the offence, the metrics to measure it, or the means to address it'.[107]

However, the issue of regulating platforms and ecosystems, important as it may be, is not the same as the concept of 'legal ecosystem' as we employ it in relation to our model. This notion is not focused only on the institutional side of the law, nor on its instrumental aspect of regulating ecosystems *from the outside*, but on the *knowledge* we should put in place to create regulatory systems *integrated* into the computer design (in platforms, applications, robots, cobots, or CPSs) in such a way that from their HMI or HRI can emerge a sustainable social ecosystem. This is what the *middle/out* and *inside/out* approaches are about.

E Smart Legal Ecosystems

As defined at the beginning of this chapter, a *smart* legal ecosystem is a legal ecosystem that is generated through intelligent design. It is the result of embedding into CPSs a set of rules and values that function in an intelligent environment encompassing the features of the IoT 4.0 and 5.0 (ethics and law) to achieve legal compliance *in real time*. It must be said right away that, to our knowledge, there is yet no legal system that can fully operate in this way, integrating human and artificial processes into behavioural patterns. The difficulty of modelling values and, broadly, the expressive side of the law cannot be ignored. However, Industry 4.0 is already heading in this direction.

Figure 5.5 shows a topological view of the OPTIMAI architecture through the smart factory framework perspective, based on a more general model of self-organized multi-agent system with big data-based feedback and coordination.[108] It is a human-centred design (HCD), adopting the holistic framework created by George Margetis, Stavroula Ntoa, Margherita Antona and Constantine Stephanidis[109] encompassing six fundamental concepts for human-centred

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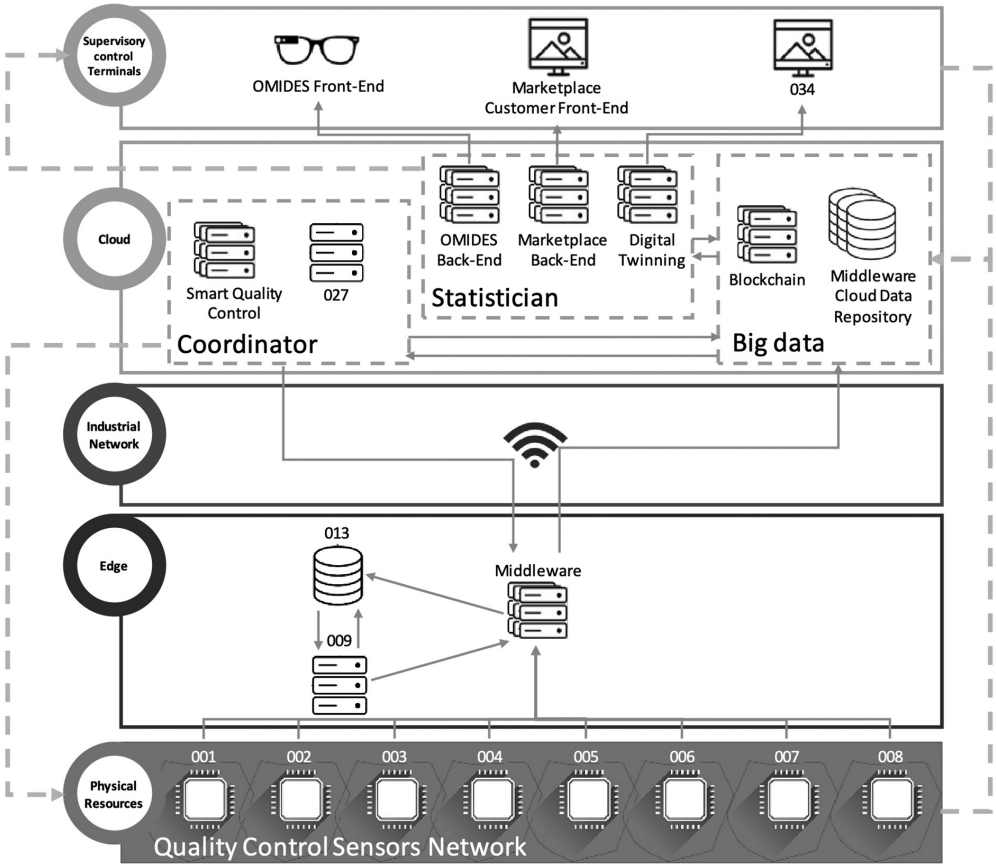
[106] Michael G. Jacobides and Ioannis Lianos, Regulating Platforms and Ecosystems: An Introduction, *Industrial and Corporate Change* (2021) 30 (5): 1131–42, p. 1132.

[107] Jacobides and Lianos, Regulating Platforms and Ecosystems (2021), pp. 1135–6. See as well, Michael G. Jacobides and Ioannis Lianos, Ecosystems and Competition Law in Theory and Practice, *Industrial and Corporate Change* (2021) 30 (5): 1199–229, pp, 1134–5.

[108] Shiyong Wang, Jiafu Wan, Daqiang Zhang, Di Li, and Chunhua Zhang, Towards Smart Factory for Industry 4.0: A Self-Organized Multi-Agent System with Big Data Based Feedback and Coordination, *Computer networks* (2016) 10: 158–68.

[109] George Margetis, Stavroula Ntoa, Margherita Antona, and Constantine Stephanidis, Human-centered Design of Artificial Intelligence, in Gavriel Salvendy and Waldemar Karwowski

artificial intelligence, namely: (1) explainable AI and human-in-the-loop; (2) semantic cognitive and perceptual computing; (3) visual predictive analytics; (4) interactive machine learning; (5) federated learning; and (6) user experience (UX) design. They pay close attention to embedding ethical principles and legal provisions into the architectural design, i.e. not only technical standards but national, international, and EU Directives and Regulations. The platform, modules, and information flows combine normative concepts stemming from blended cognition. Legal requirements follow this HCD holistic approach.[110]



Source: K.C. Apostolakis, D. Arampatzis, G. Margetis et al., OPTIMAI. D2.4: The OPTIMAI architecture specifications, 2022, p. 78.

Figure 5.5 Topological view of the OPTIMAI architecture

(eds.), *Handbook of Human Factors and Ergonomics,* John Wiley & Sons, Inc. Published, 2021, pp. 1085–106.

[110] Cf. Emma Teodoro and Andrea Guillén's work on this matter. Although their legal Deliverables are confidential, *see* https://ceur-ws.org/Vol-3531/, E. Teodoro and A. Guillén, Ethical

OPTIMAI assembles several different AI technologies to create a generic service-oriented functional architecture for Zero-defect Manufacturing (ZDM): (1) multi-sensory data acquisition; (2) distributed ledger technologies; (3) context-aware AR; (4) Delta Time-enabled production optimization inference (simulations). Therefore, OPTIMAI generates a SLE, in which blockchain technologies, simulations, and expert monitoring of the end-users are coordinated in such a way that can elicit the customers' response through the established processes. Hence, OPTIMAI SLE *emerges* from (rather than supervenes) the collective coordination of HRI interactions. Blockchain and the use of lightweight Deep Residual Networks (DRNs) can ensure that all transactions on the platform are traced in a transparent way and in real-time sequences.[111] However, smart contracts cannot be deemed legal contracts yet – i.e. producing legal effects. How could we turn them 'legal'? There are several proposals in the specialized literature to study this relationship.[112]

In addition, norms and rules, to use Ostrom's conceptualization, can be specified; but, still, the different roles of the expert and professional users should be harmonized with the exogenous variables that define the social framework, i.e. the context of use of these technologies, including scenarios in which workers and machines interact in a way that should also be described and tested.

Employment rights are particularly difficult to audit. For instance, how should a general deontic rule like 'the employer should not impinge on the employment rights of pilot site employees' be modelled? Or, focusing on equality rights, an ethical principle such as 'employees shall not be directly or indirectly discriminated against on the grounds of sex, marital status, age within the limits set by this law, racial or ethnic origin, social status, religion or beliefs, political ideas, sexual orientation, membership or not of a trade union, language, or disability'? It is our contention that this process cannot be fully hard-coded but can be partially formalized for ethical and legal compliance checking. SLEs emerge stemming from legal requirements that have been made explicit and assumed as valid in each particular setting. *Ecological validity* requires testing this assumption to achieve legal governance through a second and more refined validation process.

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and Legal Aspects of Human-centricity in Manufacturing, *Artificial Intelligence Governance Ethics and Law Workshop*, AIGEL22, 2023, pp. 182–8.

[111] *See* Lampros Leontaris, Andreana Mitsiaki, Paschalis Charalampous, Nikolaos Dimitriou, Eleni Leivaditou, Aristoklis Karamanidis, George Margetis et al., A Blockchain-Enabled Deep Residual Architecture for Accountable, In-Situ Quality Control in Industry 4.0 with Minimal Latency, *Computers in Industry* (2023) 149 (2023): 103919. 'In order to make AI results from the developed quality control system, accountable and trustworthy, we designed an integration scheme using Blockchain Paradigm deployed in private Ethereum and we applied the Proof-of-Authority consensus mechanism, to allow fast transaction speeds and trust between transaction participants. The developed framework connects the AI inspection tool at the production line with the private Ethereum, supporting the operation to track and trace an item back in the production stage.'

[112] Cf. Primavera De Filippi and Aaron Wright, *Blockchain and the Law: The Rule of Code*, Harvard University Press, 2018; Guido Governatori, Florian Idelberger, Zoran Milosevic, Regis Riveret, Giovanni Sartor, and Xiwei Xu, On Legal Contracts, Imperative and Declarative Smart Contracts, and Blockchain Systems, *Artificial Intelligence and Law* (2018) 26: 377–409. For a typology, vid. Jasper Verstappen, *Legal Agreements on Smart Contract Platforms in European Systems of Private Law*, Cham: Springer, 2023.

V CONCLUSIONS AND FUTURE WORK

Some years ago, we anticipated that law is facing significant new challenges, related to personalization of web services, unregulated contexts and scenarios, emerging data markets, non-harmonized jurisdictions, safety, and collective security.[113] We identified ten topics to be discussed. Among them, the relevance of ethics; the need to align civil, legal, and technological knowledge; and the need to solve the algorithmic-semantic puzzle.

We presented in this chapter a three-step methodology aimed at validating legal governance regulatory models from an empirical point of view: (1) a scheme for the rule and meta-rule of law to start with; (2) a meta-model for legal governance to be implemented by means of CtD; and (3) a compliance causal model to validate the generated SLE. *Legal validity* and *legal validation* processes are kept and treated in a separate analytical way with a range of differentiated techniques.

We then compared our notion of SLE with Elinor Ostrom's methodological approach (ADICO and IAD) and with her concepts of *institutional grammar* and SESs. We found Ostrom's proposals inspiring, especially her deep understanding of the conditions from which a social ecosystem can emerge. Although the analysis of working legal knowledge and techniques was off target in her institutional approach, she realized that democracy and the rule of law were essential pre-conditions for sustainable development.

Our methodology can be developed and implemented in several different fields as well (such as security, health, and banking). In banking, for instance, some recurrent legal compliance problems such as (1) the identification and verification of clients' identity required by law (known as 'Know Your Customer/KYC processes'); (2) the identification of transactions suspected of involving proceeds of crime; and (3) the control of the export of goods that may have military use or civilian use (known as 'dual use goods'), could benefit from this tripartite approach.

In the present chapter, to introduce and test our methodology for legal governance and compliance we focused on OPTIMAI, a project of smart manufacturing bridging Industry 4.0 and 5.0 and covering a wide range of production and distribution processes. OPTIMAI, a platform-driven information processing system, has built a *dual closed-loop system* on physical resources and supervisory control terminals, keeping humans in the loop. We are proposing a third normative loop to generate a SLE and a semi-automated legal validation process. This requires closer attention to the middle-ware system and to the integration of data to feeding the regulatory system. The construction of the OPTIMAI regulatory model (ORM) will depend on these data analysis requirements, on the formal compliance language to substantiate ORM, and on the metrics that are also required to validate it.

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[113] Pompeu Casanovas, Louis De Koker, Danuta Mendelson, and David Watts, Regulation of Big Data: Perspectives on Strategy, Policy, Law and Privacy, *Health and Technology* (2017) 7 (4): 335–49.