

1 A Computational Approach to Competition Impact
2 Assessment

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5 **Abstract**

6 Competition does not take place in a vacuum but is embedded within an
7 existing legal and regulatory environment. Competition authorities are thus
8 encouraged to evaluate existing laws to identify and remediate competition ef-
9 fects. To this end, organizations such as the OECD and the World Bank have
10 released guidance on the conduct of competition impact assessments. Despite
11 the importance and complexities of a competition impact assessment, the lit-
12 erature is sparse when it comes to implementation specifics. From selection of
13 laws to be reviewed to the actual assessment of legal provisions, much is left
14 to the subjective evaluation of assessors. This could mean that errors could
15 compound in the course of analysis and lead to implausible results. For ex-
16 ample: 1. There are no parameters for law selection that aligns with market
17 definitions; 2. There is no consistent, granular unit of analysis; 3. There is a
18 lack of provable basis for attributing specific competition effects to legal texts.
19 The work aims to apply techniques of computational law to these problems.

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20 First: The work will encode the norms applicable to a specific sector (digital
21 payments market in the Philippines) into forms that are amenable to compu-
22 tational processing – such as modelling market entities and interactions into a
23 knowledge graph, and the normative constraints into inference rules. Second,
24 these representations can then be subjected to automated reasoning in order
25 to provide insights useful to competition analysis, such as: determination of
26 other relevant laws, evaluation for consistency and compliance, and proving of
27 specific competition effects.

28 **Keywords:** Computational Law, Competition, Impact Assessment, Artificial Intelligence

29 1 Introduction

30 1.1 Competition and the Legal Environment

31 Competition does not take place in a vacuum but is embedded within an existing legal
32 and regulatory environment.¹ Barriers to entry and exit (which can cause failure to produce
33 a competitive market) can be due not just to the structural features of a market, or the
34 behavior of its actors, but also the policy environment maintained by the government.² The
35 law can affect competition in a number of ways: It can openly favor some players, providing
36 them with tax exemptions, and subsidies. It can also put other players at a disadvantage,
37 by making it more expensive for them to operate in the industry (through barriers to entry
38 and exit). In both of the above cases, the law works explicitly in limiting competition
39 through advantages and constraints directly addressed to industry players. The enactment

¹This evokes the vision of law not as a neutral, static stage, but as Laurence Tribe describes it - one possessed of a curvature, a shape, that can affect the movement of the actors on it. See Generally Laurence H. Tribe. “The Curvature of Constitutional Space: What Lawyers Can Learn from Modern Physics”. In: *Harvard Law Review* (Nov. 1989), pp. 1–68.

²See Erlinda M Medalla. “Understanding the New Philippine Competition Act”. In: *Philippine Institute for Development Studies (PIDS) Discussion Paper Series* (No. 2017-14 2017), pp. 1–24. URL: <http://hdl.handle.net/10419/173591> (visited on 01/08/2024), at 5.

40 of a competition policy, specifically, anti-trust law, is explicitly directed at the competitive
41 behavior of firms, and is designed to restrain monopoly and maintain market competition.

42 However, even the general legal environment outside of competition law can also work
43 against competition through more subtle mechanisms. The law can control the flow of
44 information between and amongst buyers and sellers, constraining their strategic choices.
45 More importantly, the law can allow the state itself, with its size, economic power, and
46 monopoly on regulatory powers, to be a direct player (as a buyer or seller) in any industry.³

47 1.2 Competition Impact Assessments

48 The law’s impact on competition underscores the need for detailed studies on how the
49 current legal and regulatory backdrop affects competition. This can be performed through a
50 **competition impact assessment** of the laws that operate in specific sectors of economic
51 activity. A competition impact assessment refers to the review of existing or proposed poli-
52 cies in order to determine their impact on competition.⁴ This is with the view to formulating
53 alternative policies that are more conducive to competition. The underlying logic is that

³In some cases, the general legal environment is just as important as the competition law in the maintenance of a competitive market. See generally Iftexhar Hasan and Matej Marinč. “Should Competition Policy in Banking Be Amended during Crises? Lessons from the EU”. in: *European Journal of Law and Economics* 42.2 (Oct. 2016), pp. 295–324. ISSN: 0929-1261, 1572-9990. DOI: 10.1007/s10657-013-9391-2. URL: <http://link.springer.com/10.1007/s10657-013-9391-2> (visited on 01/08/2024), which suggests that competition policy in the financial sector can be inconsistent in times of crisis. Financial regulators, through prudential standards, bear the greater responsibility in ensuring against concentration. To the extent that this overlaps with market structure concerns of competition authorities, greater coordination is required. See also Tomaso Duso, Jo Seldeslachts, and Florian Szücs. “The Impact of Competition Policy Enforcement on the Functioning of EU Energy Markets”. In: *The Energy Journal* 40.5 (Sept. 2019), pp. 97–120. ISSN: 0195-6574, 1944-9089. DOI: 10.5547/01956574.40.5.tdus. URL: <http://journals.sagepub.com/doi/10.5547/01956574.40.5.tdus> (visited on 01/08/2024), Competition policy may have significant impacts, but only to the lightly regulated sectors. On the other hand, highly-regulated firms are less likely to respond to competition policy.

⁴See OECD. *Competition Assessment Toolkit - Volume 1 (Principles)*. 2019. URL: <https://www.oecd.org/daf/competition/46193173.pdf> (visited on 10/10/2023), for Part 1 of the Organization for Economic Cooperation and Development’s (OECD) 3-part guidelines for competition impact assessment. This and subsequent volumes will be referred to collectively as the “OECD Guidelines”.

54 while governments may pursue important policy goals through legislation - there are multi-
55 ple pathways to these goals, and governments should pursue those paths that least impact
56 competition. This in turn springs from the premise that more competition is beneficial,
57 especially for the consumers.⁵

58 The Philippine Competition Commission has already conducted several such assessments
59 of selected laws - either at its own instance or upon request by Congress or regulatory
60 agencies. It has also worked with organizations such as the OECD, which has performed
61 competitive impact assessments of certain economic sectors.⁶ The OECD and other orga-
62 nizations interested in advocating for competition policy have also issued guidelines for the
63 conduct of competition impact assessments.⁷ The Philippine Competition Commission cur-
64 rently has unpublished draft guidelines⁸ that it uses to guide its competition assessment
65 exercises. The PCC Guidelines disclose that it is based on the OECD Guidelines as well as
66 the World Bank’s Markets and Competition policy Assessment Toolkit.⁹ the full documen-
67 tation of which is not publicly available. To the extent that these guidelines and instances
68 of their implementation converge into common methodology, these guidelines will be ideal-
69 ized into a “canonical approach” to competition impact assessment, and represented by the
70 OECD Guidelines as the focus of analysis.

⁵OECD, *Competition Assessment Toolkit - Volume 1 (Principles)*, at 7.

⁶See for example OECD. *Competition Assessment Reviews: Logistics Sector in the Philippines*. 2020. URL: <https://www.oecd.org/daf/competition/oecd-competition-assessment-reviews-philippines-2020.pdf> (visited on 10/10/2023); See also OECD. *Competitive Neutrality Reviews: Small-Package Delivery Services in the Philippines*. 2020. URL: <https://www.oecd.org/daf/competition/oecd-competitive-neutrality-reviews-philippines-2020.pdf> (visited on 10/10/2023).

⁷See OECD Guidelines, *supra*. See also the International Competition Network’s (ICN) recommended practices. Subsequently referred to as the “ICN Guidelines” ICN Advocacy Working Group. *Recommended Practices on Competition Assessments*. International Competition Network, 2014. URL: https://www.internationalcompetitionnetwork.org/wp-content/uploads/2018/07/AWG_RP_English.pdf (visited on 01/10/2024).

⁸“PCC Guidelines”, on file with the author.

⁹See The World Bank. *Markets and Competition Policy*. World Bank. URL: <https://www.worldbank.org/en/topic/competition-policy> (visited on 01/16/2024), Subsequently, “the World Bank Assessment Toolkit”.

71 **1.3 The Canonical Approach to Competition Impact Assess-** 72 **ment**

73 The canonical approach to conducting competition assessments starts with identifying
74 laws that are relevant to a sector, then proceeds to evaluating such laws for competition ef-
75 fects. As elaborated in the OECD Guidelines, the process of competition impact assessment
76 involves the following steps:¹⁰

- 77 **1. Identify the laws to be assessed** - This can be straightforward in the case of
78 assessing new or pending legislation or regulation. On the other hand, for situations
79 where the impact of laws on an entire economic sector is required, discretion is in-
80 volved in defining the boundaries of what will be reviewed. This is expected to result
81 in a list of "relevant laws".
- 82 **2. Apply threshold tests** - The list of relevant laws can be narrowed down through a
83 threshold test. This is based on a checklist of questions designed to identify potential
84 restrictions to competition. This will result in a smaller set of flagged laws that can
85 be subject to a more detailed review.
- 86 **3. Detailed review of flagged laws** - Performing a more detailed review to determine
87 whether or not there are "actual and significant" restrictions on competition. Those
88 with such restrictions form a set of "critical laws" for which the next stage of the
89 process should be applied.
- 90 **4. Generate alternatives** - For those critical laws where restrictions are found, identify
91 alternative measures that can achieve policy objectives while being less restrictive or
92 competition.
- 93 **5. Selecting the best option** - Once policy alternatives have been generated, a judg-
94 ment must be determined as to the "best" option. Once the "best" option has been

¹⁰The enumerated steps are from OECD. *Competition Assessment Toolkit - Volume 3 (Operations Manual)*. 2019. URL: https://web-archiver.oecd.org/2020-01-22/370055-COMP_Toolkit_Vol.3_ENG_2019.pdf (visited on 10/10/2023), at 14-15.

95 identified, legislation must be drafted and passed that will implement this policy
96 recommendation.

97 **6. Ex-post assessment** - Review and monitoring of the impacts of the law implement-
98 ing the selected policy alternative.

99 The canonical approach requires a search methodology to enumerate the laws that can
100 apply to the actors and transactions in a given market. The documentation assumes that
101 the government will select or prioritize a sector to be assessed. The guidelines suggests a
102 number of prioritization principles to aid in this determination, such as: 1. Selecting sectors
103 with high economic impact (in terms of share of GDP, consumer expenditure, employment);
104 2. Or those have been the subject of frequent complaints or interventions; 3. The constraints
105 of time, financial resources, and the availability of technical talent.¹¹ For the purpose of this
106 work, it will be assumed that selection and prioritization can proceed independently, prior
107 to the methodology to be outlined in this work. Aside from simplifying the scope of the
108 work, the assumption is compatible with the notion that selection and prioritization of the
109 sector is a matter of policy, to be made by accountable, human institutions.

110 Once a sector has been selected, the next step is to compile legislation that is relevant
111 to the sector. This, in turn, is predicated on delineating a conceptual boundary for the
112 sector. The guideline acknowledges that a boundary-setting exercise can be challenging. To
113 provide some structure into this exercise, the guidelines provide some suggestions on how to
114 proceed: 1. Focusing on legislation relevant to one ministry. Using the correlation with the
115 ministry concerned as a proxy for a relevant boundary, however, simply restates the prob-
116 lem especially where the ministry has a broad mandate. It can also risk missing laws that
117 require inter-agency coordination; 2. Focusing on standard definitions - This can be done
118 by referring to standard industry classifications, such as the United Nation's International

¹¹OECD, *Competition Assessment Toolkit - Volume 3 (Operations Manual)*, at 18-19.

119 Standard Industrial Classification of All Economic Activities¹², or the Statistical Classifi-
120 cation of Economic Activities in the European Union¹³. The guideline, however, notes that
121 these classification systems will often segregate economic activities in ways that are counter
122 to both intuition as well as grounded knowledge as to how industries are actually run.

123 Assuming that the boundary of a market sector can be defined for purposes of the find-
124 ing relevant laws - this process may still yield numerous laws for any modern regulatory
125 environment. For this, the canonical approach suggests a process for filtering relevant laws
126 in order to arrive at a set of critical laws.¹⁴

127 1.4 Problems with the Canonical Approach

128 Despite the importance of evaluating the competition impact of the legal environment, the
129 methodological toolset for impact assessment has fallen behind (in terms of sophistication
130 and rigor) those used in other areas of competition policy, such as: merger control, assess-
131 ment of anticompetitive agreements and abuse of dominance.¹⁵ According to the OECD
132 Guidelines, Step 3 and the associated competition checklist lie at the heart of the compe-
133 tition impact assessment process. Despite the importance assigned to this section of the
134 process, both the OECD Guidelines and the literature on competition impact assessment
135 do not provide a detailed, rigorous, and consistent methodology for performing this step.
136 The OECD Guidelines provide a checklist of questions that can be used to identify poten-
137 tial restrictions to competition. However, the OECD Guidelines do not provide a detailed

¹²United Nations. *International Standard Industrial Classification of All Economic Activities (ISIC)*. Revision 4. United Nations, 2008. ISBN: 978-92-1-161518-0. URL: https://unstats.un.org/unsd/publication/seriesm/seriesm_4rev4e.pdf.

¹³European Commission. *Statistical Classification of Economic Activities in the European Union*. Rev. 2. 2008. URL: <https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF> (visited on 05/13/2024).

¹⁴OECD, *Competition Assessment Toolkit - Volume 3 (Operations Manual)*, at 17.

¹⁵See Nicole Robins and Hannes Geldof. “Ex Post Assessment of the Impact of State Aid on Competition”. In: *European State Aid Law Quarterly* 17.4 (2018), pp. 494–508. ISSN: 16195272, 21908184. DOI: 10.21552/estal/2018/4/6. URL: <http://estal.lexxion.eu/article/ESTAL/2018/4/6> (visited on 01/03/2024), which proposes a greater role for financial and economic analysis in evaluating the impact of state action on competition, at 494-495.

138 methodology for applying the checklist. Much is left to the subjective evaluation of asses-
139 sors. This could mean that errors could compound in the course of analysis and lead to
140 implausible results. This rise to the following problems:

141 **Law selection** Assuming that the economic sector has been selected and its conceptual
142 boundaries have been delineated, the assessor is expected to derive from this model "an
143 exhaustive list of laws and regulations that influence the economic activities that take place
144 in each of the sectors under examination".¹⁶ There is no elaboration as to how the conceptual
145 mapping in the previous step can translate into a search strategy that can be documented,
146 refined, and shared. There are no parameters for law selection that aligns with market
147 definitions. The literature require that laws relevant to a market be subject to competition
148 analysis. Although there are well-established methods for defining a market, criteria for
149 selecting laws that will be subject to analysis are not aligned with these market definitions.
150 Assessors are likely to under- or over-select the laws.

151 **Unit of analysis** No consistent, granular unit of analysis. Competition authorities may
152 look at individual laws and analyze these for competition impact. However, a statute may
153 not be the appropriate unit of analysis, since the competition impacts operate through
154 key provisions that work with other critical provisions found in other laws. Looking at
155 more atomic levels of distinct rules within provisions can also enable more detailed forms
156 of analysis.

157 **Lack of proof** Lack of provable, measurable basis for correlating textual provision with
158 an anti-competitive effect. Even if a law is properly selected and studied at the appropriate
159 level of description, the actual evaluation of competition impact is described on an intuitive,

¹⁶The Guidelines acknowledge that this stage of the process is not trivial, since ensuring the inclusion of all relevant legislation requires casting a broad net. The guideline suggests an iterative process, which requires not just reference to texts initially found in electronic databases (as well as the laws they refer to, such as implementing rules), but also through consultation with stakeholders. OECD, *Competition Assessment Toolkit - Volume 3 (Operations Manual)*, at 21.

160 sometimes *ad hoc* basis. It is not encoded in a way that can be reliably communicated,
161 proved, and further analyzed.

162 1.5 Specific Problems with Law Search and Selection

163 The first step in the canonical approach to competition impact assessment is to find the
164 laws that are applicable to a sector. Given an industry or market sector under consideration
165 - What law “covers” an industry or a market with all its actors and transactions? The goal
166 is to arrive at either a complete or a heuristic but consistent mapping between actors (and
167 their actions relevant to a market) - and the laws that would cover these actors and actions.

168 **Risk of under-inclusion** In evaluating a legal environment, assessors may overlook
169 critical legal standards pertinent to the industry, due to a disconnect in the terms used by
170 the industry and those employed in legal contexts. This phenomenon is particularly evident
171 in emerging digital finance businesses. These entities often operate under novel designations
172 or through distinct modalities, such as exchanges and applications. Consequently, there is
173 a prevailing misconception that such entities fall outside the purview of traditional finan-
174 cial regulations. This overlooks the fact that, despite their innovative approaches, these
175 entities perform analogous functions and are subject to similar risks as their conventional
176 counterparts.

177 On the other hand, focusing on a single law nominated by a stakeholder may result in
178 losing many critical signals. This is because competitive issues such as barriers to entry,
179 disproportionate costs, and preferential treatment can arise not from a single law but from
180 the interaction of key provisions spread across several legislative enactments.

181 The OECD framework cautions that “When performing this exercise, it is important to
182 remember that, in addition to sector-specific regulation, there also exists horizontal, cross-
183 sectoral, legislation (such as planning restrictions or environmental standards) that may

184 have a considerable impact on the economic activities performed in that sector and may be
185 a cause of additional competition restrictions.”¹⁷

186 **Risk of over-inclusion** If we take a connected view of the law, all of the law can be
187 relevant to a particular market. Every law has the potential to change the relative rights
188 and obligations of parties involved in economic activity and thus result in some competitive
189 impact. Considered this way, even laws that apply to everyone and only incidentally touch
190 economic activities in a sector - can be interrogated for potential competitive impact, no
191 matter how small or contingent. The Philippine Civil Code, for example, gives a preferential
192 status for unsecured debt evidenced by a notarized instrument, over those that are embodied
193 in a private document. Family and tax law provides rights and privileges that are accessible
194 only to married heterosexuals. Nevertheless, these laws should usually not be the subject
195 of competitive impact analysis. As they apply to everyone, in a large enough population
196 their application to specific individuals can appear random and evenly distributed - any *de*
197 *minimis* competitive impact is contingent and cancel each other out. More importantly,
198 these laws do not directly relate to the sector under consideration, and their ultimate effects
199 on the actors in the sector will only be coincidental.¹⁸

200 A lawyer’s theoretical training and experience, and openness to economic thinking can
201 perform the required analysis while compensating for these limitations. However, that
202 lawyer may not always be available. It is also possible that the limited pool of legal talent
203 will not be able to scale to the demands of extensive, industry-wide competition analysis,
204 which could involve hundreds (if not thousands) of laws and regulations, all of which could

¹⁷See OECD, *Competition Assessment Toolkit - Volume 1 (Principles)*.

¹⁸“Plaintiffs stress that the LMRDA is a remedial measure and seek a liberal construction. This maxim is useless in deciding concrete cases. Every statute is remedial in the sense that it alters the law or favors one group over another... But after we determine that a law favors some group, the question becomes: How much does it favor them? Knowing that a law is remedial does not tell a court how far to go. Every statute has a stopping point, beyond which, Congress concluded, the costs of doing more are excessive — or beyond which the interest groups opposed to the law were able to block further progress.” - Richard Stomper, et al., Plaintiffs-appellees, v. Amalgamated Transit Union, Local 241, Defendant-appellant, 27 F.3d 316 (7th Cir. 1994)

205 interact with each other. Abstracting the problem into a computational form can allow
206 parts of the analysis to be done by non-lawyers (i.e., the staff of a competition authority),
207 or even by computers. The goal is not to supplant the human component of competition
208 impact analysis but to augment it.

209 **1.6 Computational Law in Aid of Competition Impact As-** 210 **essment**

211 These problems relating to scale, rigor, consistency, and predictability may be the ap-
212 propriate setting for the application of computational law, which can look at legal rules
213 as discrete units that can be evaluated. In this light, the question of competition impact
214 can be structured as a computational problem. This work aims to apply computational
215 techniques to: 1. The selection of laws for competition impact assessment, based on their
216 relevance to a market; 2. The representation of legal rules into discrete computable units;
217 3. The automated analysis and evaluation of legal rules for their competition impact. It
218 hopes to introduce improvements to the problem of search and prioritization of laws: That
219 is, the process of making an exhaustive mapping of concepts in a market in order to identify
220 relevant laws, as well as applying the threshold tests in a consistent and rigorous manner.

221 Automated reasoning can also allow competition authorities and policy makers to make
222 extensive evaluations efficiently and at scale. A responsive competition assessment system
223 should not only evaluate retroactively, for existing laws, but also conduct the exercise for new
224 or proposed legislation. While it is possible for each new law to carry not only prospective
225 effects in a particular subject matter - it is also possible for it to interact with the existing
226 legal environment in a way that would change the competition impact of prior laws. A new
227 baseline understanding of the competition impact of the entire legal environment may have
228 to be inspected with the passage of each new law, compounding the complexity of the task
229 and adding to the burden of competition authorities. Part of this regression analysis can
230 be automated through the computational approach.

231 It should be noted that the primary concern of this paper is in finding the relevant laws
232 as well as evaluating them for competition effects into a computable problem. The work
233 will explore formalizations for representing the above problems in a way that can be pro-
234 cessed by computers. The emphasis is in developing tools for the facilitation of competition
235 impact assessment. This assumes that an appropriate body is responsible for conducting
236 such assessment. This and other features of a competition assessment regime, such as the
237 location of the assessment in the larger policy development process, the involvement of the
238 competition agency, will not be within the scope of this work. Although Computational
239 Law is usually associated with automation of legal determinations through a computer -
240 it is not the goal of this work to implement an automated counterpart for the sections of
241 the competitive impact assessment process that will be encoded into a computational form.
242 Some experimental code might be featured in order to demonstrate the feasibility of some
243 proposals, but these are not production-quality implementations. It should be noted that
244 the advantage of the computational approach goes beyond machine execution of routine
245 legal tasks, but in helping develop notations through which we can understand and share
246 problems of legal reasoning.

247 **1.7 Next steps**

248 **Finding a constrained version of the problem** The goal of the proposed work is
249 to use the computational approach for competition analysis. Particularly, for the stages of
250 legal search, selection, and threshold testing. The scope of the study is further limited to
251 applications for the special case of the Philippine digital payments sector - where both the
252 assumptions, definitions, and constraints are more explicit.

253 The study can be limited to well-defined standards in competition - i.e. those that are
254 already extensively documented and tested in the economics literature, and so can be a
255 source of explicit rules on how a competitive market ought to behave. As to the laws
256 that will be evaluated, the plan is to focus on a segment that is already digitized and

257 subject to very specific constraints. The digital payments sector is a good candidate. Out
258 of necessity, the sector does not involve many entities and transactions with open-ended
259 states. It is also a field characterized by extensive, semantically rich constraints from
260 industry standards, government regulations, user contracts, and the functionality of the
261 digital platforms themselves.

262 **Miscellaneous considerations** : The problem of competition impact analysis has the
263 same shape as other bulk analysis problems of the Law Center, such as: 1. gap analysis;
264 2. impact analysis; 3. compliance analysis. They all involve some form of legal comparison
265 and evaluation - old law against new law, n-level law versus n-1 level law, etc. So an advance
266 in the solution of one problem can contribute to the other.

267 Why is all the effort towards abstraction preferable to the usual intuitive approach? In
268 addition to giving us scale and automation, the computational approach can help us in two
269 ways: 1. It can help us make our analysis more rigorous, and 2. It can help us make our
270 analysis more transparent. Sharing legal knowledge through a formalized notation can help
271 us build richer systems of legal knowledge.

272 It should be noted that regardless of the formalization, inference rules, defeasible deontic
273 logic is already embedded in the practice. Just as a baker can make a cake without knowing
274 the chemistry of baking, we can make legal determinations without knowing the formalisms
275 of logic. But just as knowing the chemistry of baking can help us make better cakes, knowing
276 the formalisms of logic can help us make better legal determinations.

277 Despite the initial wariness about the costs and consequences of large language models,
278 their growing sophistication is compelling. Recent literature suggests that knowledge graphs
279 can be embedded into large language models, making the latter more efficient, more attuned
280 to “ground truth”, and therefore more reliable. Since both argumentation frameworks and
281 proposition networks can be framed as extensions of the information contained in knowledge

282 graphs, it may be possible to combine these approaches as well.

2 An Overview of Computational Law

2.1 Historical background

The project of applying computational techniques to the legal domain - e.g. encoding law into computational terms, and mechanically applying or analyzing these - was among the earliest directions of artificial intelligence research. Despite its early promise, however, the approach did not bear fruit.¹⁹ During the 1980's there was initial optimism about the prospect of computers performing automated legal reasoning. Grossman summarizes the research and programming activity towards this end. They note that while computers cannot replace lawyers, these machines can, in time nevertheless run "legal reasoning systems" that can assist attorneys.²⁰ Computerized legal reasoning offered speed, reliability, and the ability to carry out numerous, repetitive tasks. It could also provide a consistent application of the law.²¹ It was also hoped that the availability of such systems could have knock-on effects on legal reasoning itself, molding the thought processes of legal professionals towards logical rigor, and force the field to be more explicit about its assumptions.²²

Initial approaches Early attempts at replicating legal reasoning through software tried to emulate the fact that lawyers employed both deductive and analogical reasoning when working on a case²³:

1. **Deduction** - Looking at conditions, propositions in the law as well as fact patterns,

¹⁹See Michael Genesereth and Nathaniel Love. "Computational Law". In: *Proceedings of the 10th International Conference on Artificial Intelligence and Law - ICAIL '05*. The 10th International Conference. Bologna, Italy: ACM Press, 2005. ISBN: 978-1-59593-081-1. DOI: 10.1145/1165485.1165517. URL: <http://portal.acm.org/citation.cfm?doid=1165485.1165517> (visited on 09/18/2021), at 205.

²⁰Garry S Grossman and Lewis D Solomon. "Computers and Legal Reasoning". In: *ABA Journal* 69 (1983), pp. 66-70, at 66: "Primarily, a legal reasoning system would serve as a repository of knowledge, outlining the general parameters of the law. In lieu of searching through a treatise or similar task, given a specific factual situation, the system could be relied on to present only the relevant law."

²¹Ibid.

²²Ibid.

²³Ibid., at 67.

301 and then making inferences towards legal conclusions. For example: “If *A* or *B* then
302 *C*”. The computer stores representations of operations (e.g. the inference from *A* to
303 *B*), as well as their premises (e.g. what *A*, *B*, and *C* stand for.)

304 2. **Analogy** - Looking at analogous cases, i.e., those that may have different fact pat-
305 terns but similar relationships. A computer can attempt to reason by analogy by
306 searching for relationships in fact patterns similar to those of the case at hand. The
307 system can apply the rule of one case to another based on their similarity.

308 An example of the deductive approach was JUDITH, developed in the early 1970’s by
309 Walter Papp and Bernhard Schlink. The law was modeled as a set of premises (as defined
310 by its programmers). The user goes through the premises that may be stereotypical for
311 a given problem, determining whether they applied or not (True or False). Based on this
312 knowledge, the system attempted to determine whether a cause of action exists under a
313 given set of facts.²⁴

314 On the other hand, the TAXMAN system by McCarthy had an approach similar to anal-
315 ogy.²⁵ Instead of asking specific questions (like Hellawell’s system) it maintained an internal
316 representation of: 1. The fact pattern at hand and 2. Fact patterns that are inherent or
317 usually associated with corporate reorganizations. These representations come in the form
318 of “semantic networks”, compound statements elaborating the legal relationships in these
319 fact patterns. Users were expected to enter a fact pattern (in a formal, structured language).
320 The computer would then search through the semantic network for similar relationships.
321 This required all relevant relationships to be thought of beforehand and represented in a

²⁴Another example of a system from this period using the deductive approach is Hellawell’s tax planning systems - one used to determine the treatment of redemptions, and another for the optimal choice of foreign subsidiary. Both systems involved no attempt to create an internal model of the relevant laws. Instead, the explicit tests were programmed directly into the system, and tailored to specific problems. The design and implementation of both systems were not adaptable to other areas of law Grossman and Solomon, “Computers and Legal Reasoning”, at 67.

²⁵Ibid., at 67-68.

322 formal language.²⁶

323 The systems mentioned in the previous paragraphs were limited in terms of the legal
324 problems they addressed. They dealt with areas where there were fewer ambiguities, or had
325 rules that are susceptible to mechanistic analysis. They were also limited by the technology
326 available at that time. Making the internal representations of facts and laws involved
327 complexity and a lot of resources. None of the programs had standardized, user-friendly
328 interfaces. Even then, their solutions were often superficial and were thus of limited value
329 in real world settings.²⁷

330 2.2 Definition and contemporary developments

331 According to Genesereth: “Computational law is that branch of *legal informatics*²⁸ con-
332 cerned with codification of regulations in precise computable form.”²⁹ In terms of practical
333 applications - it can provide the basis for computer systems performing compliance checks,
334 legal planning, the analysis of regulations, and related functions. Many computer applica-
335 tions aid lawyers in their tasks, but these are not within the ambit of the term. Examples
336 include legal databases to find the law, and office productivity suites to help the practi-
337 tioner prepare briefs, or systems to automate the backroom functions of the law office. In

²⁶On the other hand, Meldman’s query-based system for assault and battery cases is cited as another example of a system that applies analogy. It works by taking in as input a series of word groups that describe the facts of a case. The system will then state whether it can identify cases with similar fact patterns. It can be classified as a research tool rather than a system for automating legal reasoning. Grossman and Solomon, “Computers and Legal Reasoning”, at 69.

²⁷Ibid., at 69.

²⁸“Legal informatics is defined as the study of information, its technology, and its implication and impact in the field of law”. This is to be differentiated from “Computer law”, which is concerned with “problems relating to the social implications of information technology in the field of law.” Christopher L. Hinson. “Legal Informatics: Opportunities for Information Science”. In: *Journal of Education for Library and Information Science* 46.2 (2005), p. 134. ISSN: 07485786. DOI: 10.2307/40323866. JSTOR: 10.2307/40323866. URL: <https://www.jstor.org/stable/10.2307/40323866?origin=crossref> (visited on 11/02/2023), at 134-135.

²⁹See Michael Genesereth. *Computational Law: The Cop in the Back Seat*. CodeX: The Center for Legal Informatics Stanford University. 2015. URL: <https://law.stanford.edu/publications/computational-law-the-cop-in-the-backseat/> (visited on 09/18/2021), at 2.

338 these instances, the legal reasoning is still performed by the human agent. The computer
339 performs symbolic analysis for purposes of retrieval and presentation of data, without any
340 recognition of the rules as such.³⁰From a pragmatic perspective, Computational Law is
341 important as the basis for computer systems capable of doing legal calculations, such as
342 compliance checking, legal planning, regulatory analysis, and so forth”.³¹ The touchstone of
343 the computational project is the creation of ”Codex Machine” which contains within itself
344 an extensive databases of encoded rules, and with all the required computational resources,
345 provide responses indistinguishable from that made by a legal professional.³² Despite the
346 recency of the term, its goal is shared by early projects in artificial intelligence, which saw
347 the legal domain as a natural site for the application of computational techniques.³³

348 The prevalent approach to meeting these goals has two components: 1. First, representing
349 law (and surrounding facts) into a formal logical form and 2. Second, the ability to process
350 those representations to assist in legal determinations. This means: That it would be
351 possible through computational techniques, to arrive at consistent, correct (or at least

³⁰See Genesereth, *Computational Law: The Cop in the Back Seat*, at 2-3 for a proposed example. According to Genesereth the Turbo Tax program is a computational law application. The user supplies values, and the program makes computations of the user’s tax obligation. When prompted, it can explain its results by making references to the applicable tax law. Legal rules (whether or not taxable, the base, rate, and tax due) are encoded (however indirectly) as code, and the result of the processing is a legal determination - whether or not tax is due, and how much. But see Hans Andersson. “Computational Law: Law That Works Like Software”. CodeX – The Stanford Center for Legal Informatics, Feb. 10, 2014. URL: https://www.academia.edu/9286857/Computational_Law_Anderrson_and_Lee, at 3-4. There is a tendency to invoke a Turing test analogue for computational law system: “Any system whose users inputting, through whatever interface such system might present, a legal query to obtain a legal response would find themselves unable, given only the response, to determine whether a legal professional...had provided the system’s response.” Andersson rejects this criteria because it would include systems that only outwardly appear to be computational law without actually solving its fundamental problems. Based on his rejection of the Turing or “imitation” principle of what constitutes computational law, Andersson argues that Love and Genesereth’s inclusion of Turbo Tax within the definition is inaccurate. Although the program appears to replicate the behavior of a tax professional - it does not formally represent laws, or performs automated reasoning based on those representations. This author notes that the whole point of the imitation principle is that the intent of representation does not matter - thus avoiding many philosophical questions.

³¹Genesereth, *Computational Law: The Cop in the Back Seat*, at 2.

³²Andersson, “Computational Law: Law That Works Like Software”, at 16.

³³Genesereth and Love, “Computational Law”, at 205.

352 plausible) legal conclusions from given set of premises and operations.

353 These determinations can be descriptive, recreating in computational form the law as it
354 is, and guiding its users in evaluating whether certain actions or states of the world are in
355 accordance with the encoded rules. It can also be prescriptive, meaning the rules as encoded
356 can be analyzed and evaluated against standards (such as efficiency), or their alignment with
357 other rules, in order to arrive at more suitable rules.³⁴ Despite its aspiration of being a visible
358 system of explicit rules, so much of the law is actually dependent on tacit knowledge, i.e.:
359 Other, higher order rules (for determining applicability, validity, interpretation) entities and
360 concepts that are not provided in the legal text. Part of the project of computational law
361 is to surface that tacit knowledge.

362 2.2.1 Computable contracts

363 Wolfram on the other hand sees computational law as part of a larger trend towards
364 abstraction and formalization, not just in the law but in all spheres of human activity.
365 The development of language and systems of writing themselves can be thought of as an
366 initial step in this trend.³⁵ Written language enabled law to have coherent, codified forms,
367 as well as a record for deciding ground facts and establishing precedent. While fields such
368 as the natural sciences have progressed in terms of abstraction and formalization to build
369 more intricate systems of knowledge, the law has lagged behind. What is required is the
370 development of a symbolic discourse language for communication of legal and normative
371 concepts, not just with each other, but with computers. Wolfram uses contracts as the
372 starting point for demonstrating the feasibility of formalization and its consequences: A
373 contract in computational form can be defined relative to a set of underlying laws, that

³⁴Andersson, “Computational Law: Law That Works Like Software”, at 7.

³⁵Stephen Wolfram. “Computational Law, Symbolic Discourse and the AI Constitution”. In: *Data-Driven Law: Data Analytics and the New Legal Services*. Ed. by Ed Walters. Red. by Jay Liebowitz. Data Analytics Applications. Boca Raton, FL: CRC Press Taylor & Francis Group, 2019, pp. 144–174. ISBN: 13: 978-1-4987-6665-4. URL: <https://writings.stephenwolfram.com/2016/10/computational-law-symbolic-discourse-and-the-ai-constitution/> (visited on 01/14/2024), at 156.

374 serve as the built-in functions of his hypothetical “symbolic discourse language”.³⁶ Once a
375 contracts are converted into a program written in a symbolic discourse language, we can
376 perform all sorts of operations - like determining if a contract implies a certain outcome (or
377 is contrary, complimentary with other contractual and normative commitments).³⁷

378 One consequence of the computability of contracts is that these can then take in inputs
379 from a variety of sources (including other computable contracts), in order to resolve au-
380 tomatically.³⁸ The usefulness of computational contracts will depend on what the inputs
381 are (and their quality, availability).³⁹ Some of those inputs will be natively computational
382 - like the latency of a system, or the amount of digital currency present in an account.
383 as more and more transactions become online, these type of inputs will be more useful.
384 However, not every input is born digital, and will need to take into account the state of
385 things and events in the outside world. Digital analogues may be available for some of these
386 inputs, such as GPS coordinates for location, as well as IoT sensors for basic physical mea-
387 surements(weight, temperature, vibration). For more complicated inputs that are required
388 to produce legal consequences (i.e., is a person dead, or did the delivered goods meet the
389 stipulated quality standards) may require either manual input, or the use of AI.⁴⁰

³⁶Wolfram, “Computational Law, Symbolic Discourse and the AI Constitution”, at 157.

³⁷Wolfram also notes that even if built on a computational strata, our computable contract may still come across a problem of formal undecidability. i.e. there is no guarantee, even with a formal problem definition, that it is susceptible to solution based on systematic finite computation. *ibid.*, at 158.

³⁸Similar to, but at a higher scale and level of complexity, the automated ”working out” of options transactions in electronic markets. *ibid.*

³⁹These inputs could include: 1. Intrinsic - Such as the computer’s date and time; 2. Extrinsic - Publicly accessible data like stock price, temperature, or a seismic event (which can be consolidated or mediated through something called an ”oracle” that a computational contract has access to); 3. Non-public information - Humans, or machine learning systems can intervene *ibid.*, at 162-163.

⁴⁰The AI component, which may use machine learning techniques, will be less transparent and subject to algorithmic biases - just like human determinations which can also opaque and biased. The AI determinations, on the other hand, are at least more amenable to systematic analysis. To ensure its reliability, this component can be subjected to a security-risk model of evaluation and subject to cycles of exploit and patching *ibid.*, at 160.

390 Computational contracts can be self-enforcing, automatically running just like any soft-
391 ware process. A counterweight to this autonomy is the trustworthiness of the computed
392 determinations - i.e. how can we be sure that the computation was reached with integrity
393 (i.e. that the process was neither hacked nor erroneous)?⁴¹ Wolfram imagines that existing
394 contracts written in natural languages can be translated into a symbolic discourse lan-
395 guage, which should be complete and expressive enough to describe ethical and normative
396 systems.⁴² More likely, however, new contracts can be written directly into the symbolic
397 discourse language.

398 Adding a computable element to contracts is a way to deal with the growing cost and
399 complexity of transactions. Wolfram also suggests that binding agreements, expressed in
400 computational terms, may also be the means through which we can communicate normative
401 constraints to Artificial Intelligence.⁴³

402 **2.2.2 Relationship with Current AI Implementations**

403 Computational Law appears to overlap with artificial intelligence in terms of function.
404 Explicitly encoding the rules of law and legal reasoning can be considered an application of
405 **declarative artificial intelligence**, an approach to AI that focuses on the representation
406 of knowledge and reasoning. Recent developments show great promise from the connec-
407 tionist approach to AI, which focuses on the use of neural networks and deep learning.
408 The latter approach has been used to develop large language models (LLMs) such as GPT,
409 which can perform a variety of tasks, including generate text that reads like plausible legal

⁴¹Technologies such as blockchain, encryption, as well as regular audits may help address these concerns. Wolfram, “Computational Law, Symbolic Discourse and the AI Constitution”, at 162.

⁴²In cases of ambiguity, the translator-programmer can select an authoritative version, or provide alternative interpretations. *ibid.*, at 163-164.

⁴³The constraints we need to enforce on AI will have to be natively computational, since the behavior and possibilities of AI may be too broad, too complex to be expressed in natural language law. It would also not be enough to make it ingest the whole corpus of the law in natural language text as training data: It may be dangerous to give A.I. vaguely couched natural language constraints, since by default it will only literally follow the letter of the law, and exploit ambiguity to achieve hard-coded goals. *ibid.*, at 167.

410 reasoning. Given this state of affairs, will it not be better to develop LLMs to perform
411 the tasks of legal analysis and evaluation? One might suggest simply feeding ChatGPT
412 the corpus of existing law, and expect it to perform legal reasoning. In some ways, the
413 declarative approach is similar to the training of a machine learning model to perform the
414 same function. The difference is that the former is a more explicit, transparent, and con-
415 trollable process. The latter is more opaque, and the results are less predictable. Thus, for
416 mission-critical domains like law, there is merit in explicitly encoding rules over LLMs and
417 deep learning for the following reasons:

418 **No ground truth** In an ordinary conversation or task, humans rely on an internal
419 theory of the world, a theory of mind for the entities that it is dealing with. We have a
420 phenomenology. We are still not sure if this can be done for AI's. Certainly this is not
421 what happens with LLMs. These models do not have ground truth. Without the capacity
422 for ground truth, LLM's can spiral into delusions - making their applications unsafe for
423 mission-critical applications.

424 **Prohibitive costs** LLM's are expensive - These systems are expensive to build, train,
425 and maintain, even on a per-query basis once everything is set up. These are also expensive
426 to retrain. If a Large Language Model gets "poisoned" by malicious input - what are the
427 ways to mitigate it? How can one "nudge back" if the mechanism is hard to trace and hard
428 to explain. Fixing it will require a lot of resources and the solution might not be durable
429 (It could also affect the accuracy and the responsiveness of the model)

430 The connectionist approach to AI and declarative computational law approaches, al-
431 though distinct, can still converge and reinforce each other: Data-driven LLMs can inform
432 and enrich our techniques for encoding laws. The more varied the laws we have to encode,
433 the more diverse the rules that can form the basis of a computational law system, and the
434 more accurate and relevant will its determinations be. At the same time techniques of logic
435 used by computational law can enhance algorithms used by the data-driven approach by

436 providing a more nuanced view of legal knowledge and legal reasoning It may be possible
 437 to combine LLM’s with the declarative approach in mutually beneficial ways: Wolfram
 438 suggests that a sufficiently trained machine model can interact with norms defined in a
 439 symbolic discourse language: Overall goals and standards can be defined in the symbolic
 440 discourse language, while the machine learning model can fill in implementation details.⁴⁴
 441 Machine learning models can also be trained to convert a huge corpus of legal texts into a
 442 initial encoding in the symbolic discourse language.⁴⁵

443 2.3 Computational Law Examples

444 Let us imagine a business with the following configuration of employees and offices:⁴⁶

John manages Ken	John is in office 22	John is male
John manages Kat	Kat is in office 24	Jill is female
Jill manages Mark	Ken is in office 22	Ken is male
Jill manages Mike	Kat is in office 24	Kat is female
		Mary is female
		Mike is male

445 Logic and programming constructs allow us to: First - use of variable to represent an
 446 arbitrary number of entities (X, Y, Z for employees and offices). Second - use of logical
 447 operators to express relationships between any of the above (not, and, or, if-then). These
 448 ”representational extensions” allow us to define new relations in terms of existing relations:

449 If X is in office Z and Y is in office Z and X and Y are *distinct*, then X is an
 450 *officemate* of Y.

⁴⁴Wolfram, “Computational Law, Symbolic Discourse and the AI Constitution”, at 165-166.

⁴⁵Wolfram believes that machine learning models are likely to have limits in how they model concepts (such as the notion of space). Thus, human intervention will always be required in encoding laws and norms *ibid.*, at 157.

⁴⁶The following examples are from Genesereth, *Computational Law: The Cop in the Back Seat*, at pp. 3-5.

451 In addition to merely describing entities and their relationships, we can encode rules and
452 regulations through the use of these programmatic tools. We can ascribe the attribute of
453 illegality to some facts or relationships:

454 If X manages Y and X is an officemate of Y, then that is *illegal*.

455 Within a given set of facts (entities and relationships) and rules (deontic assertions) it may
456 be possible to derive other conclusions:⁴⁷ These patterns of reasoning are called "inference
457 rules" or rules of inference. Iterative use of inferential reasoning can generate all logical
458 conclusion (facts and rules) from within a given set of premises (facts and rules).

459 Example of inferential rules discovery and compliance check:

- 460 • John is in office 22
- 461 • Ken is in office 22
- 462 • John is an officemate of Ken
- 463 • John manages Ken and John is an officemate of Ken
- 464 • John is not Ken
- 465 • That is illegal

466 We can invert this reasoning working backwards and arranging facts to avoid illegalities

- 467 • John is in office 22
- 468 • Jill is in office 24
- 469 • Ken is in office 22
- 470 • Kat is in office 24

⁴⁷According to Genesereth, 2015: "...by matching facts and conclusions of rules to the conditions of other rules and asserting their conclusions"

471 The inference rule discovery process can be extended to look for inconsistencies within
472 a set of regulations. For example: We might require every project to have managers and
473 subordinates, and no manager have a subordinate who is also an officemate. This might
474 be inconsistent with a subsequent rule requiring special projects personnel be housed in a
475 common work room. Compliance checking (through automated legal reasoning) can feed
476 legal planning and regulatory analysis.

477 **2.4 Advantages of the Computational Law Approach**

478 Based on the above definitions of computational law, and depending on the horizon of
479 technological development considered, possible computational law implementations fall into
480 two major categories:⁴⁸

- 481 1. **Specific computational law** - Such as simply confirming the presence of necessary
482 elements of a cause of action, as in a checklist.
- 483 2. **General computational law** - Capable of making nuanced determinations if pre-
484 sented with a complex fact pattern within a specific (or even several) legal regimes.

485 **2.4.1 Enabling applications for automated legal reasoning**

486 **Rule/argument generation** Computational law could lead to the development of
487 applications that are capable of causal inference in law. Assuming facts and rules can be
488 well-defined, a computational process can derive other applicable rules.⁴⁹ The availability of
489 rule detection and automated legal analysis can enable legal self-help - actors structuring/
490 planning their activities (especially electronic transactions) to be legally valid/compliant.

⁴⁸Andersson, "Computational Law: Law That Works Like Software", at 6.

⁴⁹The simplest and oldest attempts at computational law applications often involve the mapping of legal rules into logical rules. This approach can be useful if the problems are stereotypical and clear, i.e. there is little to no context dependency that will make the application of rules contingent. Branting characterizes UCC-related problems as those most likely to be amenable to the approach. While those that involves broad standards, such as "reasonable care" is not Kevin Ashley et al. "Legal Reasoning and Artificial Intelligence: How Computers "Think" Like Lawyers". In: *University of Chicago Law School Roundtable 8.1* (2001), pp. 1-28, at 14-15.

491 Similar to word processors reducing reliance on typesetters.⁵⁰ Logical representations can
492 make it possible to derive common baseline rules, or discover bridging rules (or the exact
493 points of divergence). This will then make it easier to have analyze cross-border contracts,
494 or do comparative legal analysis.⁵¹

495 **Legal outcomes prediction** Related to the generation of other feasible rules is the
496 prediction of legal outcomes. A computer can treat factual circumstances in the present as
497 data, while the applicable rules can be represented as algorithms that can process such data
498 to determine likely results. Predictive systems may be adopted by legal practitioners, since
499 advising their clients may often involve predicting the outcome of legal controversies. Having
500 computational systems that look at the data from an uninterested perspective may be
501 helpful since lawyers' calculations may be skewed by their optimism, or by an overestimation
502 of their own skills. This can result in suboptimal outcomes for their clients, the courts, and
503 society as a whole.⁵²

504 **Document processing** Finally, computational law systems can serve the requirement
505 for the drafting, preparation, and filing of legal documents. The ability to infer rules and
506 predict outcomes can be combined with exiting sophisticated models (such as those provided
507 by natural language processing) in order to create drafts.⁵³

⁵⁰Genesereth and Love, "Computational Law", at 206.

⁵¹But see Benjamin Alarie. "The Path of the Law: Toward Legal Singularity". In: *University of Toronto* 66.4 (2016), pp. 443–445. ISSN: 1556-5068. DOI: <https://doi.org/10.3138/UTLJ.4008>, at 1-3. The following discussion on capabilities and applications of Computational Law systems may be considered modest, especially when compared to Alarie's vision of a "legal singularity" brought about by greater computational capabilities and availability of data. Using tax law as an example, some of the transformations brought about by this convergence include: 1. Improved dispute resolution and access to justice - A shift from standards (broad, adjudicated ex post facto) to a more complex but query-able system of rules (that are knowable ex-ante), 2. More complete specification of tax law. The emergence of a more complex regime that is nevertheless capable of precision, coherence, and distribution of burden (at least compared to the current system) Legal uncertainty can be eliminated under such a regime, and legal disputes will be rare. Agreed upon or discovered facts can be readily mapped to clear legal consequences.

⁵²Ashley et al., "Legal Reasoning and Artificial Intelligence: How Computers "Think" Like Lawyers", at 15-16.

⁵³Ibid., at 16.

508 2.4.2 Appropriate settings for computational

509 The availability of rule detection and automated legal analysis can enable legal self-help -
510 actors structuring/planning their activities (especially electronic transactions) to be legally
511 valid/compliant. Similar to word processors reducing reliance on typesetters.⁵⁴ Logical
512 representations can make it possible to derive common baseline rules, or discover bridging
513 rules (or the exact points of divergence). This will then make it easier to have analyze
514 cross-border contracts, or do comparative legal analysis.

515 Love and Genesereth maintains that such systems and self-help only extends to reducing
516 transaction costs for legal compliance and does not mean that parties can appear *pro-se*
517 in instances of conflict. The forum of computational law is within enterprises, and not
518 courts.⁵⁵

519 Genesereth sees potential in embedding computational law applications into software
520 that supports workflows that are subject to legal, regulatory requirements - e-commerce,
521 data privacy, etc. Genesereth points to Project Calc (A Stanford CodeX project under
522 Harry Surden), which integrates into CAD software used by architects, routines for checking
523 compliance with rules such as: building codes, environmental rules, accessibility laws.⁵⁶

524 We can embed computational law applications in devices such as cellphones, car dash-
525 boards, smart glasses so that they can provide legal guidance at the point of decision. For
526 example: An app that not only identifies the flower the picture of which you took, but also
527 informs you that you should not pick it up. Compared to simply publishing an overwhelm-
528 ing mass of laws (often in a language inscrutable to the public) digitally-mediated legal

⁵⁴Genesereth, *Computational Law: The Cop in the Back Seat*, at 7.

⁵⁵See. Citing Loftus and Wagenar: “Optimism is rewarded...The most successful trial lawyers are those whose estimates are least realistic, that is, are most overly optimistic...This means that as an institution, courts are rewarding behavior that isn’t optimally beneficial to the system as a whole... Genesereth and Love, “Computational Law”, at 206.

⁵⁶Genesereth, *Computational Law: The Cop in the Back Seat*, at 6-7.

529 determinations can help make the notice requirement of due process more meaningful.⁵⁷
530 For automobiles (whether manned and unmanned), in addition to basic functions such as
531 navigation and collision avoidance, the system can help compliance with legal requirements
532 such as: a. speed limits; b. whether or not a street is one way c. whether u-turns are
533 allowed; d. what areas allow parking.⁵⁸

534 Different systems may be required for different participants in the legal system, with
535 sophistication and capability scaling to the requirements of users along this continuum.
536 Ordinary users may only need answers for simple scenarios. Lawyers may require argument
537 generation based on legal premises and factual scenarios. Judges can use similar systems,
538 but for evaluating the basic validity of arguments and precedents. Finally, legislators and
539 policy makers can use computational tools in order to evaluate proposed rules against other
540 norms, as well as predict the impact of draft laws.⁵⁹

541 Other applications include: Enterprise-wide monitoring and automated compliance; sim-
542 ulation of impact of rule changes; automated rule changes based on specified end goals.

543 **Motivation and necessity** Beyond the technical feasibility of these systems, and the
544 intellectual curiosity they may inspire - is there sufficient motivation and necessity for the
545 development of computational law systems? Branting predicts that these systems are needed
546 due to a vast, unmet demand for legal services, particularly in the growing government sector
547 - which will need to navigate an ever more complex legal and regulatory regime in order to

⁵⁷Genesereth, *Computational Law: The Cop in the Back Seat*, at 7.

⁵⁸*Ibid.*, at 7.

⁵⁹Ashley et al., "Legal Reasoning and Artificial Intelligence: How Computers "Think" Like Lawyers", at 14. The requirements for legal professionals can be further broken down to the following functions: 1. Problem formulation - Formulate the problem in terms of the relevant legal concepts, 2. Retrieval - Gather authorities relevant to the problem as formulated, 3. Problem analysis - Determining the legal consequences that follow from application of authorities to the facts. 4. Prediction - For each of the possible outcomes borne by the analysis - what are the probabilities of each outcome?

548 make the routine legal determinations necessary to carry out its functions.⁶⁰.

549 **2.4.3 Consistency and predictability**

550 The utility that can be derived from the computational approach is compelling enough
551 to warrant its pursuit. The more obvious advantages come from the speed and reliability of
552 computers, as well as their ability to retrieve relevant legal text from memory.⁶¹ However,
553 some of the more fundamental advantages to the profession can be indirect: The rigorous
554 structured approach of these systems may "mold the thought processes of the lawyer" (and
555 law students) into a more logical pattern, and the extended use and design of such systems
556 will force legal scholars to confront and resolve the ambiguities of the law.⁶² Genesereth
557 argues that simply publishing the overwhelming mass of laws, in a form inscrutable to the
558 public is not adequate notice. Computational law, by providing digitally mediated legal
559 determinations can help address this gap.⁶³

560 Representing and analyzing laws with the computational approach can provide certain
561 advantages. It can remove or minimize the degree of legal uncertainty (characterized by
562 radicalization of legal realism, or postmodernism), and make law more transparent and
563 consistent. The casting of law within a formalism can enable advanced analysis that goes
564 beyond subjective inferences of human lawyers. Advanced analytical tools such as simula-
565 tions, derivations, combinatorics can be applied to bodies of law. Finally, lawyers and legal
566 scholars can have a stable point for discussion, without the ambiguity of language across
567 jurisdictions. This can be a basis for interdisciplinary work, as well as a basis for testability
568 and confirmation.

⁶⁰Ashley et al., "Legal Reasoning and Artificial Intelligence: How Computers "Think" Like Lawyers", at 16-17. Branting also suggests that these systems can be a form of marketing for legal expertise, i.e. software can handle low-end requirements and lead clients to human legal experts for bespoke work.

⁶¹Grossman and Solomon, "Computers and Legal Reasoning", at 66.

⁶²Ibid., at 66.

⁶³Genesereth, *Computational Law: The Cop in the Back Seat*, at 8.

569 Wolfram notes that at the immediate level, the conversion of legal constructs into the
570 computational form can give them new capabilities, such as automated annotation of im-
571 plications, simulation of results, statistics and probability analysis.⁶⁴ On the other hand,
572 lawyers and law students can think about these legal constructs at a higher level.⁶⁵ It gives
573 rise to clearer thinking about the law - without the semantic ambiguity, cultural baggage
574 of natural language. Wolfram paints the broader implications of the technology by histori-
575 cal analogy: With growing literacy and the development of technology around the written
576 word - there is a growing trend towards complexity of transactions and their corresponding
577 legal instruments. Having a computational component will lead to even greater levels of
578 complexity.⁶⁶

579 **2.4.4 Cost and efficiency considerations**

580 Building these systems do not mean starting from scratch, since we can leverage existing
581 data on systems that embody business rules, such as those used in banking or human
582 resources.⁶⁷ Computational law just extends this tendency by encoding public instead of
583 private rules.

584 **2.5 Limitations of the approach**

585 Not all of legal reasoning are amenable to translation to a computational model. Instead of
586 a outright substitute to legal reasoning by human experts, computational law is proposed as
587 an aid to a subset of tasks such as those mentioned above (e.g. authority retrieval, argument
588 generation, analysis and prediction).⁶⁸ The computational approach is often limited by the
589 following:

⁶⁴Wolfram, “Computational Law, Symbolic Discourse and the AI Constitution”.

⁶⁵Wolfram cites the Sapir-Whorf hypothesis - that is, language can affect patterns of thinking
ibid., at 164.

⁶⁶Ibid., at 165.

⁶⁷Genesereth, *Computational Law: The Cop in the Back Seat*, at 7.

⁶⁸Ashley et al., “Legal Reasoning and Artificial Intelligence: How Computers ”Think” Like
Lawyers”, at 14.

- 590 1. **Open-texture problem** In the real world where lawyers operate, both the rules and
591 assertions of facts may be open to interpretation.
- 592 2. **Incongruity with actual legal thinking** Legal decisionmaking seems to bypass
593 explicit reasoning around rules and derive from specific cases, often through analogy.
- 594 3. **Incompleteness** Formalization can only provide a finite set of rules with which to
595 analyze complex states of the world as well as its normative environments

596 **Open texture** One fundamental problem with computational law is how to square for-
597 malisms with the open-texture of the law: The complexity of the law (and the world it
598 operates in) means that the facts and rules that one wants to encode in a categorial manner
599 will be open to intepretation. Genesereth provides the example rule: "No vehicles in the
600 park". This might be obvious to a human in the community, but problematic for some-
601 one trying to define the rule. What is a "vehicle"? Is a bicycle a vehicle? How about a
602 skateboard? Roller skates? What about a baby stroller? A horse?⁶⁹ Genesereth's suggested
603 response to the open-texture problem is to limit computational law applications to cases
604 where such issues can either be 1. externalized - that is, allow human users to input their
605 judgments on open-textured concepts, through data entry or on-the-fly determinations; 2.
606 marginalized - simply do not use the computational approach in areas of law where there
607 are many open-textured concepts.⁷⁰

608 The programmatic approach (mapping facts and constructing, deriving inferential rules)
609 can express many types of rules. Some rules however are more complicated. Genesereth
610 refers to prior work from Sergot and Kowalski, et al (1986) which explores the formalization
611 of the British Nationality act as a logic program, through conversion of a text into Extended

⁶⁹Genesereth, *Computational Law: The Cop in the Back Seat*, at 6. For this matter - What is "the park"? What are its horizontal (and vertical) borders? Can a helicopter hover at ten feet? One hundred feet?

⁷⁰Ibid., at 6.

612 Horn Clauses.⁷¹ However, some legal texts are not readily formalizable with this approach.
613 Such as: 1. When the applicable rule will depend on a person’s subjective belief about the
614 facts/ (e.g. if “. . . the Secretary of State is satisfied that. . .) 2. Some rules are dependent
615 on default states that can change under some circumstances, such as contrary evidence (e.g.
616 “. . . unless the contrary is shown. . .”) and 3. Rules that require reference to other parts of
617 the law, or other laws.

618 While these problems might be insurmountable in some legal domains, Love and Gene-
619 sereth argue that domains where transactions are electronically mediated can make the
620 problems of computational encoding and analysis more manageable. These systems can
621 be considered more amenable to the computational law approach since: Like other legal
622 domains, have entities and transactions that are subject to a system of rules (statutes,
623 regulations, policies). The transactions in these systems are semantically rich - they are
624 well-defined through documentation, code, or system constraints (they also note the indus-
625 try’s move towards semantic data) The information gap problem (when it comes to factual
626 determinations) - is also addressed in these domains, since within these systems, each trans-
627 action (and agents involved) can be logged and verified. Finally, these domains are also the
628 most likely users and beneficiaries of computational law systems.⁷²

629 **Incompleteness** Complementary to the problem of open-texture are fundamental lim-
630 itations to formal, logical approaches. The limits of formal reasoning means that one will
631 not be able to generate enough explicit, categorical rules for resolving the terms of a legal
632 problem.⁷³

⁷¹“A person born in the United Kingdom after commencement shall be a British Citizen if at the time of birth his father or mother is (1) a British citizen or (2) settled in the United Kingdom” Genesereth, *Computational Law: The Cop in the Back Seat*, at 5, citing Sergot and Kowalski, et al (1986).

⁷²Genesereth and Love, “Computational Law”, at 205-206.

⁷³Genesereth, *Computational Law: The Cop in the Back Seat*, at 6.

633 **Incongruity with legal reasoning** Another possible limitation of the computational
634 approach is that not all legal reasoning is characterized by the formal logical methods
635 employed in programming. As aptly put by Edwina Rissland, et al.: “Law is not a matter
636 of simply applying rules to facts via modus ponens”. Many legal determinations are not
637 made from deducting from general principles but inducing from specific cases. We can’t
638 map enough deductive rules from a given body of law. Genesereth maintains that since
639 computational law emphasizes deductive reasoning, it cannot be applied to instances of
640 legal determinations that require analogic or inductive reasoning.⁷⁴ The use of analogical
641 reasoning is a special problem for computers, since it will require discovering (or event
642 constructing) the relevant principle that establishes that the cases are “similar”. While
643 computers can exhaustively search through a given set of predetermined rules that can
644 establish similarity.

645 Other obstacles to formalization can arise from the ways law is formulated in the first
646 place: 1. Legislation is not always coordinated, since they arise from different contexts (e.g.
647 different historical settings that confront different problems) 2. Legislation has gaps - some
648 entities, actions, relationships, are not covered by any rule 3. Legislation may overlap, or be
649 inconsistent with each other. Genesereth is convinced, however, that since the publication
650 of Sergot, et al., many of the difficulties presented have been overcome by extensions to the
651 language and reasoning of computational law.⁷⁵

652 Finally, there is some doubt as to whether or not computation can adopt the kind of
653 analogical reasoning often used in legal interpretation. Analogy does not involve merely
654 enumerating similarities from a given set of criteria. Reasoning by analogy does not proceed
655 from premise to conclusion, but is based on the discovery (or even creation) of evaluative
656 principles from which one can assert that one case is similar to another.⁷⁶ The search

⁷⁴Genesereth, *Computational Law: The Cop in the Back Seat*, at 6.

⁷⁵Ibid., at 5.

⁷⁶Ashley et al., “Legal Reasoning and Artificial Intelligence: How Computers ”Think” Like Lawyers”, at 19-20.

657 space for such principles may be infinite, given that humans can invent new ways to draw
658 similarities between one category and another. The ability to discover new analogies can
659 also be based on the human experience of being embodied, sensate, and embedded in a
660 culture - attributes that a computer may never have.

661 **2.6 Other countervailing factors**

662 Institution will require additional expertise, as well as resources to fund the development
663 costs of these systems. At the same time, lawyers are not likely to adopt systems that will
664 reduce time billings (but may do otherwise for task based billing).⁷⁷

665 **2.7 Conflict with legal realism**

666 Computational law's philosophy contrasts with the notion of Legal Realism. In its
667 stronger formulation, legal realism means that the text of the law doesn't matter, or at
668 least does not matter as much as other considerations, in order to perform a balancing of
669 interests (usually based on factors extraneous to law) on a case-by-case basis.⁷⁸ Computa-
670 tional law may not be able provide this kind of normative flexibility.⁷⁹ Instead, it is more
671 closely aligned with Legal Formalism. Thus it carries the notion that laws are definitive,
672 and exhaustively account for all the normative calculations of the legislator.

673 Given its alignment and limitation, Genesereth suggests that computational law is most
674 relevant to civil law jurisdictions - where the text of the law are interpreted literally or
675 with very constrained space for interpretation. In contrast, it is least relevant in common

⁷⁷Ashley et al., "Legal Reasoning and Artificial Intelligence: How Computers "Think" Like Lawyers", at 17.

⁷⁸In its extreme formulations, legal realism can go against the project of building a rules-based society. The author also has more practical objections: If we are not in the business of building and then recognizing enduring legal norms, then we are wasting our time teaching our students legal research and statutory interpretation. Better to instruct them on the non-legal mechanisms that actually shape decisions, such as economic interests and individual psychology.

⁷⁹Genesereth, *Computational Law: The Cop in the Back Seat*, at 5.

676 law jurisdictions marked with on-the-fly legal innovation through judicial interpretation.⁸⁰
677 Although computational law has limits when applied to cases that require analogical or
678 inductive reasoning (which often characterizes the reasoning in judge-made Laws), Gene-
679 sereth suggests that the judicial process itself can generate categorical constraints from
680 vaguely worded statutes. Judicial law can be a source of encoded rules.⁸¹ Even in common
681 law jurisdictions, however, there are categorical, codified statutes that may not be subject
682 to significant judicial discretion. Examples include legislation on data privacy, securities,
683 enterprise management, construction, electronic commerce, taxation. There is a growing
684 tendency in these fields of law to move toward greater textual specification and codification.
685 This makes them more amenable to the computational approach.⁸²

⁸⁰Genesereth, *Computational Law: The Cop in the Back Seat*, at 5.

⁸¹*Ibid.*, at 6.

⁸²To a certain extent, the end goal of the adjudicatory process is to come up with categorical interpretations of existing statutes. One can consider rules expressed in judicial decisions as expressed in judicial decisions as extensions of the legal text, and encode them computationally, as if they were part of the original statute. So to the extent that statutes are considered vague in a common law jurisdiction, judicial decisions can supplement them by coming up with interpretations which can be encoded. Genesereth is also convinced that as Computational Law becomes more useful, legislators and regulators will be encouraged to have more such categorical laws *ibid.*, at 6.

686 **3 Law as a Computable Structure**

687 **3.1 The nature of computability**

688 The premise of computational law is that once we have both rigorous formal representa-
689 tions of law, and the appropriate logical methods to analyze them, law becomes computable.
690 What is meant by a computable approach, or the computability of legal determinations?
691 The formal meaning of a problem or a domain's computability relates to whether or not it
692 can be solved through an algorithm. In other words, a problem is computable if there exists
693 a step-by-step procedure that can be executed by a computer to solve the problem.⁸³

694 Computability also means that once we have abstracted enough of the most important
695 attributes of a thing into a formalized model - we can map its behavior backward and
696 forwards in time. We can access powerful shortcuts to the things behavior - to diagnose,
697 analyze, and predict.⁸⁴ The modern world we have was achieved through computation -
698 from bridges to bombs to games and deep space probes. These are possible because we
699 could build models of the forces of nature, and predict their interactions through logic and
700 mathematics.

701 **3.2 Can the law be computable?**

702 Wolfram argues that the computability of law can flow from the computational character
703 of nature, from which all phenomena (including humans and human institutions from which

⁸³The notion of computability is derived from Alan Turing's description of problems that are amenable to an algorithmic solution (to be carried out by a computational model such as a Turing Machine). Alan M. Turing. "On Computable Numbers, with an Application to the Entscheidungsproblem". In: *Proceedings of the London Mathematical Society* 2.42 (1937), pp. 230–265. DOI: 10.1112/plms/s2-42.1.230.

⁸⁴Without computability, we are confined to recording descriptions of phenomena, and we are limited in our ability to draw insights and make predictions about a system. Similar to the state of astronomy before Newton developed the formalisms of calculus - without a proper computational model for celestial mechanics, all that could be done was observation and recording.

704 laws are derived)⁸⁵: The universe itself is built on a computational foundation, and our
705 current computational tools for representing and analyzing knowledge is the latest (and
706 perhaps ultimate) in a series of formalisms for representing and understanding reality.⁸⁶ It
707 is not necessary to get into such a fundamental claim. As will be argued below - it should
708 be enough that the computational approach capture what is essential of legal knowledge.
709 Law is not magic - it occurs within the same universe that is, to some extent, discoverable.
710 A premise of the law as a practical profession and an academic field is that it is knowable,
711 and that legal reasoning can be systematized.

712 Of course, modeling the forces acting on a physical system is one thing, but trying to
713 model the behavior of people and institutions under the constraint of law is a different
714 category. As mentioned in the previous section, complexity and incompleteness conspire
715 against us. The open-textured nature of legal concepts like “justice” means that our repre-
716 sentations and analytical tools can only go to certain levels of description. Even if we can
717 somehow develop a rich enough toolset to capture legal concepts, Gödel’s incompleteness
718 means that there will always be a gap in our formalization.⁸⁷

719 Some problems are subject to computational irreducibility. That is, even if we can reduce
720 a system’s behavior into simple rules, it is still possible for complex behavior to arise from
721 such systems. It may not be possible to make a prediction about a systems state or behavior
722 past a certain point (even if the system’s behavior can be modeled algorithmically). Which
723 also means - that if you design those rules instead of discovering for yourself. There is no

⁸⁵See Stephen Wolfram. *How to Think Computationally about AI, the Universe and Everything*. Stephen Wolfram Writings. Oct. 27, 2023. URL: <https://writings.stephenwolfram.com/2023/10/how-to-think-computationally-about-ai-the-universe-and-everything/> (visited on 12/14/2023).

⁸⁶See generally Stephen Wolfram. *A Project to Find the Fundamental Theory of Physics*. Champaign, Illinois: Stephen Wolfram, LLC, 2020. 770 pp. ISBN: 978-1-57955-035-6.

⁸⁷Gödel’s theorems on the fundamental incompleteness of any axiomatic system impacts mathematics and logic, and ultimately, the capacity of computational formalism to model reality Richard P. Feynman. *Feynman Lectures on Computation*. Ed. by Anthony J. G. Hey and Robin W. Allen. Boca Raton: CRC Press, 2018. 303 pp. ISBN: 978-0-7382-0296-9, at 52.

724 way to control against unintended circumstances.⁸⁸

725 This difficulty does not mean that the problem will be intractable. The physicist Stephen
726 Wolfram states that in the teeth of complexity and incompleteness, even the hard sciences
727 are beset by oceans of non-computability. Despite all their progress in theory-making and
728 theory-testing, scientists still have to contend with a universe that largely resists mathe-
729 matical certainty. And yet, they have found enough islands of computability amidst that
730 ocean to lay the foundations of useful things like engineering, computer science, particle
731 physics.⁸⁹

732 Our models for law will likely be incomplete and thus inaccurate. But the incompleteness
733 of a model does not mean it will be useless. A map will never be as detailed as the territory
734 that it guides us through, but a good map should have enough information to be useful.

735 A formal approach can allow smoother, more reliable collaboration and the building of
736 higher "towers of consequences"⁹⁰ - systems that will allow more detailed study of legal sys-
737 tems, as well as applications for real world problems that involve the law. For example - the
738 ability to encode legal rules into a computer program may be the key to encoding firm, nor-
739 mative("constitutional") limits on artificial intelligence that can still be read, understood,
740 and edited by humans.

⁸⁸Stephen Wolfram. "AI Law and Computational Irreducibility". FutureLaw 2023, Stanford Law School. Apr. 25, 2023. URL: <https://www.youtube.com/watch?v=8oG1FidVE2o> (visited on 01/14/2024), at 3:53.

⁸⁹See generally Stephen Wolfram. *A New Kind of Science*. Champaign, Illinois: Wolfram Media, 2002. 1197 pp. ISBN: 978-1-57955-008-0.

⁹⁰Wolfram demonstrates how a field can progress through a better formalization and encoding system: Prior to the invention of algebraic notation, problems were described through natural language text (which can be imprecise). A more formal, streamlined method made it easier to share and build off each other's ideas. Wolfram, *How to Think Computationally about AI, the Universe and Everything*.

741 3.3 Confronting objections to logic in law

742 Computational law requires some role for logic in legal reasoning. A significant goal of
743 computational law is the production of a computer system capable of producing legal advice
744 (as opposed to just textual information). This can only be possible if logic has a place in
745 law. Because if anything, a computer system’s only actual capability is demonstrating
746 a logical system.⁹¹ Similarly, only a logical system can be computerized⁹². Even in the
747 long term, understanding and designing AI systems involved in legal reasoning will require
748 a background in logic, since AI applications (even those that seemingly interact through
749 natural language), will have programming that will be undergirded by formal logic.

750 Lawyers have built a conceptual moat around the field of law, to distinguish it from the
751 hard sciences, claiming that the law, unlike these fields, will always evade a reductionist,
752 logical approach.⁹³ Thus, its concepts and reasoning are not amenable to computation
753 because these are largely not computationally reducible. Since legal concepts and rules are
754 socially constructed and in flux, they cannot be fully represented into numbers and logical
755 constructs. The objections in the legal literature can fall under the following categories: 1.
756 **Historical arguments**, i.e. that the legal reasoning has developed as a discipline separate
757 from logic; 2. **Epistemological arguments**, which rely on fundamental difference between
758 law and logic, not only in substance but in terms of subject matter; 3. Finally, there are the
759 **Practical arguments** that relate to the applicability of logic to real-world legal problems.

⁹¹Philip Leith. “Logic, Formal Models and Legal Reasoning”. In: *Jurimetrics* 24.4 (1984), pp. 334–356, at 334.

⁹²*Ibid.*, at 334.

⁹³Jeffrey Goldsworthy. “The Limits of Judicial Fidelity to Law: The Coxford Lecture”. In: *Canadian Journal of Law and Jurisprudence* 24.2 (July 2011), pp. 305–325. DOI: 10.1017/S084182090000518X, “The popular impression of legal thinking is that it is logically rigorous. But legal reasoning, whether of judges, advocates or legal scholars, rarely has the clarity and rigour of the best analytical philosophy. Often this is because the subject-matter is simply incapable of being treated as rigorously. But more importantly, legal reasoning in real cases leads to practical decisions that have drastic effects on individual’s lives or the welfare of the community, for which judges properly feel some moral responsibility. Consequently, legal reasoning can have a tendentiousness—an almost palpable gravitation towards a desired conclusion—that is lacking in the work of analytical philosophers, pure mathematicians or nuclear physicists.”

760 **3.3.1 Historical convergence of logic and law**

761 **Law and logic during the classical period** A profession as steeped in tradition
762 and the weight of history as law may view embedding logic as an unnecessary modernist
763 intrusion. However, the history of law is replete with examples of the convergence of logic
764 and law. For Aristotle, law and logic were one and the same.⁹⁴ Aristotelian logic, or what
765 we now know as classical propositional logic, was derived from analysis and systemization of
766 legal arguments and decisions.⁹⁵ This was carried on through the scholastic tradition, which
767 viewed law as a system of rules which can be logically deduced from immutable principles.⁹⁶
768 These principles, in turn, can be discovered by man through a process of reasoning. Great
769 jurists such as Thomas Aquinas, William Blackstone also proceeded along these lines.⁹⁷
770 For the longest time, logic was Aristotelian logic. One of the Aristotelian logic's central
771 theory of the judicial syllogism, where a judicial decision is justified through a form of
772 syllogistic reasoning, i.e. as an inference from normative and factual premises.⁹⁸ This form
773 of legal determination has arguably shaped the notion of separation of powers (i.e. between
774 legislation and adjudication): The legislative creates law as a set of legal norms, and the

⁹⁴Lee Lovevinger. "An Introduction to Legal Logic". In: *Indiana Law Journal* 27.4 (Sum. 1952), pp. 471–522, at 471, citing *A Treatise on Government, or The Politics of Aristotle*, Book III, c. 16, Elli's translation, 1943.

⁹⁵See Wolfram, "AI Law and Computational Irreducibility", at 14:13; See also Wolfram, "Computational Law, Symbolic Discourse and the AI Constitution", at 145. An intriguing notion propounded by Wolfram is that laws are in fact the original inspiration for logical and mathematical systems. Legal arguments served as the model for the axiomatic approach to geometry defined by Euclid. Later, in the development of scientific thought, the discovery of "natural laws" were viewed as similar to legislation, i.e. These define constraints from God (or nature) instead of a human lawmaker.

⁹⁶See Karlheinz Hülser. "Proculus on the Meaning of OR and the Types of Disjunction". In: *Past and Present Interactions in Legal Reasoning and Logic*. Springer International Publishing, 2015, pp. 7–30, at 8. Emperor Justinian's *Digestae*, in the chapter *De verborum significatione* (On the meaning of words), contains reference to the Letters of Proculus, a distinguished Roman jurist. The passage quoted from Proculus covered his discussion on logical disjunctions (OR). The fragment from Proculus is itself derived from a long tradition of adopting concepts from Stoic logic. Through its adoption in the digests, it continues to inform modern statutory interpretation.

⁹⁷*Ibid.*

⁹⁸Pablo E. Navarro and Jorge L. Rodríguez. *Deontic Logic and Legal Systems*. New York: Cambridge University Press, Sept. 29, 2014. ISBN: 978-0-521-76739-2. DOI: 10 . 1017 / CB09781139032711, at ix.

775 judge will need to reason through these premises in order to apply them to a particular set
776 of facts.⁹⁹

777 **Law and logic during and after the Renaissance** A cornerstone of the 17th
778 century naturalist doctrine (Grotius, Salamanca School, Espinoza) is that the principles
779 of law should be systematized through mathematical methods. Efforts to both define and
780 systematize characterized legal studies and there was the view that certainty of the law
781 was attainable.¹⁰⁰ A crystallization of these ideas can be found in the recently rediscovered
782 works of Gottfried Wilhelm Leibniz. Leibniz is commonly known as a leading figure in math-
783 ematics and philosophy. However, before his seminal work in those fields he was a lawyer
784 and a promising legal scholar. His work combines law and philosophy, and proceeds from
785 the premise that some of law's fundamental questions cannot be answered without philo-
786 sophical thought.¹⁰¹ Leibniz insisted that law should have a "philosophical basis", without
787 which the law is bound to be an "inextricable labyrinth".¹⁰² His forays into philosophy
788 and law seems to be partially motivated by his numerous attempts at reconciling church
789 doctrines (Protestants v. Catholics), conflicts over which led to the Thirty Years war that
790 destroyed Germany. His works on legal reasoning have only been translated and published
791 recently, indicating that he pursued a mathematical-logic approach similar to modern ideas
792 in computational law.¹⁰³ Leibniz's first legal dissertation, *Disputatio juridica de condetion-*

⁹⁹Such a separation of functions assumes law has logical attributes such as: 1. Completeness - that there is always an applicable legal norm that can solve any dispute; 2. Consistency - that there are no incompatible norms applicable to the same case. Judicial decisions rely on at least one of these holding true. Navarro and Rodríguez, *Deontic Logic and Legal Systems*, at ix.

¹⁰⁰Alberto Artosi and Giovanni Sartor. "Leibniz as Jurist". In: *The Oxford Handbook of Leibniz*. Ed. by Maria Rosa Antognazza. Oxford University Press, Dec. 27, 2018, pp. 640–663. ISBN: 978-0-19-974472-5. DOI: 10.1093/oxfordhb/9780199744725.013.38. URL: <https://academic.oup.com/edited-volume/34667/chapter/295400716> (visited on 10/10/2023), at xviii.

¹⁰¹Matthias Armgardt. "Leibniz as a Legal Scholar". In: *Fundamina* (2014), pp. 27–38, at 28–29, citing *Specimen quaestionum philosophicarum ex jure collectarum, 1664*.

¹⁰²Note that Leibniz was referring to Philosophy in its broader, classical sense, which includes logic and mathematics Artosi and Sartor, "Leibniz as Jurist", at xx.

¹⁰³Leibniz's view on legal certainty rests partly on similarities between geometry and jurisprudence: "Both have elements and both have cases. The elements are simples (simplicia); in geometry figures, a triangle, circle, etc; In jurisprudence an action, a promise, a sale, etc. Cases are complexions (complexiones) of these, which are infinitely variable in either field." *ibid.*, at xxv.

793 *ibus* used propositional logic, modal logic, and probability logic to the law on conditions,
794 a technical problem under Roman law.¹⁰⁴ His writings indicate that this direction was in-
795 spired by classical sources, which requires that law, as the "science of the just and unjust",
796 be built on "the awareness of human and divine affairs".¹⁰⁵ Leibniz's interest in Roman
797 Law as the basis of a rational legal system is the view (shared by other jurists) that the
798 Roman law tradition is more accepting of the convergence between law and science. Roman
799 law is said to take into account "the working of nature" in order to produce sound and
800 equitable decisions.¹⁰⁶

801 The three underlying ideas of Leibniz's legal investigations are:¹⁰⁷

- 802 1. Legal research and problem solving, particularly adjudication requires an interdis-
803 ciplinary dialogue. The law needs to accept ideas from other disciplines such as
804 philosophy, logic, theology, mathematics, and physics.
- 805 2. Law also needs to have an intradisciplinary dialogue, i.e., between the various schools
806 of legal thinking.
- 807 3. Law requires a more diverse range of reasoning methods and cognitive tools. Practi-
808 tioners can select the appropriate tool based on pragmatism, i.e. their effectivity in
809 solving legal problems.

810 Leibniz believed that no case, no matter how apparently perplexing, is insoluble *ex jure*.
811 Thus, he applied logic to confront legal puzzles from the classical era, arriving at a classi-
812 fication scheme for apparent and actual legal conundrums and the appropriate analytical
813 device to solve them:¹⁰⁸

¹⁰⁴ Armgardt, "Leibniz as a Legal Scholar".

¹⁰⁵ Artosi and Sartor, "Leibniz as Jurist", at 5 citing Ulpian, D.1.1.10.2, *De justitia et jure*.

¹⁰⁶ Ibid., at 6.

¹⁰⁷ Armgardt, "Leibniz as a Legal Scholar", at 5.

¹⁰⁸ This position also made him wary of judicial discretion Artosi and Sartor, "Leibniz as Jurist", at ix, xxi.

- 814 1. Cases of apparent conflict between law and philosophy (which during that time in-
815 cluded metaphysics, mathematics, empirical sciences, theology) that often arise from
816 the same terms (but with different meanings) used in law and philosophy.
- 817 2. Questions that arise from the assumption that a principle is of universal application,
818 but is in fact justifiable under particular pragmatic conditions, or simply the result
819 of defects in the underlying conceptual frameworks used by lawyers and jurists.
- 820 3. Problems that arise from the lack of a deeper logical analysis of a conceptual issue.
- 821 4. Actual legal puzzles which are cases of doubtful solution because of the convoluted
822 form of dispositions (expressions of intent), or conflict with a priority relationship.

823 Leibniz himself acknowledged that reasoning through legal problems will require more
824 than propositional logic, since such problems involve uncertainty, possibility, and the passage
825 of time. Although Leibniz's efforts to develop a logical formalism was not successful, these
826 ideas, inspired systems of logic and continue to animate the field of computational law.¹⁰⁹

827 **The challenge of legal realism** The most potent historical challenge to the notion
828 of identity between logic and law comes from Justice Oliver Wendell Holmes Jr.¹¹⁰ Legal
829 scholars continue to cite this epigram as an embodiment of the school of legal realism: "The
830 life of the law has not been logic, it has been experience".¹¹¹

831 Courts and advocates in the Philippines have cited this quote from Holmes, often without
832 its full context to the point that it has become a slogan, or the legal equivalent of a meme. It

¹⁰⁹Artosi and Sartor, "Leibniz as Jurist", at 11.

¹¹⁰See Lovevinger, "An Introduction to Legal Logic", at 472.

¹¹¹Holmes, *The Common Law*, p. 1, 1881. The full quotation is as follows: "The life of the law has not been logic: it has been experience. The felt necessities of the time, the prevalent moral and political theories, intuitions of public policy, avowed or unconscious, even the prejudices which judges share with their fellow-men, have had a good deal more to do than the syllogism in determining the rules by which men should be governed. The law embodies the story of a nation's development through many centuries, and it cannot be dealt with as if it contained only the axioms and corollaries of a book of mathematics..."

833 can be invoked to defeat a clear interpretation of the law on linguistic and rational grounds
834 in order to introduce extraneous considerations. However, the reflexive invocation of this
835 epigram in order to frustrate the application of logic is misleading.

836 If one were to read the rest of Holmes' work, one would realize that Holmes was not
837 dismissing the role of logic and rational thinking in law. Instead, Holmes was urging us to
838 include more inputs into what is still a logical process of making a legal determination.

839 In objecting to what he called "the fallacy of the logical form", Holmes:

- 840 1. Acknowledges that as a phenomena contained in the same universe as physical matter,
841 law is ultimately subject to the same underlying rules, such as causation (otherwise,
842 it would be a miracle);
- 843 2. Acknowledges that logic permeates through the practice: "The training of lawyers
844 is a training in logic" - since it involves building familiarity with logical tools like
845 analogy, discrimination, and deduction. Holmes also characterizes judicial decision
846 as expressed in the language of logic.

847 Thus, Holmes objection, and the actual divide between "natural law" and legal realism
848 is not whether or not logic should be applied at all, but to what materials logical processes
849 should work with. For the "natural law" school, they believe that there are transcendent
850 basic principles which can be grasped intuitively, or derived through deduction. On the
851 other hand, "legal realists" reject *a priori* transcendent rules and emphasize an inductive
852 approach from empirical data (or experience).

853 Hawkins, through a historical and textual analysis, argues that the statement was never
854 meant as a practical guide for legal reasoning, or the interpretation of constitutional or
855 statutory law. Instead, it is a descriptive view of the development of the common law. The
856 "logic" that the statement describes as being eschewed by the common law tradition is not
857 logic as academically understood or colloquially known, but refers to the "vain attempt to

858 impose consistency on intuitively developed law”.¹¹² To the extent that Holmes’s words can
859 serve as a foil to the application of logic in law, Hawkins finds that there is ambiguity as
860 to the scope of his objections, and thus its actual application in a legal: Is it that logical
861 reasoning has no place in law - that lawyers and judges should embrace irrationalism or
862 intuition? Or perhaps, more realistically - was Holmes merely asking for a counterweight
863 against excessive legal formalism?¹¹³ Furthermore, if “experience” defines the content of the
864 law - what constitutes this experience. More pointedly - whose experience matters?

865 It should also be noted that logic has evolved from Holmes’ schoolboy days, when most
866 likely education would only cover classical propositional logic (or syllogistic logic as orig-
867 inally systematized by Aristotle)It can be conceded that classical propositional logic, as
868 formulated during Holmes’ time, the logic that most of us are aware of (and the one usually
869 employed in programming) is not the most appropriate tool for representing legal rules.
870 Subsequent sections will discuss the more appropriate logical systems for representing legal
871 rules, such as deontic logic and defeasible logic.

872 **3.3.2 Epistemological unity between law and logic**

873 Objections to logic often point to a fundamental difference not just in method (structured,
874 formal versus discursive and intuitive), but also to their subjects. The basis of logic was the
875 assumption that valid argument can be based upon the elemental form of the proposition,
876 composed of a subject and a predicate linked by a connective. Any proposition, meanwhile
877 has a truth value - either it is true or false. There is nothing in between (the law of the
878 excluded middle).¹¹⁴ On the other hand, legal propositions are normative rather than
879 fact-stating, and we only have an incomplete picture of the general logic of norms.¹¹⁵

¹¹²See generally Brian Hawkins. “The Life of the Law: What Holmes Meant”. In: *Whittier Law Review* 33 (Winter Issue 2012), pp. 323–370.

¹¹³Ibid., at 325.

¹¹⁴Leith, “Logic, Formal Models and Legal Reasoning”, at 336.

¹¹⁵Robert S. Summers. “Logic in the Law”. In: *Cornell Law Faculty Publications* (Paper 1133 1963), pp. 254–258. URL: <http://scholarship.law.cornell.edu/facpub/1133>, at 254.

880 **Misapprehension of “logic”** Synthesizing the arguments of A.G. Guest and other
881 legal philosophers, Summers argues that most objections of this kind is often based on a
882 misuse of the concept of logic. Upon closer inspection, even basic logical propositions do
883 not refer to things in nature, but concepts that may not necessarily be subject to true-or-
884 false evaluation.¹¹⁶ Summers adds that most likely, these statements are criticisms of the
885 reasoning in particular cases, rather than general arguments against the use of logic in legal
886 reasoning.¹¹⁷ More directly, the objection can be met by referring to legal pluralism, i.e.
887 the notion that there are other forms of logic that can be used to represent legal reasoning.¹¹⁸
888 This includes, as will be discussed below, deontic and defeasible logics.

889 One problem when we discuss the role of logic in law, is what we mean by logic in the
890 first place - is it the technical, formal sense or are we using logic in the everyday, colloquial
891 sense? Logic in its formal sense relates to whether or not an argument’s conclusions follows
892 necessarily from the premises. The latter, “everyday logic”, on the other hand, is concerned
893 with whether any legal conclusion “makes sense” based on some informal standard.¹¹⁹ These
894 senses of the word “logic” are not related to each other. The main purpose of formal logic is
895 to surface “possible forms of argument and conditions of valid argument”.¹²⁰ On the other
896 hand, everyday logic is prescriptive i.e., it involves the application of beliefs, (often grounded
897 in social processes) as to what ought to be.¹²¹

898 Halper points out that complaints directed towards logic in judicial reasoning is often
899 actually directed to something other than logic, such as:

900 1. **Belligerent precisionism** - This happens when the court takes a shortcut by in-

¹¹⁶*Ibid.*

¹¹⁷*Ibid.* In cases where a decision is criticized for an “abuse of logic” (e.g. *Whiteley v. Chapel*), what may be at fault is the choice of legal premises, and not the (logical) manner in which the judge proceeds from premise to conclusion. Or, more often enough, it may be a problem with semantics.

¹¹⁸Leith, “Logic, Formal Models and Legal Reasoning”, at 340.

¹¹⁹*Ibid.*, at 335-336.

¹²⁰*Ibid.*, at 337-338. Citing McCormick (1982), *The Nature of Legal Reasoning: A Brief Reply to Dr. Wilson*, *Legal Studies*, vol. 2, no. 3 286(1982).

¹²¹*Ibid.*, at 336.

901 terpreting a word too literally, ignoring its context, history, and the purpose of the
902 rule.

903 2. **Bad faith** - It may also be the case that the court is simply being disingenuous in
904 order to pervert the law. The use of a seeming use of syllogisms and faulty inferences,
905 however, does not make the bad faith logical.

906 3. **Misapprehension of scope** - By "logic" critics may mean the simplistic notion that
907 a few express (or otherwise deducible) rules should apply to all situations; When in
908 actuality the rule does not encompass the situation, but is nevertheless characterized
909 as an inconsistency of reasoning.

910 4. **Maintenance of contradiction** - It may be possible that the Court is accommo-
911 dating contradictory rules when it upholds a new line of reasoning while allowing a
912 previous case to remain valid.

913 5. **Simplistic, rote reasoning** - The Court may just be stuck in simplistic, rote rea-
914 soning in order to avoid, or exculpate itself from moral or social considerations. And
915 "logic" is equated with this mechanism, operationalizing the fiction of the detached
916 judiciary.¹²²

917 **On the incompleteness of formal systems** Another aspect of the divide between
918 law and logic is related to the necessary incompleteness of formal systems. The incomplete-
919 ness of formal systems is a result of Gödel's incompleteness theorems, which states that
920 any non-trivial formal system will contain statements that are true but cannot be proven
921 within the system. This means that there will always be gaps in any formalization of the
922 law, and that there will always be legal questions that cannot be answered through logical
923 deduction.¹²³ This is a significant challenge to the idea of computational law, as it suggests

¹²²Thomas Halper. "Logic in Judicial Reasoning". In: *Indiana Law Journal* 44.1 (1968), pp. 33-48, at 33-35.

¹²³Rebecca Goldstein. *Incompleteness: The Proof and Paradox of Kurt Godel*. New York, London: Atlas Books, 2005.

924 that there will always be limits to what we can achieve through logical analysis. Without
925 an overall general model for the world, representations in a formalism will always be incom-
926 plete. Wolfram asserts, however that an overall scheme is not necessary, and that it would
927 be possible to capture concepts as needed.¹²⁴

928 3.3.3 Practicality of employing logic

929 **Logic in the adjudicatory process** Another, more practical line of argument is that
930 logic has no use for judges and lawyers, since their conclusion are arrived at intuitively, with
931 the reasoning is arrived at *post facto*.¹²⁵ The rule deduction skeptics adopt the position that
932 legal decisions do not arise from deduction from existing legal rules. The legal principles
933 that supposedly guide legal reasoning are too vague and subject to so much discretion,
934 that the operation of logical processes is not possible.¹²⁶ To this, Halper points to fields
935 of law, (such as real property law) that are devoid of any emotional or intuitive notions,
936 through which systematic generalizations can be derived.¹²⁷ The non-logical intuition may
937 thus be based on a judge being so steeped in the deeper overall logic of the law, and it only
938 seems intuitive since he reaches his conclusions first and then justifies them later. Logic
939 may also play a role in how a judge evaluates a particular proposition (whether or not such
940 proposition was arrived at logically or intuitively), in that the judge reasons through the
941 actual application of the proposition and considers its implications. Logical deduction is
942 useful in this stage since it involves determining the effect of a proposition on the existing
943 structure of the law. This is often conceived in logical terms, i.e. whether or not there
944 are inconsistencies.¹²⁸ There is also the argument that we should not privilege the default

¹²⁴See Wolfram, “Computational Law, Symbolic Discourse and the AI Constitution”, “At a founda-
tional level, computational irreducibility implies that there will always be new concepts that could
be introduced...[C]omputational irreducibility implies that none of them can ever be ultimately be
complete”.

¹²⁵It is asserted that the formalized, logical form of the decision is used to legitimize a decision
based on emotion, prejudice, or rote of training. Halper, “Logic in Judicial Reasoning”, at 36-38.

¹²⁶Ibid., at 36-38.

¹²⁷Summers, “Logic in the Law”, at 255.

¹²⁸Halper, “Logic in Judicial Reasoning”, at 36-38.

945 ways of thinking in the law. These intuitive, psychological processes are exactly the kind
946 we need to scrutinize with logic for possible inconsistencies. While Halper concedes that
947 legal decision making is not purely logical, and the presence of a clear body of rules will not
948 remove judicial discretion, or eliminate the influence of nonlegal considerations.¹²⁹

949 Although not couched in formalisms of modern symbolic logic, instances of both deductive
950 and deductive thinking are inherent in legal reasoning:

951 In his selection of competing propositions and in his consideration of the pro-
952 priety of subsuming a particular case under a certain general rule, a judge is
953 not, of course, guided by logic. He is guided by insight and experience. But in
954 his application of the proposition selected, and in his testing of its implications
955 before he adopts it, he uses a deductive form of reasoning in order to discover
956 its potentialities. The directive force of the principle may be exercised along
957 the line of logical progression, and a judge must always keep in mind the effect
958 which his decision will have on the general structure of the law.¹³⁰

959 Summers criticizes that this is incomplete, i.e., that logic can play a role even in the
960 selection of premises necessary to decide particular cases. Guest also asserts that inductive
961 logic is not applicable to law. However, Summers points out that when lawyers advise clients
962 they often use a form of inductive logic when they make predictions and generalizations from
963 individual cases.¹³¹ In a way, a lawyer already treats legal questions as a computational
964 problem, having his own estimation function based on past data such as the history of the
965 controversy, the applicable law, and the court's past decisions.

966 **Logic against “Judicial subterfuge”** There is often a perceived tension between
967 “rule of law” defined as “strict adherence to legal norms and their logical implications”,

¹²⁹Halper, “Logic in Judicial Reasoning”, at 36-38.

¹³⁰Anthony G. Guest. “Logic in the Law”. In: *Oxford Essays in Jurisprudence*. Oxford: Oxford University Press, 1961, pp. 176–197, at 188.

¹³¹Summers, “Logic in the Law”, at 255-256.

968 and the aspiration to "do justice", often in the form of providing a "happy ending" for the
969 individuals before them. This leads to judicial subterfuge, in the form of spurious inter-
970 pretation of the law.¹³² Goldsworthy acknowledges that there are hard cases characterized
971 by indeterminate law. In which case judges must exercise creativity and in effect create
972 new law. The problem lies in judges allowing considerations outside of the law in order to
973 supplant determinate law. Often, the first step to this is engaging in the pretense that an
974 otherwise determinate law is indeterminate, and thus the appropriate opportunity for de-
975 ploying judicial creativity. Courts can delude themselves as to the content of the law, based
976 on their long immersion in legal culture - which results in *post facto* legal rationalization of
977 their intuitive convictions as to the proper legal solution. There is no evidence that a judge's
978 intuitions as to practical consequences should be privileged over sound legal reasoning, and
979 the preference for intuitive solutions, while appealing for the immediate case may erode the
980 rule of law over the long term. The use of logic can provide a practical constraint on legal
981 interpretation, bolstering it against judicial subterfuge.¹³³

982 **3.4 Modern Approaches to Law and logic**

983 Computer scientists and philosophers have made many attempts to use logical tools to
984 represent the intricacies of legal language and legal reasoning. This stream of work is based
985 on the assumption that logic is a component of legal reasoning.¹³⁴

¹³²Goldsworthy, "The Limits of Judicial Fidelity to Law: The Coxford Lecture", at 307.

¹³³Logic can also help prevent a related shortcoming of the judicial process, that of "well-meaning sloppiness of thought" - characterized by undefined or poorly defined concepts, failing to interrogate the rigor of arguments *ibid.*, at 318.

¹³⁴See generally Matthias Armgardt, Patrice Canivez, and Sandrine Chassagnard-Pinet, eds. *Past and Present Interactions in Legal Reasoning and Logic*. Vol. 7. Logic, Argumentation & Reasoning. Cham: Springer International Publishing, 2015. ISBN: 978-3-319-16020-7 978-3-319-16021-4. DOI: 10.1007/978-3-319-16021-4. URL: <https://link.springer.com/10.1007/978-3-319-16021-4> (visited on 03/16/2024).

986 In legal theory (as well as AI research into the law domain), the logical aspects of legal
987 reasoning is divided into two principal approaches:¹³⁵

988 First, the formal approach - where legal decisions (e.g. the judge's justification) are
989 arrived at through a mainly deductive process. Deductive reasoning draws conclusions
990 from a set of general principles or premises that are given or established. This is related to
991 formal symbolic logic.

992 Second, the dialectic (or argument theory) approach, which views legal justification as
993 arising from an adversarial process, where parties use discretion to evaluate between rea-
994 sonable alternatives. The approach borrows much from so-called "informal logic".

995 The logical and dialectic approaches are seen as divergent, incompatible modes of legal
996 reasoning, and for a long time have gone on separate tracks of development and application.
997 The logical approach was seen as a tool for the legislative process, advancing the goal of
998 representing laws as a set of consistent statements. Meanwhile, the dialectic approach
999 was often applied to case-based problems that characterized litigation and judicial decision
1000 making - legal justifications derived from a process of presenting and evaluating pro and
1001 contra cases.¹³⁶ Nevertheless, Advancements in both legal theory and technology may
1002 allow for the unification of the divergent approaches (of logic and dialectics). Within the
1003 case-based reasoning that defines the dialectic approach, there is acknowledgement that
1004 consistent logical rules can be formalized. Within the logic approach, on the other hand,
1005 researchers have developed models that take into consideration the incomplete and defeasible
1006 nature of legal argumentation. ¹³⁷

1007 The foregoing analysis will cover debates covering the first approach. Much of the work
1008 in the field has emphasized the deductive approach, due to its seeming ubiquity in legal

¹³⁵Henry Prakken and Giovanni Sartor, eds. *Logical Models of Legal Argumentation*. Netherlands: Kluwer Academic Publishers, 1997. ISBN: 0-7923-4413-8. DOI: 10.1007/978-94-011-5668-4, at 1.

¹³⁶*Ibid.*

¹³⁷*Ibid.*

1009 reasoning. The deductive approach is viewed as essential to legal interpretation and ap-
1010 plication: Lawyers will analyze the text, structure (and history) of a statute to determine
1011 meaning and intent. These will then serve, along with a background of other established
1012 rules, as premises for determining applicability to specific cases.¹³⁸

¹³⁸Jaap Hage. "A Theory of Reasoning and a Logic to Match". In: *Artificial Intelligence and Law* 4.3-4 (1996), pp. 199–273.

1013 4 Overview of encoding and analysis approaches - 1014 Ontologies and Descriptive Logic

1015 The proposed work is based on restating the problem of competition impact analysis in
1016 computational terms:

- 1017 1. *The Relevance Problem* - Given a law, is it **relevant** to the sector for which the
1018 assessment is being made?
- 1019 2. *The Threshold Testing Problem* - Given a rule within a relevant law, is the rule
1020 **compliant** with the norms laid out by the threshold test?

1021 From a computational point of view, the problem of competition impact assessment is a
1022 problem of logical comparison and evaluation. It involves comparing the provisions of the
1023 law that cover a sector with a set of standards, and then evaluating the extent to which the
1024 law complies with the standards. The standards can refer to the OECD threshold tests (and
1025 are further elaborated in the economics literature, usually based on models of a competitive
1026 market). In order to proceed with automating this evaluation, a computational law system
1027 will require: 1. A system for encoding the content of legal text, as well as 2. Algorithms
1028 that can process these encodings.

1029 Based on the previous chapter, we are proceeding from the notion that law and ques-
1030 tions of law are largely computable problems.¹³⁹ Facilitating computation of law requires
1031 encoding systems for both problems: First to represent, then to analyze these represen-
1032 tations(determine relevance, and evaluate for compliance). These appear to be distinct
1033 problems and require different encoding systems. The encoding methodology for this study
1034 uses two divergent approaches, each applicable to a different aspect of the law. The first
1035 approach aims to capture the semantic content of the law through ontologies, which are used
1036 to model the entities and relationships in a domain. The second approach is concerned with

¹³⁹A computable question is one that can be computed by a sufficiently powerful “Turing machine”.

Table 1: Encoding and Analysis Approaches

Problem	Encoding	Analysis
<p>Relevance Testing:</p> <p>Does the law map with the industry being assessed? (Actors, transactions)</p>	<p>Ontologies (Ontology Web Language)</p>	<p>Reasoning engines to determine relationships:</p> <ul style="list-style-type: none"> - No mapping? - Identity? - Classification? - Mereological? - Inference?
<p>Threshold Testing:</p> <p>Given a specific rule within a relevant law - How does this rule relate to the norm of the threshold test?</p>	<p>Inference rules (Prakken, Sartor) - LegalRuleML</p>	<p>Argumentation Frameworks</p> <p>Propositional networks</p>

1037 representing the normative constraints contained in the law as a set of defeasible inferential
 1038 statements in deontic logic.¹⁴⁰ This chapter provides an overview of both approaches, with
 1039 a focus on how they can be applied to the domain of competition law.

1040 Since every modern computer language is Turing complete (i.e. it can fully implement a
 1041 Turing machine), these programming languages are capable of computing legal questions.
 1042 The only constraints will be time, memory, and computing power. Andersson (2014) asserts
 1043 that most software tools (general purposes, modern languages) are overkill for implementing
 1044 the requirements of a computational law system. It would be more efficient (cost-benefit
 1045 wise) to develop and use domain-specific languages for computational law.¹⁴¹ However, it
 1046 is very difficult to come up with domain specific languages specific to law - this may be a
 1047 function of few lawyers knowing how to program, and few programmers understanding law.

¹⁴⁰It may be possible to combine both the semantic and normative aspects. Both ontologies and inference statements are based on logic and can be arranged into network structures. In the future, machine learning may be used to automatically translate rules into logical formalisms. Meanwhile, the exercise will be undertaken by humans.

¹⁴¹See Andersson, “Computational Law: Law That Works Like Software”, at 21.

1048 4.1 Ontological Representation of Legal Semantics

1049 4.1.1 Definition and benefits

1050 Law provides a description of the world - which can be made legible as a configuration
1051 of entities and relationships. The entities are the actors, transactions, and objects that are
1052 the subjects of the law. The relationships are the connections between these entities, and
1053 the attributes that describe them. This aspect of the law can be encoded as an ontology.
1054 An **ontology** is a formal, explicit description of concepts that are part of a domain.¹⁴²
1055 It consists of: 1. **classes** that represent concepts; 2. **properties** that describe features
1056 of these concepts, including their relationship with each other; and 3. **restrictions** to the
1057 way these classes and attributes are defined.¹⁴³ An ontology of classes, along with specific
1058 instances of these classes, constitute a **knowledge base**, although as a practical matter
1059 there can be little to distinguish this from an ontology.¹⁴⁴ Ontologies can be used to make
1060 web pages (or other electronic resources) more “understandable” to electronic agents. Many
1061 disciplines are developing standardized ontologies used by experts to encode, annotate, and
1062 share knowledge in their respective fields, providing a common vocabulary researchers and a
1063 source of machine-readable definitions.¹⁴⁵ Noy (2001) suggests that for extensive domains
1064 of knowledge, ontologies can provide the following benefits:

¹⁴²Natalya F Noy and Deborah L McGuinness. “Ontology Development 101: A Guide to Creating Your First Ontology”. In: *Stanford Medical Informatics Technical Report* (SMI-2001-0880 Mar. 2001). URL: <http://www.ksl.stanford.edu/people/dlm/papers/ontology-tutorial-noy-mcguinness-abstract.html>, at 3. The term ontology originally referred to a branch of philosophy concerned with the study of being. It was borrowed by computer science to refer to the formal definition of objects in a domain, and the relationships between these objects. See Lamy Jean-Baptiste. *Ontologies with Python: Programming OWL 2.0 Ontologies with Python and Owlready2*. Berkeley, CA: Apress, 2021. ISBN: 978-1-4842-6551-2 978-1-4842-6552-9. DOI: 10.1007/978-1-4842-6552-9. URL: <http://link.springer.com/10.1007/978-1-4842-6552-9> (visited on 04/03/2024), at §3, p. 61.

¹⁴³Michael De Bellis. *A Practical Guide to Building OWL Ontologies*. Oct. 8, 2021. URL: <https://www.michaeldebellis.com/post/new-protege-pizza-tutorial> (visited on 01/31/2024), at 6.

¹⁴⁴Noy and McGuinness, “Ontology Development 101: A Guide to Creating Your First Ontology”.

¹⁴⁵For medicine, for example, there is SNOMED (Price and Spackman, 2000) and the Unified Medical Language System (Humphrey and Lindberg, 1993); For describing products and services for the purpose of trade regulation, see the United Nations Standard Products and Services Code(UNSPC), at <https://www.unspsc.org/>

- 1065 1. *Sharing and collaboration* Experts and practitioners can represent their shared un-
1066 derstanding.
- 1067 2. *Enabling reuse* Users can build on existing ontologies - extending or refining them as
1068 needed.
- 1069 3. *Making assumptions explicit* Assumptions can become explicit in the design of an
1070 ontology, making it easier to question and resolve them as necessary.
- 1071 4. *Separating domain knowledge from operational knowledge* We can analyze a class of
1072 concepts in the abstract, independent of particular instances.
- 1073 5. *Analyzing domain knowledge* Once a representation is available, it can be subjected
1074 to formal analysis.

1075 An ontology can be formally expressed in a computer language. This work will use the
1076 Web Ontology Language (OWL) to express ontologies. The choice is largely based on the
1077 OWL's broad adoption, and the availability of supporting software and documentation.
1078 OWL is a language that is based on Description Logic, a subset of first-order logic that
1079 is used to represent knowledge in a structured and formal way.¹⁴⁶¹⁴⁷ For prototyping and
1080 visualization purposes, the author will use the Protégé ontology editor, which is a widely
1081 used tool for creating and editing ontologies in OWL.¹⁴⁸

¹⁴⁶See Noy and McGuinness, "Ontology Development 101: A Guide to Creating Your First Ontology", at 3.

¹⁴⁷OWL is a standard that is maintained by the World Wide Web Consortium (W3C), the organization that sets standards for the web. It is used to represent knowledge in a way that is machine-readable and can be processed by computers. OWL is based on the Resource Description Framework (RDF), a standard for representing information on the web. RDF is used to represent information in the form of triples, which consist of a subject, a predicate, and an object. OWL extends RDF by providing a way to represent classes, properties, and relationships between classes and properties. It also provides a way to represent restrictions on classes and properties, such as cardinality constraints and value constraints. OWL is used in a wide range of applications, including the Semantic Web, data integration, and knowledge representation. It is a powerful language that can be used to represent complex knowledge in a structured and formal way.

¹⁴⁸See Mark A. Musen. "The protégé project: a look back and a look forward". In: *AI Matters* 1.4 (2015), pp. 4–12. DOI: 10.1145/2757001.2757003. URL: <https://doi.org/10.1145/2757001.2757003>.

1082 Managing and retrieving data from ontologies is more efficient and cost-effective compared
1083 to Large Language Models (LLMs). To make corrections, one simply needs to identify and
1084 modify the specific entity and attribute. This approach is more appropriate for making
1085 precise factual determinations where accuracy is prioritized over expressiveness. The use
1086 of ontologies is also more transparent and interpretable compared to LLMs. The structure
1087 of the ontology can be visualized and understood by humans, and the reasoning process
1088 can be traced and explained. This is important for legal applications, where the reasoning
1089 process must be transparent and understandable to the parties involved.

1090 4.1.2 Ontology components: classes and properties

1091 **Classes** are the primary focus and building blocks of an ontology. These describe concepts
1092 in a domain.¹⁴⁹ Since we are concerned with modelling entities that interact with each other
1093 and the law, our ontology can have a **Person** class that represents the legal definition of a
1094 person - an individual or entity that has the capacity to enter into legal relations. A class
1095 can have **subclasses** that represent more specific concepts.¹⁵⁰ For example, the **Person**
1096 class can have subclasses such as **Natural_Person** to represent a human individual and
1097 **Juridical_Entity**, such as a corporation. Individuals (or *instances* of these classes) are
1098 the actual objects in the domain of interest.¹⁵¹ For example, the **Natural_Person** class can
1099 have instances such as **Alice** and **Bob**.

1100 **Properties and inheritance** describe the attributes of and relationships among classes
1101 and instances. The class definition of the **Person** class can have **has_name** property that
1102 describes the name of a person, which can be provided for an instance of that class. Proper-
1103 ties can also be used to describe the relationships between classes. For example, the **Person**
1104 class can have a **has_child** property that describes the relationship between a parent and

¹⁴⁹Noy and McGuinness, “Ontology Development 101: A Guide to Creating Your First Ontology”,
at 3.

¹⁵⁰*Ibid.*, at 3.

¹⁵¹See De Bellis, *A Practical Guide to Building OWL Ontologies*, at 7. At the same time, classes
can be thought of as sets that contain individuals.

1105 a child. The `has_child` property can be used to connect a `Natural_Person` instance to
1106 another `Natural_Person` instance that is their child. Properties can also have restrictions
1107 that define the cardinality of the property, the value of the property, or the relationship
1108 between the property and other properties. For example, the `has_child` property can have
1109 a restriction that specifies that a child can have at most two parents. Subclasses inherit
1110 the properties of their parent classes, and can have additional properties that are specific
1111 to them.¹⁵²

1112 4.2 Ontology construction

1113 There is no one “right” methodology for constructing an ontology. Noy(2001) proposes
1114 an iterative approach: With a rough, initial pass, filling details along the way. It is a
1115 question of what is most appropriate for the applications in mind and the developments
1116 anticipated for the ontology. There should at least be a sense of isomorphism, or closeness,
1117 between an ontology and the common understanding of the domain.¹⁵³ This can be achieved
1118 by reflecting on the statements that describe the domain. The nouns correspond to the
1119 classes/instances, while the verbs and adjectives correspond to the attributes.

1120 The ontology to be used for this work shall be designed based on the following process
1121 outline in Noy(2001), with some details provided by DeBellis (2021):

- 1122 1. Determine the domain and scope of the ontology
- 1123 2. Consider reusing existing ontologies
- 1124 3. Enumerate important terms
- 1125 4. Define the classes and class hierarchy
- 1126 5. Define the internal structure of classes

¹⁵²See De Bellis, *A Practical Guide to Building OWL Ontologies*, at 7.

¹⁵³Noy and McGuinness, “Ontology Development 101: A Guide to Creating Your First Ontology”, at 4.

1127 6. Define the restrictions of attributes

1128 This short tour of the design process will also serve as an opportunity to describe how
1129 ontologies can model the semantic content of the relevant competition law, as well as some
1130 of the early design decisions taken.





1131 **STEP 1: Determine domain and scope of the ontology** The first step requires
1132 us to specify the domain of interest, as well as the contemplated uses of the ontology. This
1133 study is concerned with several domains, each of which can be modelled through separate
1134 ontologies: 1. The entities and transactions in the digital payments market in the Philip-
1135 pines, as described by the relevant laws; and 2. The idealized configuration of entities and
1136 transactions in a competitive market, as described by the OECD threshold tests. This work
1137 will focus on the OECD Guidelines since it has become the *ad hoc* basis of the Philippine’s
1138 competition impact assessment regime. It is also the most comprehensive and most updated
1139 resource of this type available to the public. Other similar guidelines, such as those issued
1140 by the International Competition Network, the Asia Pacific Economic Cooperation, and the
1141 UK’s Competition and Markets Authority will be used to supplement our understanding
1142 of the norms applicable to competition impact assessment. The primary purpose of the
1143 ontology is to enable the evaluation of laws governing a particular sector for competition
1144 effects. For this chapter, we will use the first OECD threshold test standard as an example.
1145 The OECD tests for the following competition concerns:

1146 For this demonstration of the design process we are only concerned with A1, which flags
1147 a law as having competition issues if it “Grants exclusive rights for a supplier to provide
1148 goods or services”. Note that although the header for Section A by itself is not a threshold
1149 test, and its general normative requirement (i.e., that it not “limits the number or range of
1150 suppliers”), it is considered part of the domain since it may still provide information as to
1151 required classes and properties.

Figure 1: The OECD Threshold Test Checklist

COMPETITION ASSESSMENT CHECKLIST

Competition assessment should be conducted if a legal provision has any of the following effects:

<div style="background-color: #76b82a; color: white; padding: 5px; text-align: center; font-weight: bold; font-size: 1.2em;">A</div> <p style="text-align: center; font-weight: bold; margin: 5px 0;">Limits the number or range of suppliers</p> <p>This is likely to be the case if the provision:</p> <ul style="list-style-type: none"> <input type="checkbox"/> A1 Grants exclusive rights for a supplier to provide goods or services <input type="checkbox"/> A2 Establishes a license, permit or authorisation process as a requirement of operation <input type="checkbox"/> A3 Limits the ability of some suppliers to provide goods or services <input type="checkbox"/> A4 Significantly raises cost of entry or exit by a supplier <input type="checkbox"/> A5 Creates a geographical barrier for companies to supply goods, services or labour, or invest capital 	<div style="background-color: #76b82a; color: white; padding: 5px; text-align: center; font-weight: bold; font-size: 1.2em;">B</div> <p style="text-align: center; font-weight: bold; margin: 5px 0;">Limits the ability of suppliers to compete</p> <p>This is likely to be the case if the provision:</p> <ul style="list-style-type: none"> <input type="checkbox"/> B1 Limits sellers' ability to set prices for goods or services <input type="checkbox"/> B2 Limits freedom of suppliers to advertise or market their goods or services <input type="checkbox"/> B3 Sets standards for product quality that provide an advantage to some suppliers over others, or are above the level that some well-informed customers would choose <input type="checkbox"/> B4 Significantly raises costs of production for some suppliers relative to others (especially by treating incumbents differently from new entrants)
<div style="background-color: #76b82a; color: white; padding: 5px; text-align: center; font-weight: bold; font-size: 1.2em;">C</div> <p style="text-align: center; font-weight: bold; margin: 5px 0;">Reduces the incentive of suppliers to compete</p> <p>This may be the case if the provision:</p> <ul style="list-style-type: none"> <input type="checkbox"/> C1 Creates a self-regulatory or co-regulatory regime <input type="checkbox"/> C2 Requires or encourages information on supplier outputs, prices, sales or costs to be published <input type="checkbox"/> C3 Exempts the activity of a particular industry, or group of suppliers, from the operation of general competition law 	<div style="background-color: #76b82a; color: white; padding: 5px; text-align: center; font-weight: bold; font-size: 1.2em;">D</div> <p style="text-align: center; font-weight: bold; margin: 5px 0;">Limits the choices and information available to customers</p> <p>This may be the case if the provision:</p> <ul style="list-style-type: none"> <input type="checkbox"/> D1 Limits the ability of consumers to decide from whom they purchase <input type="checkbox"/> D2 Reduces mobility of customers between suppliers of goods or services by increasing the explicit or implicit costs of changing suppliers <input type="checkbox"/> D3 Fundamentally changes information required by buyers to shop effectively

1152 **STEP 2: Consider reusing existing ontologies** The knowledge base can be also
 1153 be based on existing ontologies that have already been developed for some knowledge do-

1154 mains or specific activities. For example, the financial sector is already covered by the
1155 Financial Industry Business Ontology (FIBO), a knowledge graph that models the entities
1156 and transactions in the financial sector.¹⁵⁴It is a standard that is already being used by
1157 financial institutions, regulators, and other stakeholders. For concepts related to law, we
1158 may derive from the design of LegalRuleML¹⁵⁵. Finally, the Wikidata project is a knowledge
1159 base that models data that can be found in the open web.¹⁵⁶ Whenever appropriate, we
1160 can use these ontologies directly, or design our ontology to be compatible with them.

1161 **STEP 3: Enumerate important terms** We next proceed to listing the important
1162 terms that the ontology needs to describe and explain, as well as their relevant properties
1163 - **property attributes** can qualify classes (i.e. what they are “like”), while **functional**
1164 **attributes** can describe what the classes can do, or what can be done to them.¹⁵⁷ The rule
1165 of thumb is to consider the nouns of statements as the classes of the ontology, while adjectives
1166 and verbs can be considered as the properties. For the competition impact assessment
1167 ontology, we can start with the following terms (with implied terms in parentheses):

1168 The ontology designer should also take note of any term that may be in the statement
1169 being modelled, but are nevertheless implied by the other terms. For example, since the
1170 standards mention a **Supplier**, it can be inferred even at this point that we need to model
1171 the ultimate recipient of the goods and services supplied - a **Consumer**. Both **Supplier** and
1172 **Consumer** are subclasses of **Person**, which we will also need to define and elaborate later
1173 on. Finally, since the standards in the threshold test are meant to apply to laws - hence the

¹⁵⁴See EDM Council. *The Financial Industry Business Ontology*. FIBO. URL: <https://spec.edmcouncil.org/fibo/> (visited on 01/18/2024).

¹⁵⁵Oasis Open. *LegalRuleML Core Specification Version 1.0*. Aug. 30, 2021. URL: <http://docs.oasis-open.org/legalruleml/legalruleml-core-spec/v1.0/legalruleml-core-spec-v1.0.html> (visited on 10/06/2023), See also See <https://www.gecad.isep.ipp.pt/ieso/contract/v1.0.0/#description> for a basic contract ontology.

¹⁵⁶See Wikimedia Foundation. *Wikidata*. URL: https://www.wikidata.org/wiki/Wikidata:Main_Page (visited on 01/18/2024).

¹⁵⁷Noy and McGuinness, “Ontology Development 101: A Guide to Creating Your First Ontology”, at 6.

Table 2: Example terms for the ontology

Nouns (Classes)	Verbs or Qualifiers (Attributes)
Right (Person)	limit
Supplier (Consumer)	number range
Good	grant
Service (State)	provides
(Law)	exclusive

1174 need for a **Law** class. The **State** class is also implied, as the standards assume that there is
 1175 a state that is enacting and enforcing the law.¹⁵⁸

1176 **STEP 4: Define the classes and class hierarchy** Several approaches are open
 1177 to determining the classes and their place in the hierarchy (i.e. the subclass-superclass
 1178 relationship). There is the **top-down approach** which is to start with the most general
 1179 concepts, and then proceed to the more specific cases. Alternatively, one can also take a
 1180 **bottom-up approach**, which means to start with defining the most specific classes, then
 1181 determine if these can be grouped into general concepts (i.e. generate common superclasses).
 1182 The more realistic approach is a combination of both, i.e. define the salient concepts
 1183 and then generalize or specialize as needed. No method is best - it would depend on the
 1184 circumstances surrounding the modeling, i.e. if a general view is available, if data is granular
 1185 enough to describe specific cases.¹⁵⁹ To determine which terms can be classes or subclasses,
 1186 a good rule of thumb is that objects that are capable of independent existence (rather than
 1187 descriptions of other objects) can be the principle classes in a class hierarchy. Once classes
 1188 are identified and defined, arrange them hierarchically into a taxonomy. This can be done

¹⁵⁸Although the text of the OECD tests refers to some concepts in the plural (e.g. “Goods”), the naming convention will use the singular form. Classes represent sets and can contain multiple instances. Thus, it is not necessary to define singular forms of classes as subclasses.

¹⁵⁹Noy and McGuinness, “Ontology Development 101: A Guide to Creating Your First Ontology”, at 6-7.

1189 by asking for each class, whether it can be an instance of the same class.¹⁶⁰

1190 For the competition impact assessment ontology, we can start with the following config-
1191 uration of classes and subclasses:

1192 • **Person** - An individual or entity with legal capacity. This can have the following
1193 subclasses:

1194 – **Natural_Person** - A human individual, to which the class of **Consumer** belongs.

1195 – **Juridical_Entity** - A legal entity, which can include a **Corporation** - which
1196 in turn is the superclass of any **Supplier** object (an entity that provides a **Good**
1197 or a **Service**).¹⁶¹

1198 • **Right** - A legal entitlement (or permission, in deontic terms) that can be granted
1199 or limited by the **State** through a **Law**. The right concerns the ability to offer and
1200 enter into a contract concerning a **Provision**, which can have the following subject
1201 matters:

1202 – **Good** - Physical objects that can be supplied by a **Supplier**. Can refer to any
1203 tangible object that can be bought or sold.

1204 – **Service** - Intangible objects that can be supplied by a **Supplier**. Can refer to
1205 any contractual performance.¹⁶²

1206 Class hierarchies show how concepts are related. They use terms like “is-a” or “kind-of”
1207 to show these connections. When one class is a subclass of another, it means the subclass

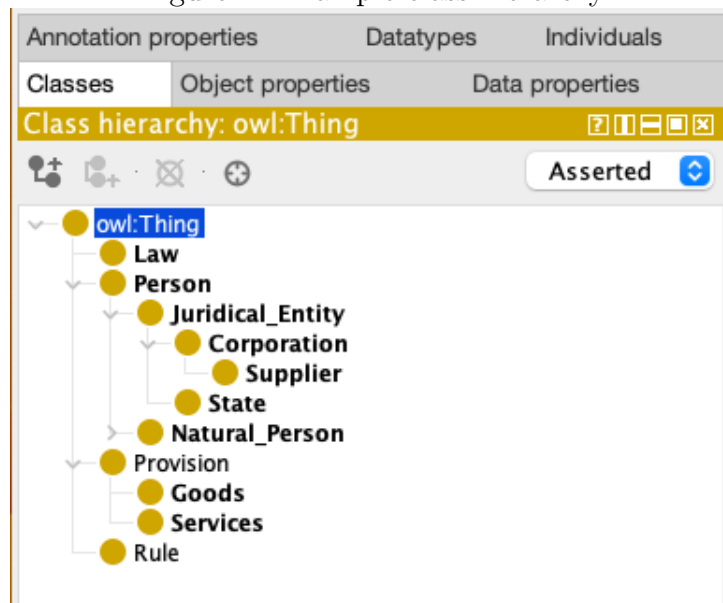
¹⁶⁰Noy and McGuinness, “Ontology Development 101: A Guide to Creating Your First Ontology”, at 7-8.

¹⁶¹Note the simplifying assumptions that we are holding for now in order to facilitate the design of the ontology. In the real world, a corporation can be a consumer, and a natural person can be a supplier. The artificial distinction however, may be “true enough” for the purposes of our ontology.

¹⁶²The classes of Good and Service can be bound by reference to another ontology, such as the United Nations Standard Products and Services Code (UNSPC).

1208 represents a more specific type of the general concept represented by the main class.¹⁶³ A
 1209 subclass relationship is transitive, i.e. "If B is a subclass of A and is a subclass of B, the C
 1210 is a subclass of A".¹⁶⁴ It may also be useful to determine at this point which classes are
 1211 *disjoint*, i.e., that no individual can be an instance of more than one of those classes.¹⁶⁵ In
 1212 our example, the `Natural_Person` and `Juridical_Entity` classes are disjoint. Objects that
 1213 are instantiated as either of those classes can only belong to one class or another. The class
 1214 hierarchy, as constructed in Protégé can be visualized as shown in the following figure:

Figure 2: Example class hierarchy



1215 Note that in OWL, all classes are subclasses of a root class called `owl:Thing`, the class
 1216 that represents the set containing all individuals. All empty ontologies still contain one
 1217 class called `owl:Thing`.¹⁶⁶

¹⁶³Noy and McGuinness, "Ontology Development 101: A Guide to Creating Your First Ontology", at 12.

¹⁶⁴Ibid., at 13.

¹⁶⁵Ibid., at 16.

¹⁶⁶De Bellis, *A Practical Guide to Building OWL Ontologies*.

1218 **STEP 5: Define the internal structure of classes** The internal structure of
1219 the classes can be defined through its properties or attributes.¹⁶⁷ For every class in our
1220 ontology, we are concerned with both intrinsic and extrinsic properties:¹⁶⁸

1221 • **Intrinsic properties** - There are the essential, or inherent to the class itself. These
1222 properties are essential to the identity and nature of the class, independent of external
1223 factors or contexts. They are characteristics that an instance of the class possesses
1224 purely by being an instance of that class. For the class **Person**, intrinsic properties
1225 might include a **has_name** - since each legal person, whether an individual human
1226 being or a corporation, has a name.

1227 • **Extrinsic properties** - These are context-dependent, relational attributes of a class.
1228 Extrinsic properties are those that depend on external factors or the context in which
1229 an instance of the class exists. These properties are not essential to the identity of the
1230 class and can change depending on the environment, relationships, or interactions with
1231 other entities. For the class **Person**, extrinsic properties might include the person's
1232 current location, occupation, marital status, or the clothes they are wearing.¹⁶⁹

1233 Subclasses inherit the properties of their parent classes, and can have additional properties
1234 that are specific to them.¹⁷⁰ For example, the **Natural_Person** class can inherit the **has_name**
1235 property from the **Person** class, and can have additional properties such as **has_age** and
1236 **has_address**. The **Juridical_Entity** class can inherit the **has_name** property from the
1237 **Person** class, and can have additional properties such as **has_registration_number** and
1238 **has_legal_address**.

¹⁶⁷Also called slots in earlier documentation

¹⁶⁸Noy and McGuinness, "Ontology Development 101: A Guide to Creating Your First Ontology", at 8.

¹⁶⁹A form of extrinsic properties that relate the class to other classes are mereological properties, i.e. a class can also have can have physical and abstract parts (e.g. the parts of an engine or the courses of a meal)

¹⁷⁰Noy and McGuinness, "Ontology Development 101: A Guide to Creating Your First Ontology", at 9.

1239 **STEP 6: Define the attribute restrictions** The properties of a class can have
1240 restrictions that define the cardinality of the property, the value of the property, or the
1241 relationship between the property and other properties.¹⁷¹ We can define the cardinality of
1242 an attribute - how many values a property can have. The `has_name` for a person can have a
1243 single cardinality - that is, a person is allowed to only have one legal name. Other properties
1244 can have multiple cardinality. For example, the `has_child` property of a `Natural Person`
1245 class can have a restriction that specifies that a child can have at most two parents, or
1246 several friends. We can also define restrictions for acceptable values that can be entered for
1247 each property: The `has_name` property can have a restriction that specifies that the value of
1248 the property must be a string(i.e. a series of text characters), or that the `has_age` property
1249 can have a restriction that specifies that the value of the property must be a positive
1250 integer. By specifying the domain and **range** of an attribute, we can place restrictions on
1251 the relationships of classes. The **domain** of a property refers to the set of all objects that
1252 can have that property asserted about it.¹⁷² The **range** of a property, on the other hand,
1253 the set of all objects that can be the value of the property.¹⁷³ For example, the fact that a
1254 `Law` can contain many `Rules` can be modelled by the `has_rule` attribute. The `has_child`
1255 property can also have a restriction that specifies that a child must be a `Natural Person`
1256 instance.

1257 When defining a domain or range of an attribute, Noy(2001) recommends finding the
1258 most general classes or class that can serve the purpose. Nevertheless the domain or the
1259 range should not be too general, i.e. the classes in the domain of an attribute should be
1260 described by the attribute, and the instances of all the classes in the range of an attribute
1261 should be potential values for the attribute.¹⁷⁴

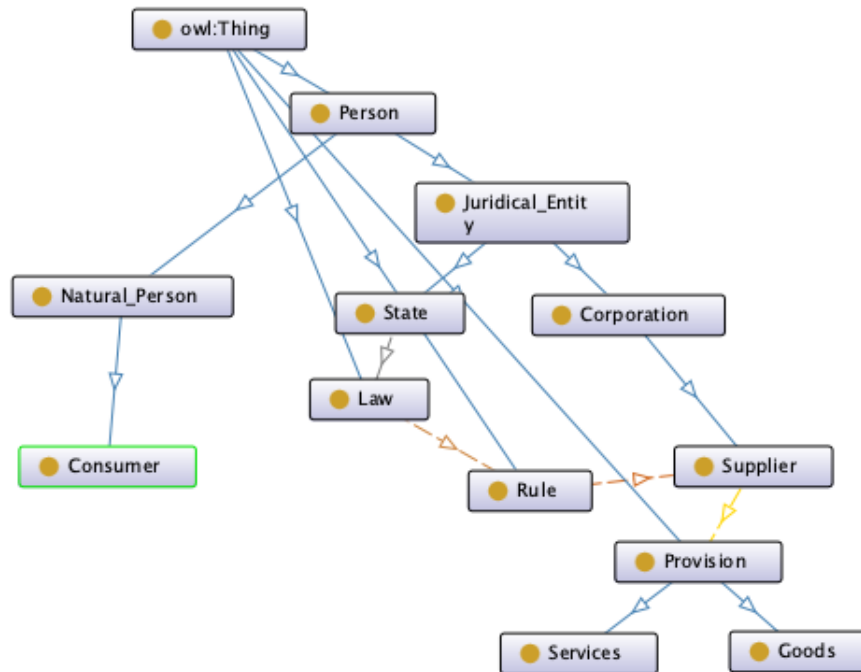
¹⁷¹Noy and McGuinness, “Ontology Development 101: A Guide to Creating Your First Ontology”,
at 9.

¹⁷²De Bellis, *A Practical Guide to Building OWL Ontologies*, at 26.

¹⁷³Ibid.

¹⁷⁴Noy and McGuinness, “Ontology Development 101: A Guide to Creating Your First Ontology”,
at 10.

Figure 3: Initial class diagram



1262 4.3 Representation of normative constraints

1263 4.3.1 Inference rules

1264 The threshold test of competition impact assessment can be stated more formally as
 1265 follows: Given a set of rules (i.e., the rules that cover an industry) - does it comply with or
 1266 diverge from the idealized norm of the threshold test? In previous assessment exercises, to
 1267 make things manageable logistically, the author has proposed making individual provisions
 1268 the unit of analysis. However, even a provision can still express several rules, each of which
 1269 can be independently evaluated. Therefore rules will serve as our unit of analysis.

1270 Ontologies only give us a part of the picture. Besides the entities, their attributes and
 1271 interactions - all these are subject to constraints and transformations based on law. These
 1272 only provide static data about the semantics of entities and their interactions - but these do

1273 not reflect the legal constraints that act upon those objects, and how the semantics could
1274 be qualified, transformed, or annulled by such constraints. Another way of putting it is
1275 that knowledge graphs reflect only the whats and the who's, not the oughts and ought nots
1276 that contained in legal knowledge.

1277 Legal provisions may be restated into atomic inference rules, which have the structure -
1278 If P then Q . It is also possible to state a rule categorically as simply Q , but this should be
1279 rare in operation.¹⁷⁵

1280 Take for example the simple rule “If a lane is designated as a bus lane, then only buses
1281 can drive through it”. This can be broken down to several inference rules:

- 1282 • If [Lane has Bus Only Markings] then [Lane is Designated]
- 1283 • If [Lane is Designated] then \neg [Driver Enters]
- 1284 • If [Driver Enters] then [Violation]

1285 Once we have formal representations, the next step would be to apply analytical methods
1286 grounded in logic. We can trace the chain of inferences (via *modus ponens*), discover other
1287 rules, even look for potential inconsistencies.

1288 4.3.2 Deontic Logic

1289 Legal statements are for the most part, not composed of factual statements. They do
1290 not describe the state of the world as it is, but how it ought to be. They can't be assessed
1291 for truth values. Furthermore, legal conclusions are arrived at under an informational envi-
1292 ronment marked by incompleteness, uncertainty, and inconsistency.¹⁷⁶ Logicians have since

¹⁷⁵See Giovanni Sartor. “A Formal Model of Legal Argumentation”. In: *Ratio Juris* 7.2 (July 1994), pp. 177–211. ISSN: 0952-1917, 1467-9337. DOI: 10.1111/j.1467-9337.1994.tb00175.x. URL: <https://onlinelibrary.wiley.com/doi/10.1111/j.1467-9337.1994.tb00175.x> (visited on 06/20/2023).

¹⁷⁶See Kathleen Freeman and Arthur M. Farley. “A Model of Argumentation and Its Application to Legal Reasoning”. In: *Artificial Intelligence and Law* 4.3-4 (1996), pp. 163–197, at 165.

1293 developed a form of logic, called Deontic Logic, which is not concerned with True or False,
1294 but oughtness: Whether certain acts or states of the world are: Obligatory, Prohibited, or
1295 merely Permitted.¹⁷⁷

1296 Deontic Logic was influenced by modal logic (which concerns modalities, or expressions
1297 that qualify the truth of propositions, i.e., necessity and probability) Although notions of
1298 Deontic Logic have been explored in fourteenth century Europe as well as Islamic thought
1299 (in the 10th century), its modern version grounded in symbolic logic is based on the work
1300 of Von Wright (1951).¹⁷⁸

1301 Instead of the binary values of True or False, Deontic Logic accommodates six normative
1302 states:

- 1303 1. It is obligatory that (OB)
- 1304 2. It is permissible that (PE)
- 1305 3. It is impermissible that (IM)
- 1306 4. It is omissible that (OM)
- 1307 5. It is optional that (OP)
- 1308 6. It is is non-optional that (NO)

1309 Recasting the earlier example under the Deontic mode:

- 1310 • If [Lane has Bus Only Markings] then [Lane is Designated] - No changes because this
1311 is actually a factual statement.

¹⁷⁷See G.H. von Wright. “Deontic Logic”. In: *Mind* 60.237 (Jan. 1951), pp. 1–15, for the original use of the term and the first modern systemization of the field; See also Paul McNamara and Frederik Van De Putte. “Deontic Logic”. In: *The Stanford Encyclopedia of Philosophy*. Ed. by Edward N. Zalta. Spring 2022. Metaphysics Research Lab, Stanford University, 2022. URL: <https://plato.stanford.edu/archives/spr2022/entries/logic-deontic/> (visited on 06/08/2022), for an updated overview.

¹⁷⁸McNamara and Van De Putte, “Deontic Logic”, at § 1.

- 1312 • If [Lane is Designated] then \neg [Driver Enter] becomes: $O([Lane\ is\ Designated] \rightarrow \neg$
 1313 [Driver Enters]) - The inference is neither true nor false, but has the deontic modality
 1314 of Obligation (O).
- 1315 • If [Driver Enters] and [Lane is Designated] then [Violates] becomes $O([Driver\ Enters]$
 1316 $\wedge [Lane\ is\ Designated] \rightarrow [Violation])$ - That is, if the car enters the lane when the
 1317 lane is designated as a bus lane, then we must find a violation

1318 4.3.3 Defeasibility and argumentation

1319 Another attribute of legal propositions is that they are **defeasible**. This means that
 1320 they are tentative - accepted until some other proposition - a new fact that activates an
 1321 exception, better evidence, or even a higher law - defeats our original proposition.¹⁷⁹

1322 Legal conclusions are arrived at based on knowledge that is incomplete, uncertain, and
 1323 inconsistent. Despite this, an adequate theory of legal reasoning should provide a sound
 1324 basis of what to believe. Argumentation theory is suited to the problem because it takes into
 1325 consideration contrasting claims under an environment of uncertainty and inconsistency.¹⁸⁰

1326 The model proposed by Freeman views argument in the following ways:

- 1327 1. As a structure for supporting explanation - It consists of discrete units of arguments
 1328 that connect claims with data
- 1329 2. As a dialectical process - It consists of a series of moves by opposing parties that
 1330 either support or attack a given claim¹⁸¹

¹⁷⁹See generally Giovanni Sartor. "Defeasibility in Legal Reasoning". In: *Rechtstheorie* 24.3 (1993), pp. 281–316.

¹⁸⁰Freeman and Farley, "A Model of Argumentation and Its Application to Legal Reasoning", at 163-164.

¹⁸¹*Ibid.*, at 167.

1331 Freeman’s model integrates the notion of burden of proof - the level of support necessary
1332 for any one party to “win” the argument. This serves as filter, turntaking mechanism,
1333 and termination criteria. The process enables the generation of decisions that could fall
1334 anywhere within the continuum of skeptical and credulous.¹⁸²

1335 **4.4 Automated analysis and evaluation**

1336 The canonical approach requires evaluation of the relevant laws for features that match a
1337 predetermined list of factors (usually based on the economics literature). It relies on both
1338 a reading of the text, and the lawyer’s training on how the text is most likely interpreted
1339 and enforced. What usually happens, based on the recommendations of these guides, is an
1340 appeal to the lawyer’s intuition as to the intent and consequences of the legal text. Some
1341 of these guides suggest, to balance out the inherent subjectivities in that determination:
1342 Consulting other stakeholders (regulators and industry stakeholders). While this cross
1343 analysis might go a long way towards making the conclusions less stilted, there is still
1344 no proof of work that can be shared and independently studied, changed, and evaluated.
1345 We should be able to rely on a transparent chain of reasoning proceeding from plausible
1346 assumptions into consistent propositions, that can be shared, analyzed, built on top of each
1347 other.

1348 Once we have the rules encoded, the goal is to perform automated evaluations. We can
1349 look for internal inconsistencies, or gaps in the coverage of industry entities and transac-
1350 tions. Then we can compare one set of rules - such as the legislation under competition
1351 impact assessment, with the standards set by the economic literature, or the competition
1352 authority, or international organizations. Once law is reduced to a formalized structure,
1353 then it becomes amenable to direct comparison - for finding difference and inconsistency.
1354 Unlike intuitive assessments, though, the reasoning process is exposed from the start - the
1355 assumptions are provided (or at least very easy to look up), and each step towards the

¹⁸²*Ibid.*

1356 conclusion is available for proof.

1357 Ontologies and inference rules can be combined into network structures, and it is possible
1358 to compare network structures - i.e. to what extent these structures are similar or different.
1359 But beyond some of the more obvious methods, this work will explore two pathways that will
1360 enable computers to compare and evaluate the encoded rules: 1. Argumentation frameworks
1361 and 2. Propositional networks.

1362 The first takes into account the dialectic nature of arriving at a legal determination.
1363 Conclusions about law are often only arrived at after an argument - one side presents a
1364 plausible reading of the law, another counters with a supposedly better reading of the law, or
1365 evidence of factual circumstances that would make the law inapplicable, or a higher law.¹⁸³
1366 The initial proponent could counter, and on and on until the arguments are exhausted and
1367 a decision has to be made by some process and standard. In the computational law field,
1368 there are so called argumentation frameworks. These are tools for modeling both rules
1369 and facts into arguments. Normative claims can be encoded just like rules, while the facts
1370 embodied in knowledge graphs can serve as evidence, or a warrant that either supports or
1371 undercuts a claims. In order to be processed an argumentation framework, we need to add
1372 information as to how all the claims and warrants relate to each other - either supporting or
1373 attacking. A reviewer can set the burden of proof, the weight of different kinds of evidence,
1374 and the standard required for an argument to prevail over the other.

1375 Another method to be explored is through propositional networks. Propositional networks
1376 are an extension of game theory.¹⁸⁴ It is used in artificial intelligence, used for playing games
1377 and programming logic. Under this approach, entities and transactions can be modeled

¹⁸³See generally Frans H. Van Eemeren et al. *Handbook of Argumentation Theory*. Dordrecht: Springer Netherlands, 2014. ISBN: 978-90-481-9472-8 978-90-481-9473-5. DOI: 10.1007/978-90-481-9473-5. URL: <https://link.springer.com/10.1007/978-90-481-9473-5> (visited on 06/20/2023).

¹⁸⁴See Michael Genesereth and Michael Thielscher. *General Game Playing*. Red. by Ronald J. Brachman, William W. Cohen, and Peter Stone. Synthesis Lectures on Artificial Intelligence and Machine Learning 24. Morgan & Claypool Publishers, 2014.

1378 as they are in a knowledge graph - related to each other through states, attributes, and
1379 transactions. Unlike the static representation of knowledge graphs, however, propositional
1380 nets allow us to model transitions in both entities and relationships that can be caused
1381 either by constraints or actions - which can be provided by law. Propositional networks can
1382 be used to model the behavior of entities and transactions over time, and how they interact
1383 with each other.

1384 The approach should combine the norms in our deontic propositions with the structured
1385 information in a knowledge graph, such that the norms can interact with the semantic
1386 information. Because the law can assume that the [Driver] is an adult and is licensed, and
1387 if neither of those are true, then a different set of norms apply. At the same time, a state
1388 of [Violation] would mean that the status of [Driver] could be modified i.e., suspended or
1389 annulled.

1390 5 Overview of Encoding and Analysis Approaches 1391 - Normative Component

1392 In order to carry out automated reasoning of law, we have to encode legal norms into
1393 computational forms. In the previous section, ontologies and description logic, helped us
1394 define the descriptive component of the legal knowledge (in this case the OECD Competitive
1395 Impact Assessment tests) that we seek to encode. The analysis that can be performed on
1396 an ontology-based data structure can reveal implicit relationships between entities (such as
1397 inheritance, equivalence), as well as inconsistencies. However, ontologies only give us a part
1398 of the picture. Besides the entities, their attributes and interactions - all these are subject
1399 to constraints and transformations based on law. These only provide static data about the
1400 semantics of entities and their interactions - but these do not reflect the legal constraints
1401 that act upon those objects, and how the semantics could be qualified, transformed, or
1402 annulled by such constraints. Another way of putting it is that ontologies reflect only the
1403 whats and the whos, not the oughts and ought nots that are contained in legal knowledge.

1404 In this chapter, we shall cover the requirements of a logical system for representing
1405 important normative features of a body of rules: First, that it should capture the conditional
1406 nature of legal inferences; Second, it should involve modalities other than True or False -
1407 that is, it should work on normative states (for example, whether propositions are permitted,
1408 forbidden, or obligatory); Finally, it should also allow for the possibility of inferences being
1409 defeated by additional information. The chapter shall describe these features in turn, and
1410 propose Reified IO Logic as an encoding system that integrates all these requirements.

1411 The choice of encoding system is based on Robaldo (2020)'s description of a computational
1412 knowledge base for legal rules,¹⁸⁵ which accomodates several levels of encoding:

¹⁸⁵Livio Robaldo, Cesare Bartolini, and Gabriele Lenzini. "The DAPRECO Knowledge Base: Representing the GDPR in LegalRuleML". in: *Proceedings of the 12th Conference on Language Resources and Evaluation (LREC 2020)*. Marseille, May 11–16, 2020, pp. 5688–5697, at 5688-5689.

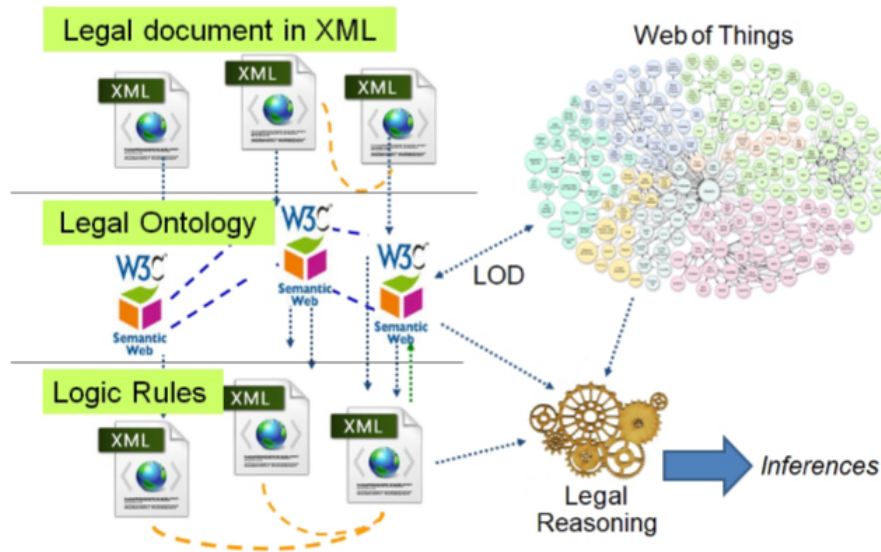
- 1413 1. **Legal text** - Written in a human readable language but tagged and structured
1414 through an XML-based markup (such as LegalDocML, an OASIS standard for le-
1415 gal markup). At this level, the system designer encodes the law as is, but provides
1416 markup for some sections in order to signal the structure of the document, as well
1417 as highlight concepts that are relevant to the ontology and logic layers. This allows
1418 systems to associate these elements with subsequent logical encodings the represent
1419 their meaning. This will allow components of the text to be linked to the subsequent
1420 encodings and support automated processing.
- 1421 2. **Legal ontology** - This consists of the formalized naming and definitions of concepts
1422 that are contained in the human-readable rules, as described in the previous chapter.
1423 Concepts and relationships are encoded in OWL, and will serve as the predicates to
1424 be used in Thehe normative logic layer. The ontology can also be described in terms
1425 of Description Logic, and can support some analysis. Howeverm this ontology layer
1426 alone is not fit for legal reasoning, as it does not account for deontic aspects of the
1427 rules, or accounts for their defeasibility.
- 1428 3. **Normative logic** - This layer represents the normative content of the rules, rep-
1429 resented as logical formulae. This logic layer is formalized in a defeasible form of
1430 deontic logic and then encoded in LegalRuleML.

1431 5.1 Availability of Multiple Logical Systems

1432 In stating that we will translate legal rules into a logical encoding, we mean “logic”
1433 as a formal method that can support deductive reasoning. That is, proving a conclusion
1434 by means of at least two other propositions.¹⁸⁶ The term includes not just Aristotelian
1435 syllogism, but can accomodate other forms of deductive inferences, such as the logic of
1436 alternatives, compound propositions, and of relationships, and the study of propositions

¹⁸⁶Ruggero Aldisert, Stephen Clowney, and Jeremy Peterson. “Logic for Law Students: How to Think Like a Lawyer”. In: *University of Pittsburgh Law Review* 69 (2007), pp. 1–22, at 2.

Figure 4: Layered Architecture of Encoding(Robaldo, 2020)



1437 themselves.¹⁸⁷ Burgin (2022) provides a high-level overview of the evolution of logical sys-
 1438 tems: From loose collection of rules related to belief systems to more modern, formalized
 1439 logics.¹⁸⁸ The diversity of logics can provide tools for the representation of various aspects
 1440 of knowledge. Each logic can capture and emphasize a certain level of description, or com-
 1441 prehend specific problems.

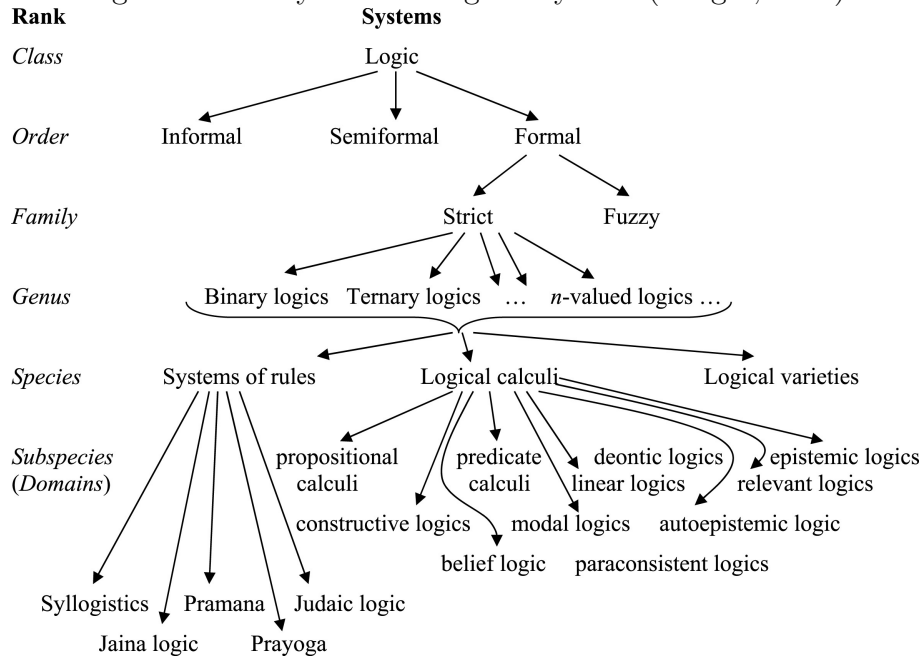
1442 The development of novel logical systems now allow us to have a more focused view
 1443 of a problem.¹⁸⁹ For example: Triadic logics which allows for intermediate truth values,
 1444 rejecting the law of the excluded middle; A fuzzy logic, which has instead of True or False,
 1445 an infinite continuum of possible values, along with a more informal process of inference.

¹⁸⁷Guest, “Logic in the Law”.

¹⁸⁸See generally Mark Burgin. “Evolution of logic as an information processing mechanism in advanced biological systems”. In: *Bio Systems* 221 (2022), p. 104758. ISSN: 0303-2647. DOI: 10.1016/j.biosystems.2022.104758. URL: <https://www.sciencedirect.com/science/article/pii/S0303264722001393>.

¹⁸⁹Susan Haack. “On Logic in the Law: “Something, but Not All””. In: *Ratio Juris* 20.1 (2007), pp. 1–31. ISSN: 0952-1917, 1467-9337. DOI: 10.1111/j.1467-9337.2007.00330.x. URL: <https://onlinelibrary.wiley.com/doi/10.1111/j.1467-9337.2007.00330.x> (visited on 03/26/2024), at.

Figure 5: Family Tree of Logical Systems(Burgin, 2022)



1446 Then there are deontic logics, with new operations such as “obligatory”, “permitted”, and
 1447 “forbidden”.¹⁹⁰

1448 5.2 Legal Norms as Conditional Inferences

1449 In more conventional forms of logic, we can readily represent factual statements. Take for
 1450 example the proposition, earlier made explicit as a fact in the ontology, that corporations
 1451 are also persons:

All Corporations are Persons(All S is P) (1)

1452 ¹⁹⁰Deontic logics in particular have attracted legal theorists as a way to make formal, rigorous representations of the structure of legal orders. A variation of the idea of deontic modes is a component of the encoding system proposed later in this chapter Haack, “On Logic in the Law”, at 11-12.

1453 The predicate Persons is descriptive of the subject Corporations. If the proposition is
1454 admitted, it follows that no Corporations are not Persons. If the proposition is denied, then
1455 it follows that some Corporations are not Persons.

1456 However, let us take a normative or legal statement, “Any person who shall abuse its
1457 market dominance shall be guilty of a criminal offense”. The predicate “guilty of a criminal
1458 offense” is not necessarily descriptive of the subject “person who abuses market dominance”.
1459 The relationship between the components of the proposition hinges on the injunctive “shall”,
1460 which is not descriptive of what is, but instead denotes what ought to be under certain
1461 contingencies.¹⁹¹ Normative propositions are more comparable to the structure of causal
1462 inferences: If p then q . Instead of making factual predictions, however, they are statements
1463 of what ought to be.¹⁹² Sartor states that legal provisions may be restated into such atomic
1464 inference rules, with the basic if p then q structure.¹⁹³ It may also be possible to state a
1465 rule categorically as simply q , but this should be rare in operation.¹⁹⁴

1466 Take for example rule A1 in the OECD Guidelines, that a provision should be flagged
1467 if it “Grants exclusive rights for a supplier to provide goods and services”. This can be
1468 broken down to several inference rules:

¹⁹¹Guest, “Logic in the Law”, at 183-184.

¹⁹²Guest also clarifies that these are not necessarily imperative statements or commands. *ibid.*, at 184.

¹⁹³The consequent of each rule is a literal; and the antecedent is a conjunction of literals. A literal is an atomic formula or the negation thereof. A positive literal has the form ‘ $p(x)$ ’ where ‘ p ’ is a predicate symbol and ‘ x ’ is a list of terms. On the other hand, a negative literal has the form ‘not $p(x)$ ’ where ‘not’ is a logical negation. The complement \bar{q} of a literal q denotes the literal opposed to q : If q is a positive literal p , then \bar{q} represents the negative literal not p ; if q is the negative literal not p , then \bar{q} represents the positive literal p . Sartor, “A Formal Model of Legal Argumentation”, at 179.

¹⁹⁴Sartor’s formalization also admits of these so-called “degenerate inference rules”. These enable unconditional derivation of any instance of their conclusion A. These categorical inference rules can be used to express some forms of ungrounded assertion, such as: 1. Statements of undisputed empirical evidence (the facts that justify a law or court decision); 2. Basic (and very general) normative postulates; 3. Tentatively advanced propositions for which no ground is currently available *ibid.*, at 179.

If [Law Requires Single Supplier] then [Rights are Exclusive] (2)

If [Rights are Exclusive] then [Flagged] (3)

1469

1470 Where [Rights are Exclusive] stands for p and [Flagged] stands for q .

1471 Initially, we can think of rules of substantive law as statements of the specific factual
1472 conditions upon which specific consequences depend. The applicability of the condition can
1473 be contingent on several conditions, as well as the absence of exceptions.¹⁹⁵ Thus:

If events $x_1 \dots x_n$ is the case, and unless there are $y_1 \dots y_n$, then z is the case. (4)

1474

1475 A legal system can be represented as a body of such propositions that can be evaluated
1476 not based on truth or falsity, but by some other normative standard (such as social benefit,
1477 or compliance with other higher rules). Once we have formal representations, the next step
1478 would be to apply analytical methods grounded in logic. We can trace the chain of inferences
1479 (e.g. via *modus ponens*), discover other rules, even look for potential inconsistencies.¹⁹⁶

¹⁹⁵Jerome Michael and Mortimer J. Adler. “The Trial of an Issue of Fact: I”. in: *Columbia Law Review* 34.7 (Nov. 1934), pp. 1224–1306. ISSN: 00101958. DOI: 10.2307/1116103. JSTOR: 1116103. URL: <https://www.jstor.org/stable/1116103?origin=crossref> (visited on 12/11/2024), at 1241.

¹⁹⁶Inference rules are mono-directional, to be used/understood only forward (*modo ponente*) and not backward (*modo tollente*). The consequent q can be derived whenever the antecedent p is satisfied. However, the negation of p cannot be derived when q is assumed to be false. The “if” connective in inference rules is not the same “if” in logical conditionals. Sartor, “A Formal Model of Legal Argumentation”, at 179.

1480 5.3 Deontic Logic

1481 Legal statements are for the most part, not composed of factual statements. They do not
1482 describe the state of the world as it is, but how it ought to be. They cannot be assessed for
1483 truth values. Logicians have since developed a form of logic, called Deontic Logic, which
1484 is not concerned with True or False, but oughtness. Although notions of Deontic Logic
1485 have been explored in fourteenth century Europe as well as Islamic thought (in the 10th
1486 century), its modern version grounded in symbolic logic is based on the work of von Wright
1487 (1951).¹⁹⁷ Under von Wright(1951)’s classic formulation, it is concerned with the following
1488 modes of obligation:¹⁹⁸

- 1489 • **Obligatory** - That which we ought to do
- 1490 • **Permitted** - That which we are allowed to do
- 1491 • **Forbidden** - That which we must not do

1492 For von Wright the starting point of his deontic system is the concept of “Permitted” as
1493 the basic operator - e.g. a proposition can ϕ is Permitted, $P\phi$. Other operators can then
1494 be defined in terms of P :¹⁹⁹

$$F\phi =_{df} \neg P\phi - \text{something Forbidden is not Permitted} \quad (5)$$
$$O\phi =_{df} \neg P\neg\phi - \text{something Obligatory is something not Permitted not to do} \quad (6)$$

1495
1496 Deontic logic was later axiomatized and developed to what is now known as Standard
1497 Deontic Logic (SDL). Under SDL, the primary operator is Obligation, denoted as by the

¹⁹⁷McNamara and Van De Putte, “Deontic Logic”, at § 1.

¹⁹⁸Von Wright, “Deontic Logic”, at 1.

¹⁹⁹Donald Nute, ed. *Defeasible Deontic Logic*. Dordrecht: Springer Netherlands, 1997. ISBN: 978-90-481-4874-5 978-94-015-8851-5. DOI: 10.1007/978-94-015-8851-5. URL: <http://link.springer.com/10.1007/978-94-015-8851-5> (visited on 11/23/2024), at 2.

1498 symbol \bigcirc (or “ought”). The Permitted operator can be defined as:²⁰⁰

$$PE\phi =_{df} \neg \bigcirc \neg\phi \quad (7)$$

1499

1500 That is, ϕ is Permitted if and only if it is not an Obligation that not ϕ . We can thus
 1501 construct all the other operators in terms of \bigcirc (See Table 3 at 81 below).²⁰¹

Table 3: SDL Definitions of Deontic Operators

Definition	Implication	Example
$\bigcirc(\text{OB})$	A proposition is obligatory if it must occur	It is OBLigatory to pay taxes
$PE\phi =_{df} \neg \bigcirc \neg\phi$	A proposition is permissible iff (if and only if) its negation is not obligatory	It is PERmitted to drive a car
$IM\phi =_{df} \bigcirc \neg\phi$	A proposition is impermissible iff (if and only if) its negation is obligatory	It is IMPermissible to smoke in a restaurant
$OM\phi =_{df} \neg \bigcirc \phi$	A proposition is omissible iff it is not obligatory (can be omitted or not done without violating a norm)	It is OMissible to attend that party (you can attend or not attend)
$OP\phi =_{df} (\neg \bigcirc \phi \wedge \neg \bigcirc \neg\phi)$	A proposition is optional iff neither it nor its negation is obligatory	It is OPTional to work from home
$NO\phi =_{df} (\bigcirc \phi \vee \bigcirc \neg\phi)$	A proposition is non-optional iff it is either obligatory or impermissible	It is NON-optional to wear a seatbelt while driving

²⁰⁰Nute, *Defeasible Deontic Logic*, at 2.

²⁰¹McNamara and Van De Putte, “Deontic Logic”, at § 1.2.

1502 Recasting the earlier example under the Deontic mode:

If [Law Requires Single Supplier] then [Rights are Exclusive] (8)

If [Rights are Exclusive] then \bigcirc [Flagged] (9)

1503

1504 The inference that the law should be flagged is neither True nor False, but has the
1505 deontic modality of Obligation. Once represented formally, it may be possible to evaluate
1506 a specific statement based on the axioms and theorems of the chosen system of deontic
1507 logic. For example, in von Wright’s classical system, there exists the Principle of Deontic
1508 Distribution which provides that: “If an act is the disjunction (“or”) of two other acts,
1509 then the proposition that the disjunction is permitted is equivalent to the disjunction of
1510 the propositions that the first act is permitted and the proposition that the second act is
1511 permitted”.²⁰²

$P(\phi \vee \psi) \leftrightarrow P\phi \vee P\psi$ (10)

1512

1513 Applying this to the proposition that a Supplier is permitted to supply goods or services,
1514 then the permission is distributed individually to the supply of goods as well as the supply
1515 of services. While this distributive property is a feature of this particular system of deontic
1516 logic, it is not universally accepted, and we can discard this axiom if it conflicts with our
1517 normative intuition.

²⁰²Nute, *Defeasible Deontic Logic*, at 2.

1518 5.4 Defeasibile Deontic Logic

1519 Another attribute of legal propositions is that they are **defeasible**. This means that
1520 they are tentative - accepted until some other proposition - a new fact that activates an
1521 exception, better evidence, or even a higher law - defeats our original proposition.²⁰³

1522 Substantive legal provisions often have a **positive condition**, the event or circumstance
1523 that must obtain for the purported legal consequence to be arrived at. At the same time,
1524 these conditions are most likely subject to exceptions - elements that according to some
1525 antecedent norms has to be absent in order for the legal consequence fo apply: The sum
1526 of positive conditions embody the determination of the legislator of what circumstances
1527 should normally give rise to the legal consequences. On the other hand, the exceptions
1528 represent special circumstances that can override the positive conditions, making the legal
1529 consequences not applicable. Legal conclusions are often subordinated structures: The
1530 presence of other legal provisions (that are of equal or higher priority in a hierarchy of
1531 norms), which may provide (or negate) conditions and exceptions.²⁰⁴ The goal of legal
1532 reasoning in actual cases is to show that certain acts, claims, decisions comply or does
1533 not comply with the law. This requires demonstrating that the presence (or absence) of
1534 conditions and exceptions.²⁰⁵ Thus, legal conclusions are arrived at based on knowledge that
1535 is incomplete, uncertain, and inconsistent²⁰⁶ - on plausibility rather than truth. Despite
1536 this, an adequate formalization of defeasible reasoning should provide a sound basis of what
1537 to believe.

²⁰³See generally Sartor, “Defeasibility in Legal Reasoning”.

²⁰⁴This arises from what Stuart Hampshire calls the “inexhaustibility of description” Any situation can embody an inexhaustible set of features, but we can only confront and understand part of it at any given time. See Juan Carlos Bayon. “Why Is Legal Reasoning Defeasible?” In: *Diritto & Questioni Pubbliche* 2 (2002), pp. 1–18, at 3; Citing Stuart Hampshire, ed. *Public and Private Morality*. Cambridge: Cambridge University Press, 1991. 143 pp. ISBN: 978-0-521-22084-2 978-0-521-29352-5, at 30.

²⁰⁵Bayon, “Why Is Legal Reasoning Defeasible?”, at 3.

²⁰⁶See Freeman and Farley, “A Model of Argumentation and Its Application to Legal Reasoning”, at 165.

1538 Various such formalizations have been developed to embody defeasibility of reasoning.
1539 For our purposes, a system of defeasible reasoning should allow for the representation of
1540 various propositions and their attributes: 1. Atomic "facts" that are taken as a given; 2.
1541 Rules (whether or not they are subject to exceptions); 3. Defeating propositions and/or
1542 superiority relationships; 4. In the case of legal statements especially, their deontic modal
1543 values (Obligatory, Permitted, or Forbidden). A system of defeasible reasoning should also
1544 enable operations on these propositions, such as resolving conflicts and making plausible
1545 inferences. For example - through prioritization of certain rules and/or the evaluation of
1546 supporting or undercutting evidence.²⁰⁷

1547 In Defeasible Deontic Logic (DDL), legal norms are the positive conditions that prescribe
1548 behavior through Permission, Obligation, and Prohibitions. These norms may be subject
1549 to exceptions (which are also expressed as norms).²⁰⁸ DDL allows for the representation
1550 of facts, defined as whatever can be considered as conclusive unambiguous statements.
1551 Facts can include: either a state of affairs or actions already performed (both considered to
1552 always hold true). Based on our ontological definitions, we can state that "Acme Inc. is a
1553 corporation" through:

Corporation(Acme Inc.) (11)

1554

²⁰⁷Hanif Bhuiyan et al. "Traffic Rules Encoding Using Defeasible Deontic Logic". In: *Frontiers in Artificial Intelligence and Applications*. Ed. by Serena Villata, Jakub Harašta, and Petr Křemen. IOS Press, Dec. 1, 2020. ISBN: 978-1-64368-150-4 978-1-64368-151-1. DOI: 10.3233/FAIA200844. URL: <http://ebooks.iospress.nl/doi/10.3233/FAIA200844> (visited on 11/23/2024), at 9; See also Sanjay Modgil and Henry Prakken. "The ASPIC+framework for Structured Argumentation: A Tutorial". In: *Argument & Computation* 5.1 (Jan. 2, 2014), pp. 31–62. ISSN: 1946-2166, 1946-2174. DOI: 10.1080/19462166.2013.869766. URL: <http://content.iospress.com/doi/10.1080/19462166.2013.869766> (visited on 11/27/2023).

²⁰⁸Hanif Bhuiyan et al. "A Methodology for Encoding Regulatory Rules". In: *Proceedings of the 4th International Workshop on Mining and Reasoning with Legal Texts Co-Located with the 32nd International Conference on Legal Knowledge and Information Systems (JURIX 2019)*. International Workshop on Mining and Reasoning with Legal Texts 2019. Vol. 2632. Madrid, Spain: Rheinisch-Westfaelische Technische Hochschule Aachen, Dec. 11, 2019, at 2.

1555 A rule in DDL is a relationship between a set of antecedents or premises (clauses), rep-
1556 resented as X_1, \dots, X_n and the consequent conclusion or conclusion (effect) of the rule, is
1557 represented as Y . The strength of the relationship between the premises and conclusion
1558 allows us to differentiate between strict rules, defeasible rules, and defeaters:²⁰⁹

1559 **Strict rules** (encoded as $X_1, \dots, X_n \rightarrow Y$) are inferences in the classical propositional
1560 sense. If the premise is indisputable, then so is the conclusion. E.g. "A Corporation is a
1561 Supplier":

$$\text{Corporation}(\text{Acme Inc.}) \rightarrow \text{Supplier}(\text{Acme Inc.}) \quad (12)$$

1562
1563 **Defeasible rules** (encoded as $X_1, \dots, X_n \Rightarrow Y$) are inferences that are generally true,
1564 but can be defeated by other information. An example in the guidelines is that a Supplier
1565 cannot be an exclusive provider unless the economic sector allows for a natural monopoly:

$$\text{Corporation}(\text{Acme Inc.}) \Rightarrow \text{ExclusiveSupplier}(\text{Acme Inc.}) \quad (13)$$

1566
1567 From this, we can conclude that a corporation can be an exclusive supplier, unless there
1568 is evidence to the contrary.

1569 **Defeaters** (encoded as $X_1, \dots, X_n \rightsquigarrow Y$) are rules that can prevent a conclusion. Building
1570 on the previous example, we can maintain that:

²⁰⁹Bhuiyan et al., "A Methodology for Encoding Regulatory Rules", at 8-9.

$$\neg(\text{Sector_AllowsNaturalMonopoly}(\text{Acme Inc.})) \rightsquigarrow \neg\text{ExclusiveSupplier}(\text{Acme Inc.}) \quad (14)$$

1571

1572 Defeasible logic can resolve conflicting information by allowing the prioritization of rules
 1573 through the superiority (\succ) relation. E.g. $r1 \succ r0$ means that rule $r1$ takes precedence over
 1574 rule $r0$. This can be used to resolve conflicts between rules, or to determine the applicability
 1575 of a rule in a given context.

1576 Finally, DDL takes into account deontic properties such as Obligation (O), Permission
 1577 (P) and Prohibition (F) and their relationships in SDL. For example, as to the attribute
 1578 `ExclusiveSupplier`, the Prohibition against acting an exclusive supplier is equivalent to
 1579 the Obligation not to act as an exclusive supplier.

$$[F]\text{ExclusiveSupplier} \equiv [O]\neg\text{ExclusiveSupplier} \quad (15)$$

1580

1581 Thus. the rule that disallows exclusive suppliers (subject to the exceptions for natural
 1582 monopolies) can expressed as:

$$\emptyset(\text{Empty Set}) \Rightarrow [F] \text{ ExclusiveSupplier} \quad (16)$$

$$(\text{Sector_AllowsNaturalMonopoly}(\text{Acme Inc.})) \Rightarrow [P] \text{ Exclusive Supplier} \quad (17)$$

1583

1584 5.5 Encoding Into LegalRuleML

1585 All the logical systems discussed above build on each other and allow us to have a for-
1586 malized representation of legal norms, enabling various operations and evaluations on these
1587 norms. Efficient, automated reasoning with these norms can be achieved by applying the
1588 logical model into a machine-readable format. The interest from the Artificial Intelligence
1589 and Law communities computational representation of norms has led to the development
1590 of digital formats for encoding the logical aspect of legal texts, such as the Rule Markup
1591 Language (RuleML),²¹⁰ Semantic Web Rule Language (SWRL), Rule Interchange Format
1592 (RIF), and the Legal Knowledge Interchange Format (LKIF).

1593 LegalRuleML, an XML-based standard developed and maintained under the auspices of
1594 the Organization for the Advancement of Structured Information Standards (OASIS),²¹¹
1595 represents a convergence of many of these previous efforts, with broad support from both
1596 industry and academic communities.²¹² LegalRuleML allows for the modelling of both con-
1597 stitutive rules and prescriptive rules as if-then statements (antecedent and consequent) with
1598 deontic effects, as well as properties and operations related to defeasibility. For example,
1599 the defeasible rule on prohibition of exclusive supply, as represented earlier can be encoded
1600 as a statement in LegalRuleML:

²¹⁰W3C. *RuleML - W3C RIF-WG Wiki*. 2005. URL: <https://www.w3.org/2005/rules/wg/wiki/RuleML> (visited on 01/12/2025).

²¹¹Oasis Open, *LegalRuleML Core Specification Version 1.0*.

²¹²Tara Athan et al. "OASIS LegalRuleML". in: *Proceedings of the Fourteenth International Conference on Artificial Intelligence and Law*. ICAIL '13: International Conference on Artificial Intelligence and Law. Rome Italy: ACM, June 10, 2013, pp. 3–12. ISBN: 978-1-4503-2080-1. DOI: 10.1145/2514601.2514603. URL: <https://dl.acm.org/doi/10.1145/2514601.2514603> (visited on 12/16/2024).

LegalRuleML Sample

```
<lrml:Statements key="oecd-guidelines-v1">
  <lrml:ConstitutiveStatement key="rulea1-v1">
    <ruleml:if>SectorAllowsNaturalMonopoly</ruleml:if>
    <ruleml:then>...</ruleml:then>
  </lrml:ConstitutiveStatement>
</lrml:Statements>
```

1601

1602 Detailed discussion of LegalRuleML's features (e.g. reification, temporal management,
1603 ontology references) will be provided as they are implemented in encoding the competi-
1604 tion impact assessment guidelines. Besides the rich set of modern features, and a design
1605 approach that can accommodate multiple theories of logic and norms, there are practical
1606 advantages to employing LegalRuleML:1. It is an open standard, with the full specification
1607 and documentation available online; 2. It has broader support compared to other formats,
1608 leading to a larger codebase of examples and related applications; 3. As an XML-based
1609 format, it can be connected to any ontology, readily providing the rules with semantics.

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1637 pp. 3–12. ISBN: 978-1-4503-2080-1. DOI: 10.1145/2514601.2514603. URL: <https://dl.acm.org/doi/10.1145/2514601.2514603> (visited on 12/16/2024).

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1639 Bayon, Juan Carlos. “Why Is Legal Reasoning Defeasible?” In: *Diritto & Questioni*
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1641 Bhuiyan, Hanif et al. “A Methodology for Encoding Regulatory Rules”. In: *Pro-*
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1650 1-64368-151-1. DOI: 10.3233/FAIA200844. URL: <http://ebooks.iospress.nl/doi/10.3233/FAIA200844> (visited on 11/23/2024).

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