

Taming the Complexity of Legal Change for Business Process Compliance

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Appendix (available online via <http://link.springer.com>)

A Appendix

The appendix contains supplementary materials that support the main text, including:

- (1) Table 10 presents an overview of shared and KA-specific coding
- (2) Figure 10 presents an example of a legal change defined across the different taxonomy layers discussed in Sect. 6
- (3) Table 11 contains the complete list of included papers divided by jurisdiction and project
- (4) Table 12 shows the distribution of papers using semantic web-based representations
- (5) Table 13 presents the types of changes supported by logical representations)

	Key Activities			Format		Technology			Change	
	SH	Goal	Origin	Input	Output	Type	Tracking Type	Automation	Type	OP
KA1 Representation	✓	✓	✓	✓	×	×	×	×	✓	✓
KA2 Tracking	✓	✓	✓	✓	✓	✓	✓	✓	×	×
KA3 Interpretation	✓	✓	✓	✓	✓	✓	×	✓	×	×
KA4 Impact Analysis	✓	✓	✓	✓	✓	✓	×	✓	×	×

Table 10: Coding Strategy. All contributions are coded regarding their stakeholders (SH), Goal and the origin of the legal knowledge they process. Using this initial coding we identify Key Activities (KA) which enable further coding with aspects specific to each activity such as the Change Operation (OP)

Text Before the Change: Financial institutions must verify customer identity before processing transactions above 10.000€, unless exempted by law.

Text After the Change: Banks and credit unions must verify customer identity using biometric data before processing transactions above 5.000€, unless exempted by law or authorized by the customer.

Textual Layer	Business Process Compliance Layer
- "Financial institutions" → "Banks and credit unions" - "10.000€" → "5.000€" - Added "using biometric data" and "or authorized by the customer"	<u>Statement Sub-layer</u> 1) Change Type: Modified 2) Type of Statement: Normative Statement (Obligation)
Semantic Layer	<u>Concept Sub-layer</u> 1) Change Type: Modified and Added 2) Concepts Changed: - Actor: "Financial institutions" → "Banks and credit institutions" - Action: "Verify customer identity" → "Verify customer identity using biometric data" - Action Object: "Transactions above 10.000€" → "Transactions above 5.000€" - Condition: Added "using biometric data" - Constraint: Lower transaction threshold (5.000€) - Exception: Added "authorized by the customer"
Deontic Layer	
- Stricter obligation: Lower transaction threshold and mandatory use of biometric data. - More permissive exception: Adds "authorized by the customer"	

Figure 10: Example of a Legal Change Defined Across the Taxonomy Layers

Juris. Context	Project	Reference
EU Legislation	NA	Schmitz et al. (2017a); Ajani et al. (2016); Fabrizi et al. (2021); Palmirani (2022); Schmitz et al. (2017b)
	Luxembourg National Research Fund	Abualhaija et al. (2024a)
	JSPS KAKENHI	Fungwacharakorn et al. (2023a)
	EUCases, MIREL, ProLeMAS	Tamargo et al. (2017); Boella et al. (2016a)
	AGILE project	van Engers and Boer (2011)
	Netherlands Organisation for Scientific Research	Boer et al. (2009)
	Drafting legislation in the area of the AI and dig.	Palmirani et al. (2021)
Italian Legislation	NA	Palmirani and Cervone (2013); Lesmo et al. (2009); Brighi and Palmirani (2009); Spinosa et al. (2009); Brighi et al. (2008); Robaldo et al. (2012); Boella et al. (2019); Lesmo et al. (2013); Francesconi and Passerini (2007)
	Energie Sisma Emilia research project	Palmirani et al. (2017)
	ICT-FP7, CIRSFID, ICT4Law	Gómez-Sebastià et al. (2012); Lesmo et al. (2009); Palmirani et al. (2011); Palmirani and Brighi (2009); Lesmo et al. (2008)
Other EU Countries	NA	Hemberg et al. (2015); Szoke et al. (2012); Górski (2019); de Maat and Winkels (2010); Garofalakis et al. (2016a)
	Spanish Government and JPS KAKENHI	Serrano and Satoh (2019)
	Civil Justice Program of the EU (The Netherlands)	Slingerland et al. (2018)
	Dutch Parliament - MetaVex	de Maat et al. (2009)
	E-POWER, Dutch Tax and Customs Administration	Boer et al. (2004)
	French National Research Agency	Boella et al. (2016b)
	Polish National Center for Research	Smywinski-Pohl et al. (2021)
UK / Australia / US	NA	Arnold-Moore (1995, 1997); Atkinson and Bench-Capon (2023); Lu et al. (2022); Al-Abdulkarim et al. (2016)
	Weightmans	Al-Abdulkarim et al. (2019)
	Xcential Corporation, XCiteDB LLC, Govable	Hershowitz and Mador-Haim (2023); Mador-Haim and Hershowitz (2023)
	US Department of Homeland Security, Hewlett-Packard Labs, and ONR Award	Breaux and Gordon (2013)
	Enterprise Ireland and IDA tech Centre Grant	Butler et al. (2015)
Other Countries	NA (India)	Sunkle et al. (2015)
	JSPS and MEXT (Japan)	Ogawa et al. (2007); Yamakoshi et al. (2020); Fungwacharakorn et al. (2023b)
	Brasilian Public Institute (Brazil)	Fernandes et al. (2020)
Others	NA	Boella et al. (2009); Rotolo (2010); Palmirani and Brighi (2006); Garofalakis et al. (2015, 2016b); Tamargo et al. (2021); Moguillansky et al. (2024); Carrasco et al. (2013); Rotolo et al. (2021); Governatori et al. (2005)
	CAPES and Alexander von Humboldt Foundation	Maranhão (2017); Maranhão and Sartor (2019)
	Politechnika Poznanska grant	Martinek and Cybulka (2005)
	MIREL	Tamargo et al. (2019); Cristani et al. (2017)
	NICTA	Governatori and Rotolo (2010); Governatori et al. (2013)
	Norwegian Research Council	Stolpe (2010)
	ESTRELLA	Governatori et al. (2007)
	Visualynk	Arias et al. (2022)

Table 11: Distribution by jurisdictional context and project

Representation	Reference
ADF	Al-Abdulkarim et al. (2016) , Al-Abdulkarim et al. (2019)
Akoma Ntoso	Palmirani et al. (2017) , Palmirani and Liga (2022) , Palmirani et al. (2021) , Palmirani (2022)
ANGELIC	Atkinson and Bench-Capon (2023)
Legal Ontology	Lame and Desprès (2005) , Butler et al. (2015) , Ajani et al. (2016)
MetaLex	van Engers and Boer (2011) , Schmitz et al. (2017a) , de Maat and Winkels (2010) , de Maat et al. (2009) , Szoke et al. (2012) , Boer et al. (2009)
Multiple	Carrasco et al. (2013)
NIR XML	Palmirani et al. (2011) , Spinosa et al. (2009) , Brighi and Palmirani (2009) , Spinosa et al. (2009) , Robaldo et al. (2012) , Lesmo et al. (2013) , Boella et al. (2016a) , Boella et al. (2019) , Lesmo et al. (2009) , Brighi et al. (2008) , Palmirani and Brighi (2006) , Fabrizi et al. (2021) , Francesconi and Passerini (2007) , Palmirani and Brighi (2009) , Lesmo et al. (2008)
RDF	Schmitz et al. (2017b) , Boer et al. (2004)
SGML	Arnold-Moore (1997) , Arnold-Moore (1995)
Temporal extension of NIR XML	Palmirani and Liga (2022)
USML	Mador-Haim and Hershowitz (2023)
XML	Hershowitz and Mador-Haim (2023) , Ogawa et al. (2007) , Garofalakis et al. (2015) , Garofalakis et al. (2016b) , Sunkle et al. (2015) , Smywinski-Pohl et al. (2021) , Garofalakis et al. (2016a)

Table 12: Semantic web-based representations

O/T Format	Types of Changes	Ref.
Belief revision / AGM	Adding exceptions, removing rules, and modifying rule priorities	Governatori et al. (2013)
	Expansion, revision, contraction	Boella et al. (2009) , Boella et al. (2016b)
	Derogation	Stolpe (2010)
Defeasible logic	Substitution, derogation, annulment	Governatori et al. (2005)
	Abrogation and annulment	Governatori and Rotolo (2010)
Temporal Deontic Logic (TDL)	(Backward and forward) abrogation and annulment	Cristani et al. (2017)
	Substitution, derogation, annulment, abrogation	Governatori et al. (2007)
	Retroactive legal change	Rotolo (2010)
Temporal Belief Revision (TBR)	Expansion, contraction, revision	Moguillansky et al. (2024)
	Temporal aspects of legal norms (existence, force, effects)	Tamargo et al. (2019) , Tamargo et al. (2017)
Defeasible logic and temporalized belief revision	Contraction, expansion, revision, temporal aspects of legal norms	Tamargo et al. (2021)
Belief revision on input/output logics	Contraction, expansion, refinement	Maranhão (2017)
Input/output logics architecture	Adding, deleting, refining rules	Maranhão and Sartor (2019)
Multi-agent system	Temporal aspects of legal norms (existence, force, effects)	Rotolo et al. (2021)
Provision dynamic model in event calculus and prolog	Suspended, prolonged, retroactive, repealing, change	Martinek and Cybulka (2005)
Dynamic complexity using a mathematical model plus visualization	Document modification and repeal of law	Palmirani and Cervone (2013)
Customized formal method	Expansion (promulgation), contraction (annulment and abrogation)	Gómez-Sebastià et al. (2012)

Table 13: Types of changes supported by logical representations