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ORIGINAL RESEARCH

Designing an Intelligent Contract with Communications and Risk Data

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Abstract
Contract automation is a challenging topic within Artificial Intelligence and LegalTech. From digitised contracts via smart contracts, we are heading towards Intelligent Contracts (*iContracts*). We will address the main challenge of iContracts: the handling of *communications* and *risk* data in contract automation. Our Research Question reads: to what extent is it possible to develop an *ontology* that automates contracts with communications and risk data? The article *designs* and *conceptualises* an iContract ontology. Our findings validate the conceptual expressiveness of our ontology. A brief discussion highlights the value of the ontology design and its application domains. From the results, we may conclude that the current method is innovative and that further research is necessary for handling more complex use cases.

Keywords Artificial intelligence · Trustworthy AI · Ontology engineering · Contract automation · Intelligent contracts · Preventive/proactive law

Introduction

The promise of a gift is different from the gift of a promise. Both are attractive. However, soon, the following questions will arise. Which one is better, or which one is always the best? Can we utilise an ontology to guide us in difficult decisions? Moreover, to what extent can Artificial Intelligence's (AI) involvement aid us?

While global media frequently advance statements discussing the replacement of humans by robots in the labour market, social confusion ensues [1]. The same holds for the legal world. So, the aim of our analysis is twofold: (1) to clarify the state-of-the-art innovations in contract automation (i.e., a particular field of AI and Law), and (2) to establish the technological foundations of Intelligent Contracts (iContracts).

In the last twenty years, the field of *contract automation* has experienced three major innovations. The first deals with the digitalisation of contract management (henceforth *digital contracts*), where certain contractual processes are digitised, such as signing, drafting, storing, reviewing, sharing, and analysing contracts [2]. The second innovation regards the rise of *smart contracts* showing that parties can reach and execute agreements via programming [3]. Today we are facing the third innovation, namely *iContracts*. iContracts introduce a hybrid approach between human and computer interventions aiming at achieving full automation with self-executing contracts [4]. iContracts announce a series of new state-of-the-art innovations in the space of contract automation with respect to their compliance with Hybrid AI principles [5].

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Automation with Communications and Risk Data

While iContracts are advancing, they face two main challenges. They concern the *communication processes* preceding the drafting of contracts and the *risk analysis* of contracting clauses. The first challenge is the lack of standardised communication processes which increases the difficulty in deciphering *real communication* from *mis-communication*. The second challenge is that the analysis of risk is not systematised for the purposes of automated computer processes, which adds heavy burdens on the human expert who conducts the analysis as well as the contractors who may experience adverse consequences if risk is not managed well.

These challenges are usually neglected in automation. During the communication, contracting parties exchange useful information that may affect the design of contracts. Typically, a legal expert leverages the information and analyses the risks that may derive by heart only. For example, from the relevant legal rules [6] the expert drafts a contract by experience. As a result the communications and risk data often remain *implicit* in contract automation. A *mini-challenge* here is to make them *explicit*.

Such mini-challenges can contribute in making implicit communications and risk data explicit. In order to establish a solid foundation for such explicit expressions, we start focussing on simple freelance agreement case studies. Gradually, this form of automation can be applied in more complex case studies, including for example enterprises or government contractors. So far, the main alternative for freelancers or organisations is mostly involving physical contract interventions that are hardly scalable. The focus of our research aims at displaying how iContracts may benefit from small-scale challenges (mini-challenges) to future application in more complex environments.

The basic ideas have been described in our article *Towards a Foundation for Intelligent Contracts* at ICAART23 (International Conference on Agents and Artificial Intelligence) [7]. Our current article improves the readability, explainability and understandability of the ideas in the ICAART publication by expanding upon the context of the research and by providing additional examples and clarifications to continue our line of research.

Turning Implicit Data Into Explicit Data

To handle the two challenges, our solution should begin at clarifying: *what type* of communication and risk data should be made explicit? This is difficult since communication and risk data are involved in all stages of the contracting process, which includes: (1) contract drafting, (2) contract execution and monitoring, as well as (3) contract dispute resolution. Provided that the initial communication and risk data analysed during stage (1) will affect later on information in stage (2) and thereafter stage (3), we should begin our investigation with the stage (1).

Having selected a contracting process stage, it is also necessary to select on a relevant contract category. Automating the legal communication and risk analysis has the potential to benefit in first instance the contracting parties. The ultimate beneficiary of such automation would be the non-legal experts, since they can leverage the automation of the contracting process. However, one should neither pass by the inclusion of any legal expert nor make an attempt to neglect any human expertise. At this moment we are cautious to note that automation cannot be immediately successful for all types of contracts. Therefore, our research focusses on a straightforward contracting case study.

To automate the workflow, a technological system should (1) process specific contract communications and risk data as input and (2) yield a contract as output. Hence, our investigation should begin by identifying or defining such data. Due to temporal lack of literature for the specific types of automation, there are yet no available data sources structured accordingly. Hence, as matters now stand, it becomes imperative for AI and LegalTech researchers to *structure* the available data for automating a contract in the present context. Obviously, the most prominent challenge is: *how the communication and risk analysis processes can be handled in a harmonised, scientific manner?* To address both issues, we utilise the power of ontology engineering. Ontology engineering studies the granular representation of the meaning and syntax of concepts, data and entities and their relations in a provided domain and assists with representing knowledge in specific domains in a manner friendly for the computers to understand [8].

Our Motivation

We became interested in studying this topic by the following three observations. (1) Preventing disputes is more effective than resolving disputes. (2) Legal risk technology in larger organisations is often based on manual processes, that smaller organisations are rarely able to afford. (3) Legal risk management derives as the outcome of communications for a specific legal agreement between at least two parties.

Research Question and Contributions

It has become clear that an ontology can be the method that helps the systematic study of our challenge. Hence, the discussion logically follows to start with an ontology that makes explicit the communication and risk data in contract automation. The considerations above lead us to the following Research Question (RQ).

RQ: *to what extent is it possible to develop an ontology that automates contracts with communications and risk data*

Our research contribution is dual. First, we emphasise that the inclusion of communications and risk data in automation is absent in existing LegalTech solutions. This is validated by key word search on the largest LegalTech solutions database in the world: LegalComplex. Second, we design an ontology (called the Onassis Ontology) for contract automation which shows that automation based on communications and risk data is possible and essential for iContracts. The ontology is *validated* by the application of a Knowledge Graph on a case study for freelance agreement. Our ontology shows how communications and risk data contribute to the development of *effective* and *responsible* contract automation, which reduces the need for the physical involvement of legal experts.

Research Structure

To answer the RQ, we structured the article as follows. In Sect. "Relevant Literature", the relevant literature is described. Section "Research Methodology" presents how we conduct key word search in the database for LegalTech solutions and design the ontology within the context of the case study. Then, Section "Results" presents the database findings and applies the KG on the case study. Section "Discussion" discusses the database findings as well as the ontology design and its applications. Finally, Sect. "Conclusion" answers the RQ and provides our conclusion.

Relevant Literature

The literature Section is structured as follows. Section "Contract Automation" introduces the literature on contract automation solutions. Then, Section "Contract Communications and Risks" introduces contract communication and risk literature. Subsequently, Section "Intelligent Contracts" introduces the state-of-the-art literature on iContracts. For a good understanding, Section "Contract Automation Ontologies" presents the relevant ontology literature on contract automation. Finally, in Section "State-of-the-Art" we introduce a table showing the state-of-the-art and associated main pitfalls. We *do not* discuss physical, digital or smart contracts in the literature, because they are only indirectly related to our research scope.

Contract Automation

In most jurisdictions around the world, contracts are defined as follows.

- **Definition 1**: A **contract** is a legally binding agreement, verbal or written [9].

For an agreement to be binding, certain requirements must be met. Those requirements are usually laid out in the contract law of the relevant state, which typically also ensures that conflicts can be resolved through the court system of that state. In general, contracts are governed by private law and in each jurisdiction there are well-defined rules for contracting. Typically, those rules may be substantially divergent.

The two largest online databases on available contract automation solutions are:

1. Stanford University's *Legaltechlist*,[1] and
2. Legalcomplex's *Legalpioneer*.[2]

The *Legaltechlist*, is a strictly curated database while the *Legalpioneer* database is a more extensive database. At the time this research was conducted (May 2023), Stanford's website has a total of 2,094 results and Legalpioneer's website has 9,608 business cases archived. In these databases, the amount of available contract automation solutions that relating with this research will be identified after a global inspection of the content of both databases related to our topic (iContracts). We decided to focus on identifying companies in *Legalpioneer* due to the larger amount of available data. These data are expected to support the importance of our research scope.

Thus we started small negotiations with the owner of Legalpioneer, and after some investigation on our goal, we were given access to the results of the proprietary analytics tools of Legalcomplex. The tools included advanced search and analytics on the Legalpioneer data for identifying and analysing data with a higher degree of accuracy.[3] The database, however, does not include state-of-the-art solutions that have not reached or are yet to reach the market.

A general trend observed with contract automation solutions is that they gather significant attention in the LegalTech innovation. Our research will help clarifying what the percentage of the total contract automation solutions within the available LegalTech solutions today.

Contract Communications and Risks

Most of the available literature on contract communication is focussed on *contract negotiations*. The word *communication* concerns in our context to a larger extent how contracting parties *should* talk with each other, in order to (1)

[1] https://techindex.law.stanford.edu.

[2] https://www.legalcomplex.com and https://www.legalpioneer.org/.

[3] https://www.legalcomplex.org/.

gain a negotiation advantage, (2) reach an agreement and (3) avoid the escalation of conflicts. Here we remark that in our research, the word *communication* refers to the substantive information that is directly relevant for the design of a contract. The general trend of AI in this context focusses on the role of *chatbots* in intelligent automation [10].

So far, in this and other literature, communications data are not connected with risk data, whatever the context of contracting automation may be. Still, contract communications literature is sufficiently advanced to assist with the management of relevant communications data, even for new purposes such as the one of managing legal risk. Our research will help clarifying the partitioning of the percentages of contract automation solutions.

The first framework for the management of contractual risks emerged in 1950 with the introduction of *Preventive Law* by the lawyer and attorney Louis M. Brown [11]. Brown believed that preventive law concerns the *cost difference* between entering into and avoiding legal costs. He thought that legal problems arise because of legal risks. At the end of the century, his student, Eduard A. Dauer, started the development of a systematic analysis for the management of legal risks [12]. In 2002, the academic Thomas D. Barton took an interest in continuing this line of research by advancing Dauer's analysis further with his own method [13, 14].

Around the same time, in 1998, the lawyer and academic Helena Haapio introduced the concept of *Proactive Law* [15]. Proactive law is a future-oriented approach to law and legal agreements, placing an emphasis on legal knowledge to be applied before things go awry.[4] The difference between preventive and proactive law is that the latter, except from the preventive dimension, adds the promotive dimension in terms of good and desirable behaviour [16]. Haapio is mostly concerned with the application of proactive law in contracts.

In 2010, she created a synergy between proactive law and the United States school of law as a competitive advantage with the academic George J. Siedel [17]. As a consequence of this synergy, in 2013 they published the book *A Short Guide to Contract Risk* where they analyse contractual legal risks [18].

At around the same time in 2010, Haapio introduced the theory of legal design, which advances the theory of Preventive/Proactive Law (PPL) by translating all complex legal language into clear language expressions and visualisations, so that contracts can be understood by everyone before legal problems arise [19].

Today the research of PPL focusses on smart contracts [20]. The novelty from the use of smart contracts in LegalTech stems from the adoption of computer code instead of human language for managing contracts [21]. It is from this perspective that the school of legal visualisation under PPL is conducting research on smart contracts, so that the smart contract rules are *better understandable* and *accessible* for contractors [22] [23]. Haapio often emphasises the importance of design for contracts, but that it is particular so for smart contracts [24].

In 2004, the academic Jon Iversen introduced *Legal Risk Management* [25]. Then, in 2007, the academic Tobias Mahler discovered a difficulty in *defining legal risk* and *how diverse it is* [26]. Following the introduction of a compliance risk management by ISO (International Organization for Standardization) in 2014 [27], Mahler along with the academic Samson Essayas, set out to systematically analyse and model compliance risk in 2015 [28]. Recently in 2020, ISO introduced the first Legal Risk Management (LRM) standard focussed exclusively on legal risk for organisations and defines *legal risk* as follows [29].

- **Definition 2**: **Legal risk** is risk (effect of uncertainty on objectives) related to legal, regulatory and contractual matters, and from non-contractual rights and obligations.

By building upon the literature of PPL our research shows how it is possible to develop an ontology for analysing and visualising contract risk. We designed the *Enriched Bow-Tie Ontology* (EBTO) [30]. It is an extension of the Onassis Ontology, describing how it is possible to manage all types of risk-including contract risks-explicitly [30]. Then, we discovered that when the risk analysis conducted by a legal expert on EBTO is *visualised* to the contracting parties as end users, their *level of trustworthiness* increased [31]. The EBTO and its impact on trustworthiness are not discussed in this article for the purpose of maintaining a controllable research scope.

Intelligent Contracts

The step from smart contracts to iContracts can only be performed when one is able to manage and prove milestones. On a macro level, applying this technology in a complex legal situation unfolding in, for example, an energy project would require higher sophistication. This higher sophistication is examined under the aegis of *intelligent contracts* or *iContracts* [32]. So far iContracts are defined as follows.

- **Definition 3**: An **intelligent contract** (or **iContract**) is a contract that is fully executable without human intervention.[5]

[4] http://www.juridicum.su.se/proactivelaw/.

[5] https://bravenewcoin.com/insights/pamela-morgan-at-bitcoin-south-innovating-legal-systems-through-blockchain-technology.

The field of iContract (i) will introduce a hybrid contract automation approach and (2) will consider the need for contract automation that corresponds to the complexities of reality, aiming at the transition of automation into a *full self-executing automation*, with minimal human intervention or without it, if possible [4]. Motivated by the developments in Industry 4.0, this field is most evidently under construction [33], where a high level of complexity drives the need for such innovation [34, 35]. Despite the large academic call for the need of iContracts and the developing frameworks for its adoption [36], many acceptance challenges are evident in practice [37]. The key value of iContracts is that they can leverage information from various data sources, including smart Internet of Things (IoT) sensors, for automated monitoring of contract data [37]. IoT sensors are essential for the monitoring of contract data in complex industrial structures and benefit iContracts with automated data collection. The IoT applications in iContracts can range from environmental monitoring for CO2 emissions tracking, to quality control of machinery and compliant inventory management. It should be noted here that iContracts can be implemented in both centralised and decentralised systems [38].

The iContract developments prove that the monitoring and execution of contracts is more related with *project management*. However, the level of project management with respect to technological readiness is diverse. For example, in a freelance agreement, where there is a lack of IoT sensors, it is harder to monitor a contract and manual effort is needed. Yet, the complexity of the contract overall is smaller and the execution process can be more manageable. In relation to construction, the complexity of the contract is much larger, with multiple sub-contractors involved. Despite the existence of IoT sensors and the higher degree of automated monitoring, the execution of contracts will be more cumbersome.

The iContracts literature is not sufficiently developed yet. That occurs for multiple reasons. One of the fundamental reasons is that there is no widely adopted iContract solution yet in the market. Our research contributes towards this direction by showing the design of an iContract. Additional research limitations relate to end user adoption of iContracts. That is also caused to a large degree on the lack of available iContract solutions. One of our observations is that research on iContracts has decreased in the past 2 years. Potentially, it is due to the fact that when iContracts was initially highlighted, its development complexity was large and as a result created a relative stagnation in research. Our research contributes towards this direction by offering to scientists an iContract "playground" (the Onassis Ontology) to experiment in multiple ways with practically applicable iContracts.

Contract Automation Ontologies

So far ontologies have been applied multiple times in legal context, but not for the specific context of contract automation via *communication* and *risk* data. For a better understanding of the available literature, we provide five examples:

- for the structuring of legal norms and court decisions [39]
- for posing legal questions related to legislative sources and answering them [40]
- for compliance purposes in complex multi-lingual, multi-jurisdictional environments [41] [42]
- for online case analysis [43]
- for case recommendations [44]

In relation to contract automation in general, ontologies have been used:

- for conceptualising contracting terms and promoting interoperability regarding concepts [45]
- for data exchanges for blockchain-based smart contracts [46]

They do so on an infological and datalogical-level. The ontologies have also been used to help the automation of public procurement processes.[6] Moreover, they have been exploited more generally, albeit at a higher level of abstraction, for:

- blockchain-based smart contracts [47]
- other research concerning contracts [48], and
- contract risk management [49].

The closest research to date on our subject is that of Legislate ,[7] where they use an ontology for *drafting* and *negotiating* contracts as well as representing *rights* and *obligations*, which happens behind closed doors as their KGs[8] are protected by a patent on semantic document generation.[9]

The contribution of our research to the literature is that in addition to all ten applications, our research applies ontologies from the perspective of *communication* and *risk* data automation. The potential of applying ontologies in the legal domain may even reach the level of developing industry-wide interoperability standards, in the same way as occurred

6 http://contsem.unizar.es/def/sector-publico/pproc.html

7 https://legislate.ai.

8 https://www.legislate.tech/post/knowledge-graphs-know-more-about-your-contracts.

9 United States Patent 11087219.

Table 1 State-of-the-art and main pitfalls

	State-of-the-Art	Main Pitfall
Communications data	Chatbot	Low trustworthiness
Risk data	Bow-tie method	Time-consuming
Communications and risk data	Implicit connection	Requires human analysis
Ontology engineering	Contract data	Limited and restricted data

in the financial industry via the Financial Industry Business Ontology (FIBO).[10]

Essentially, our ontology contributes towards five important directions in relation to literature. First, it applies ontology engineering on a practically relevant legal risk management level. Second, it shows how it is possible to connect communications and risk data via an ontology. Third, it provides a technological tool to organisations interested in adopting contract automation solutions. Fourth, the ontology shows how it is possible to make explicit the usually implicit communications and risk data within the context of contract automation. Fifth, it offers a new working process to legal experts interested in scaling the delivery of their services with a higher degree of effectivity and responsibility.

State-of-the-Art

In order to clarify the relevant literature review, we define the (1) state-of-the-art in contract automation as well as its (2) main pitfalls on four relevant levels related to our research: (a) communications data, (b) risk data, (c) communications and risk data, as well as (d) ontology engineering. Table 1 shows the state-of-the-art and its main pitfalls.

Table 1 shows four relevant points for the state-of-the-art and its associated main pitfalls related to our research. First, that the most advanced way to manage communications data are chatbots, which are not trusted significantly by end users (in our parallel publication we discuss this issue in greater detail [31]. Second, that the best available method to manage risk data is the bow-tie method, although it's process is time-consuming and not widely adopted (we also discuss this matter in detail in our parallel publication [30]. Third, that there is no available explicit connection between communications and risk data, which is currently based on human analysis. Fourth, that ontology engineering today is applied on available contract data, which, due to the lack of explicit inclusion of communications and risk data, are limited to available data.

Research Methodology

The research methodology initially focusses on the analysis of Legalcomplex data which is based on Key Word Search (Section "Key Word Search"). Then, the methodology employs the stage of *determining* the case study (Section "Case Study"). Moreover, ontology engineering is introduced (Section "Ontology Engineering"), as well as its *design* and *conceptualisation* (Section "Ontology Design and Conceptualisation") to arrive at its *validation* (Section "Ontology Validation").

Key Word Search

To gather data we requested Legalcomplex to conduct key word search, with the expectation of identifying the available solutions of contract automation today. Legalcomplex has classified contract automation solutions into the following five categories:

1. contract negotiation
2. contract risk management
3. contract drafting
4. contract extraction
5. contract management

Since they have classified *communications automation* as *negotiation automation*, the conducted search follows the relevant classification. More specifically we may state that, according to Legalcomplex, contract negotiation consists of seven steps. According to the definition, they are collections of:

1. Names
2. Dates
3. Amounts
4. Clauses
5. Signatures
6. Entity and Structure
7. Ownership and Conflict

Legalcomplex conducted key word search on the words: (1) *contract automation*, (2) *contract negotiation*, (3) *contract risk* and combined (4) *contract negotiation and risk*.

[10] https://edmcouncil.org/page/financialindustrybusinessontology.

According to the owner of Legalcomplex, they used their algorithm to obtain the totals. The key word search was determined by the following specific questions that the authors provided to Legalcomplex:

1. What is the total number of legaltech solutions?
2. What is the total number of contract automation solutions?
3. What is the total number of contract negotiation solutions?
4. What is the total number of contract risk management solutions?
5. What is the total number of solutions of contract automation that combine contract negotiation and contract risk management?

Case Study

The case study concerns a contract regarding the provision of freelance services. The scope of this article will be limited to this case study, to reduce the contextual complexity of contract communication and risk analysis required before drafting such a contract to a sufficient degree for making our scientific investigation. A freelance agreement includes sufficient complexity which is usually recorded in 3 to 10 page contracts, versus direct investment agreements for example that may include up to 1000 page contracts.

To get this agreement, a Non-Disclosure Agreement (NDA) was downloaded from the open-source legal documentation database of Capital Waters[11] and adjusted to fit the needs of our case study. Thereafter, the focus was placed on applying the NDA agreement within the context of a freelancer agreement. There are various online contract templates that could help us in this case. They can be easily accessed online.[12]

If the automation proves to be successful, gradually it can be applied to more complex types of contracts. Ideally, a Foreign Direct Investment (FDI) contract between an energy company and a government can also be automated in this way. Yet, as explained below, freelancer contracts are already complex for the current state-of-the-art technology.

Ontology Engineering

During a contract agreement a variety of explicit and implicit information is exchanged between stakeholders. Explicit information include contracting clauses, signatures and relevant documentation. The communication and risk analysis that begins before a contract is drafted usually remain implicit. Our challenge is concerned with how to make such implicit information explicit.

To address this challenge, we perform a quick scan around the question: how can Data Science (DS) and AI help us? DS and AI present three available options related to (1) Machine Learning (ML), (2) Relational-Data Models (RDM) and (3) Ontology Engineering. ML refers to algorithms that conduct cost-effective calculations, that would be burdensome for humans, in the realm of inductive reasoning which is probabilistic in nature [50]. ML includes Deep Learning (DL) and today Large Language Models (LLMs). RDMs concerns the structuring and management of data in compliance with the principles of First Order Logic (FOL) in databases that include a finite amount of predicates [51]. As for ontology engineering, we already introduced it in the introductory section as the study of granular representation of the meaning and syntax of concepts, data and entities and their relations in a provided domain and assists with representing knowledge in specific domains in a manner friendly for the computers to understand [8]. The three options present different advantages and disadvantages to address our challenge.

First, a *Machine Learning* (ML) approach, when can an unsupervised ML algorithm be applied to any available contract data? Yet, such data are hard, if not impossible, to identify, find or obtain. Second, a *relational-data model* can be developed that handles various data sources and their connections. However, such a model may be limited for the application of AI, considering that the identification of relevant data sources in our cases is not possible. Third, *ontology engineering* is an option. Ontologies show how it is possible to handle interconnected data sources with a great variety of data types, by creating semantic specifications.

The concept of an ontology is taken two reasons. (1) There is high conceptual complexity involved in making implicit data explicit. (2) We are facing multiple unknown information regarding the number and interconnected nature of data sources.

Ontologies introduce benefits that are in particular helpful with tackling our challenge. They are able to support the structuring of data in a scientific manner [52]. The benefits of developing an ontology relate to interoperability, standardisation, conceptualisation, inferential reasoning and information retrieval. For a proper characterisation we would like to emphasise the difference between an ontology and a relational data base. The former can be seen to use languages driven by a dictionary for communication while the latter uses body language without a dictionary for communication. Moreover, an ontology is (1) extendable, (2) can support additional solutions and (3) may clarify limitations.

An ontology is able to serve as the backbone of an explainable "intelligent" platform where modern technologies are incorporated and tested [53]. The core module of

[11] https://www.capitalwaters.nl.

[12] See for example: https://community.weagree.com/model-contracts/.

this platform will utilise modern models and techniques in the field of AI. In our research, the *value of the ontology* stems from its ability to support the implementation of communication and risk management in contract automation.

Ontology Design and Conceptualisation

As mentioned in the introductory Section, ontology engineering is able to contribute in simplifying the evident complexity in automating communications and risk data during contracting. The ontology helps to:

1. *clarify* the relevant concepts involved in the automation,
2. *identify* relations among the concepts,
3. *inform* decision making by highlighting technological opportunities and risks,
4. *guide* the development of algorithms and collection of relevant data sources, and
5. *offer* a flexible and adjustable technological infrastructure to support contract automation.

To design an ontology, requirements need to be gathered. They are gathered based on the case study and a literature review. Taking into consideration the requirements, we arrived at the Onassis Ontology. It is visualised in a simplified form in Fig. 1 and as a scientific "puzzle" in Github (with clear explanations), where all details are connected and visualised.[13]

The ontology that we designed retraces the interactive process of *asking* ***questions*** and *giving* ***answers*** between a legal expert and a contractor (see Fig. 1 right upper half) leading to the collection of relevant communications data. Such data are processed by a legal expert who relates them with the relevant contract risks (see Fig. 1 left upper side). The process that we aim to frame for automated methods (and that ultimately will lead to a formal contract) designed lays the following ontological conceptualisation.

In the Onassis Ontology we see the starting points of the above-mentioned interactive process between the legal expert and the contractor. The legal expert writes a question for the contractor who has previously selected a specific scope for the contract (in Fig. 1 the "U" sign denotes that a predicate connects with two or more objects). By replying to the question, the contractor provides an answer. The answer includes information that can be extracted to update (1) one or more *variables* of a paragraph (see Fig. 1 right under half). Each (2) *paragraph* is part of (3) a *section*, whereas multiple sections form (4) a *contract* (see Fig. 1, lower half). The variable, paragraph, and section follows a numerical order within the constituent parts of the contract. The paragraphs of a section (i.e., the section itself) are grouped under standardised topics and are regulated by legal rules.

The contract contains a number of agreements, which include not exclusively the offering, acceptance and the setting of expectations between the contractors (see Fig. 1 red line in left half). An agreement here is conceived as a consensus involving at least two different parties and regarding an answer and a question. Every time that a question is asked by a legal expert and an answer is provided by a contractor, an agreement takes place. The contract and agreement are always associated with a risk that is defined by the legal expert (see Fig. 1 upper half). The risk, as well as all the additional constituent parts of the contract, can be reviewed by the contractor before signing the contract. He/she/it is ultimately in charge to decide whether or not to enter in a legally binding agreement with the other involved party or parties.

The risk analysis is not provided in detail, because it is described in [30, 31]. In summary, the risk management extension, called the *Enriched Bow-Tie Method* [30] (not discussed here), helps a legal expert analyse and visualise contract risk.

Ontology Validation

The logical consistency of the ontology has been tested by launching the specialised reasoner Hermit 1.4.3.456 on sample data in the Protégé editor. The use case employed is presented in the results.

In parallel research we will show that the ontology is not only *validated* with the Knowledge Graph, but that it can also be *re-programmed* via a prototypical web application [54].

In particular, we will detail how the web application supports contractors and legal experts in negotiating, analysing and preventing risk, and finally in drafting a contract according to the Onassis Ontology [54]. The Onassis Ontology (a *model / terminology*) is instantiated into a contract (*data / assertions*).[14] The source code for the prototype web application is accessible via Github,[15] including a user guide, screenshots of typical usage, operational and Docker hosting instructions to ensure replicability, and instantiated Onassis Ontology contract data created by application users.

[13] The Onassis Ontology is accessible at https://github.com/onassisontology/onassisontology and is protected by the open-source GNU General Public License https://www.gnu.org/licenses/gpl-3.0.html.

[14] An example of an Onassis Ontology-based contract data file created by contractors and legal experts is available on Github: https://github.com/onassisontology/icontracts-back-end/blob/main/example_iContract_ontology_data.ttl.

[15] See https://github.com/onassisontology/icontracts-back-end and https://github.com/onassisontology/icontracts-front-end.

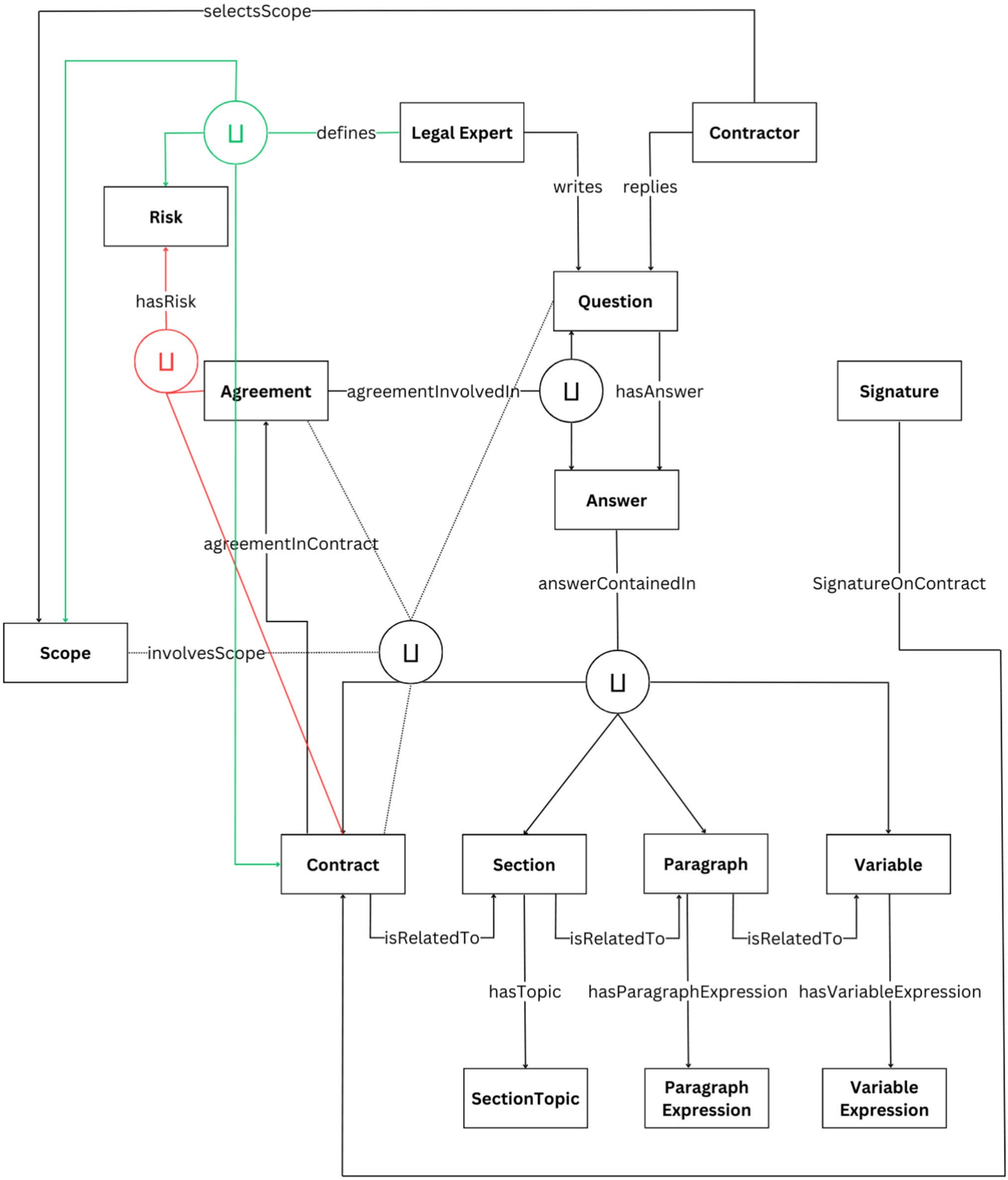

Fig. 1 Visualisation of onassis ontology

Results

The results of our research are twofold. The first result is ("Contract Automation Solutions") *the percentage* of available contract automation *solutions* related to the scope of this research based on the Legalcomplex data. The second result is ("Knowledge Graph") the KG that works as a

Table 2 Application domains of legaltech solutions

Top	Automation	Application	Communications	Application	Risk	Application
1	Infor	Industry Cloud	Vlocity (Salesforce)	Cloud and Mobile Software	Aravo Solutions	Third-Party Management
2	DocuSign	eSignature	Pactum	Negotiations	Epoq	Legal Documents
3	Icertis	Contract Management	Robin AI	Contract Management	Powerlytics	Predictive Analytics
4	Seismic	Customer Management	Spendflo	SaaS Buying Optimisation	Intellinetics	Document Management
5	Workfront (Adobe)	Project Management	Trim	Bill Negotiations	Hypernative	Web3 Asset Protection
6	Snapdocs	eClosing	ParelyPro	Contract Management	Nayms	Insurance Marketplace
7	Ontra	Legal Operating System	Common Paper	Contract Management	Sparrow	Digital Asset Solutions
8	Coda	Document Management	Along	Customer Management	Insurdata	Geocoding Data Management
9	Onit	Legal Workflow	Contraktor	Contract Management	DocLogix	Document Management
10	AirSlate	Document Workflow	Valla	Workers Platform	Finch	Personal Finance

validation mechanism for the ontology. The second result is further validated with use cases ("Use Case Scenario").

Contract Automation Solutions

After the key word search in Legalcomplex the following four classes of findings were traceable, for (1) contract automation, (2) contract automation based on communications data, (3) contract automation based on risk data and (4) contract automation based on communications and risk data. More specifically, our findings are as follows:

1. out of the total of 10,448 LegalTech solutions, 590 solutions (5.6 percent) focus on contract automation;
2. out of the contract automation solutions, 51 (8.6 percent) focus on contract communications;
3. out of the contract automation solutions, 50 (8.4 percent) focus on contract risk;
4. (surprisingly both for the researchers and owner of Legalcomplex) there was *no* solution focussing on both contract communications and contract risk.

The final result (4) was so surprising for us and possibly for the reader. The results indicate that despite the abundance of contract automation solutions, there is a significant omission for solutions which are focussed on communications **and** risk data analysis. It is an omission on both sides.

The Legalcomplex search helps us also discover the top ten solutions for each category investigated. In order to understand the focus of each of the top solutions for each of the three vertical with solutions, namely (1) contract automation, (2) contract communications and (3) contract risk, we now develop a new Table 2 below.

Table 2 shows that in contract automation industrial cloud is prevalent and that the space is diverse with applications in multiple areas from contract and project management to document and customer management. As for contract communications, again cloud is dominating although 4 solutions are focussing on contract management, showing the significant of communications for contract management. Then, as for contract risk, Third-Party Management is the primary application and a trend is observed to apply risk management in the financial and insurance domains with five solutions focussing on that direction.

Knowledge Graph

The knowledge graph plays the role of validating the ontology design and visualisation by leveraging practical case studies and connecting data deriving from them with the designed ontology concepts. If the connection suffices to represent all relevant data in a case study, we may conclude that our ontology is well designed and conceptualised.

To validate the *coherency* of the ontology with the domain knowledge, we did run competency questions on the instance data that we structured via the vocabulary terms of the Onassis Ontology. The validation process displays the level of expressiveness of the vocabulary. For instance, the Onassis Ontology fully supports the use case scenario in Fig. 2. The visualisation is to be seen via the GitHub page (see the link in the footnote).[16]

Following the development of the Onassis Ontology based on the case study and the literature, we may conclude that the KG design (given in Fig. 2 in a simplified format and on Github as a scientific "puzzle" [17]) indeed convincingly shows that the development of a KG is *possible*. The validation proof is by stepwise verifying that it is possible

[16] https://github.com/onassisontology/onassisontology.

[17] https://github.com/onassisontology/onassisontology.

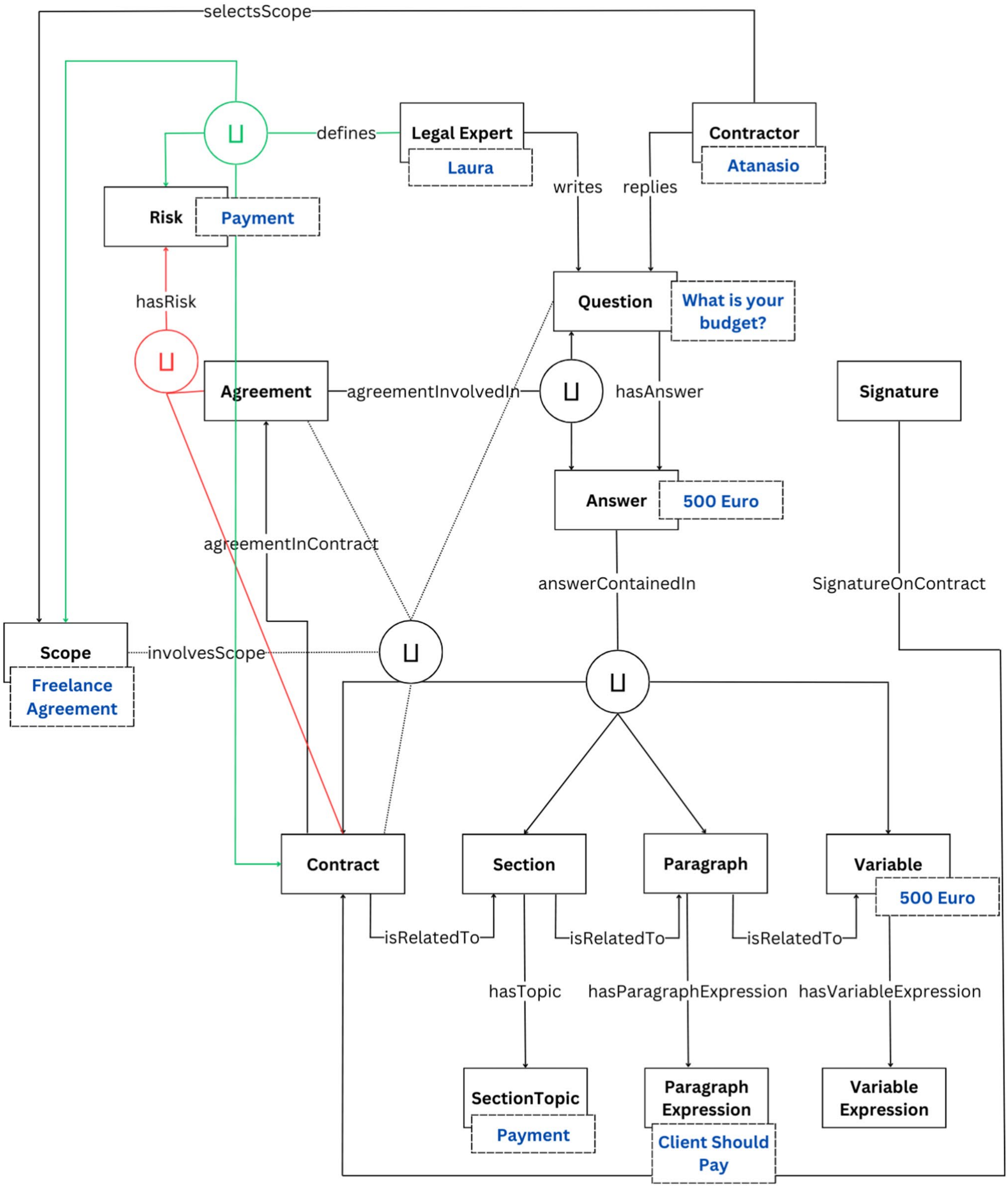

Fig. 2 Visualisation of the use case scenario modelled with Onassis's ontological expressiveness

to add selected data points derived from any new case study to the ontology.

In the figure, individuals are represented as rectangles. Their associated datatype values are highlighted in blue. Relationships are represented as arrows. The KG follows

Table 3 Additional knowledge graph validation examples

Category	Question	Answer/variable	Risk	Rule
Insurance	What is the number of your professional liability insurance?	12,345	Insurance coverage	Freelancer must possess professional liability insurance
Payment Terms	What is your preferred payment method?	Final Delivery Payment	Delayed payments	Client should comply with the payment schedule
Confidentiality	How many years should confidential protection last	5	Information leak	Freelancer should maintain all information confidential
Intellectual Property	What type of intellectual property protection do you prefer	Full IP Protection	IP Ownership	Client reserves all IP rights
Scope Changes	What is your preferred way to be informed about potential scope changes	In writing	Delayed changes	Potential scope changes should be communicated explicitly
Delivery	What is the deadline for the delivery of your work in full?	22/5/2023	Project completion	Professional should deliver the necessary work by the stipulated deadline
Communication	What is your preferred communication channel?	Whatsapp	Lack of sufficient communication	The project communication should occur via the specified channels
Dispute Resolution	What jurisdiction should regulate the resolution of a potential dispute	Dutch Law	Dispute	All disputes should be resolved in accordance with the specified law
Termination	How should the parties communicate about the potential termination of the project	In writing	Project Termination	A project should be terminated in accordance with the specified procedure
Acceptance Criteria	What type of client rating is necessary to stipulate an acceptable deliverable	7 in scale from 1 to 10	Quality Control	A client should rate each deliverable from a scale of 1 to 10

the logic described in Fig. 1, starting with the abstract level and following with the physical level. That is to say, once the legal expert has selected a scope and defined the risks and questions for an agreement, the contractor is able to select a scope, answer the questions and the contents of the contract are updated as a result.

Use Case Scenarios

To diminish the complexity of Fig. 2 by a straightforward use case scenario we introduce two human beings, viz. Laura (a legal expert) and Atanasio (a contractor) (all case study data are visualised in blue in Fig. 2). The use case scenario shows how the contractors provide answers to legal questions, out of which relevant variables are extracted to update a contract. Understanding the KG relies on the prior understanding of the Onassis Ontology, given that the KG follows the Ontology to model a specific use case to examine its validity.

In the use case scenario, Laura, who is seen as a legal expert, defines both the *scope* of the agreement to be a freelance design agreement and the *risk* (which in this case is a payment risk). Successively, she writes the question "what is the budget?" and waits for an answer. Atanasio, as a contractor, selects the scope of the agreement and takes a freelance design agreement. The answer provided by Atanasio updates the *variable* uniquely identified by a *number*, *paragraph*, *section* and *contract*. The *variable*, *paragraph* and *section* have an order number in their related parts. The question asked by Laura and the answer provided by Atanasio are involved in the agreement, which can have a maximum of one question and one answer. In fact, for every question asked and answer given, a uniquely identified agreement is created.

Multiple agreements can be part of a same uniquely identified contract. Once Atanasio has completed the review of the legal document he can sign it by adding his signature on the contract. This action will legally bind the parties involved in the various agreements connected to the same scope within a sole contract.

The data shows that our ontology structure is robust for the requirements of a freelance agreement. That is because, once a contract has been structured into sections and paragraphs the relevant variables can be identified that inform a Legal Expert as for the specific legal questions to be asked. We do mention freelance agreement specifically, given the relative simplicity of a freelance agreement compared to more complex agreements (i.e., FDI), of which the validation requires further experimentation.

The KG validation can be repeated in multiple case studies as seen with the ten additional examples in Table 3 .[18]

Beyond the validation of the ontology design and conceptualisation, the use case scenarios are useful in expanding our understanding of how Onassis Ontology works in plain cases in contrast to more complex cases. Essentially, the difference between the plain and complex cases is that the clause data required for processing are significantly larger in terms of size (which may increase the relative level of quantity and quality complexity). For so long as the Onassis Ontology is able to process a large amount of data, complex case studies can be processed too.

Discussion

The discussion concentrates on analysing six issues. They are the database findings (in "Database Findings"), the ontology engineering implications (in "Ontology Engineering Implications"), the AI applications (in "Artificial Intelligence Applications"), the contract automation implications (in "Contract Automation Applications"), the insurance implications (in "Insurance Applications") and the contract risk standardisation (in "Contract Risk Standardisation").

Database Findings

The findings are that contract automation is a significant category of LegalTech solutions. Moreover, communications and risk data automations are each on its own important categories of contract automation solutions. Yet, the combined contract automation based on communication and risk data is so far not discussed in the literature. Without their connection we miss the opportunity to improve risk analysis based on quality communications data.

The finding that 5.6% of the total LegalTech solutions focus on contract automation proves that the innovation in intelligent contracting is substantial. Yet, the finding that zero percent of those contract automation solutions focus on the automation of communication *and* risk data, proves how far we still are from adopting mature intelligent contracting solutions.

Perhaps this observation is the essential missing link all along our research path, perhaps not; time will tell. Still, we acknowledge and recognise here that both automating the communication *and* risk processes are vital components for self-executing contracts.

A general comment on the inspected data is that most of the technologies investigated how to address the *legal experts* as users and *not the contractors* as users. This means that most technology innovation in LegalTech focusses on the legal experts as the end users of legal innovation. One explanation is that LegalTech often requires legal knowledge and expertise, which is to be found with the legal experts and not with the contractors. When regarding the contract communication automation solutions we have to admit that none of the them generates the contracts as an output automatically. As for the contract risk automation solutions, even though legal risk is part of every contracting process, such solutions are not widely available. Most risk-related solutions identified relate to compliance automation.

Ontology Engineering Implications

Looking back at the pricing example of our research introduction, the ontology can help contractors specify an optimum pricing in balance with a normative specification of the qualitative expectation for both parties. As we presented, this can be done by finding a middle ground between two sets of answers that the contractors have provided. On top of that, it is possible to incorporate additionally more data from other contractors and yield an average that represents the optimum expectations for both parties in the agreement. In this way, the risk between two parties for a dispute is minimised, as well as the potential consequential costs for both of them.

In summary, in this section we show the *value of the ontology* as a practical tool (in "Ontology as a Practical Tool"), the *conceptualisation of the semantics* (in "Conceptualisation of Semantics"), the *two levels of innovation* (in "Two Levels of Innovation"), the *relevance* of ontology engineering (in "The Relevance of Ontology Engineering") and the *final validation* (in "The Validation").

Ontology as a Practical Tool

The ontology is introduced to legal research, representing how a mature legal expert handles contracts. Such a careful handling has not taken place so far, at least not according to the literature on the ontological representation level. Given that legal studies and practice involve the use of language as input and output, it is not common for the current research to represent legal reasoning procedures in a computationally friendly manner. In that respect, the ontology engineering is a new approach as it provides a *practical tool* for the legal world rather than providing just another theory. By practical tool we refer to a tool that can be used for the automation of a process that would otherwise require repetitive human labour. Such automation is innovative because it addresses two basic repetitive labour domains for legal experts today, namely the communications and risk data management, which today are often managed implicitly.

[18] For efficiency purposes the variable is shown as the answer, even though in certain cases the variable is not necessarily the whole answer. Moreover the Scope, Section and Parties remain the same.

With the rise of LegalTech, the production of appropriate tools in academic research is becoming more common. Our research further illustrates the need for such practical tools. Furthermore, the ontology adds value for both smart contracts and iContracts, as it shows the extent to which certain processes can be programmed and those which cannot. In particular, for blockchain-based smart contracts, an added value is that it can be embedded in the backbone of a decentralised system to facilitate the cryptographic exchange of smart contract information, without the need for intermediary verification. It also helps clarify how far away we are from achieving the self-execution aim of iContracts.

Conceptualisation of Semantics

An innovative aspect of our ontology is that it has conceptualised a new domain, which benefits the world of ontology at a vocabulary level. In extension, this innovation is relevant for semantics, as it clarifies how the semantics of contract automation work at this level of conceptualisation. The ontology has been designed to minimise the appearance of unnecessary concepts. It represents-according to the workflow, the ontology, and the case study application-all relevant concepts and their properties for the generation of a contract based on *contract communication* and *risk data*. The Ontology shows how it is conceptually possible to generate a contract that includes risk management controls based on specific communication-based information extracted.

The end-value of the ontology should be examined by an experimental view on future research, in particular from two perspectives. The first perspective needs to ensure that the activities *involving the legal expert* are designed in a trustworthy manner, meaning that the legal rules and risks involved in a contract are taken into consideration in responsible manner. The second perspective needs to ensure that the activities *involving the contractors* are designed in a trustworthy manner. Only then it is possible to validate the design of the ontology and justify its application in real-life experimental use cases. Our parallel research already validates the two perspectives to a certain extent [30, 31, 54]. We plan to test the efficiency of the ontology against further use cases in the future, which entails its expansion. Moreover, we aim to create a richer taxonomy (by richer we refer to an ontology with larger amount of concepts and relations to comply with the requirements of more complex case studies) with external ontologies after testing the present ontology with other use cases.

Two Levels of Innovation

By making the ontology publicly available we achieve *two* levels of innovation. First, we stay connected with state-of-the-art developments *as the feedback* based on iterations *increases* as opposed to if this ontology would stay behind closed doors. It also becomes more accessible to the public and its development becomes more academically trustworthy.

Second, the *open source model* does not go along with the monopolistic power that some corporations follow when dealing with innovation. Here the adage is certainly valid: monopolies slow down general innovation and societal progress.

The Relevance of Ontology Engineering

The present research is relevant for three reasons. First, the Onassis Ontology provides a framework for managing risks in contract automation in a *trustworthy manner* as well as *preventing contract disputes*. Second, it paves the way for showing how it is possible to standardise contract drafting languages in order for contracting to become more interoperable. Third, it maximises the value contractors extract from contract automation via the application of AI in a more trustworthy manner than the available technologies, due to making explicit an analysis process which is usually implicit.

The Validation

Our results validate that Onassis Ontology fits for plain cases and clauses. The larger the complexity of a case, the larger the amount of clause data that should be processed. With the validation of the ontology we show its potential value and how it can influence contract automation significantly [54]. Legal experts may no longer be involved physically in contracting processes between two or more parties; their interaction may only occur by using a computer. The contractors are able to: (1) obtain a contract more rapidly and (2) trust its content, without having to enter into extensive discussions in the contract formation phase. It is apparent that the Onassis Ontology significantly simplifies the contracting process. Moreover, due to structuring the ontology based on scientific reasoning and the collection of data, advanced analytics can be applied to extract nuanced information in the contracting process, which eventually prove invaluable for preventing disputes resulting from contracts or meta-data [55].

Artificial Intelligence Applications

The value of the ontology for AI is that it *reduces complexity* and *helps clarify* how advanced ML algorithms can be applied. Moreover, it helps to make the algorithmic results *explainable* and *interpretable* [56].[19] Still, in some cases involving data, such as risk data, an almost unavoidable bias is present and should be addressed. A first remedy might be, before applying any algorithm potential biases should be addressed.

At this point, we mention three relevant AI applications that can be implemented with the ontology engineering technique to achieve a higher degree of automation. The reason why we refer to such AI Applications at this point and to such degree is to provide some initial guidance to follow up research as for the potential ways AI algorithms can be leveraged within the Onassis Ontology. Of course, further investigation is necessary to validate the implementaiton of these and additional AI applications on the Ontology.

A) *Text extraction* can be used to automatically extract the **answers** of the contracts from the questions.
B) *Data extraction* can also be used to automatically extract **risks** for a specific contract.
C) *Text generation* can be used to draft a **contract based on extracted risk data**.

Based upon this three risk-diminishing practices, we can see how ML algorithms can also be applied for classification or prediction. For example, we can *classify data for communication purposes* or how we can *predict the risk of a contract*.

As a result of AI applications, certain analytic benefits may arise as well. In general, an ontology can be used to analyse qualitative theory quantitatively. Moreover, following the same pricing example, we can quantify what is more precise or faster: (a) the traditional contracting process, (b) the programmed smart contract process, or (c) the hybrid intelligent contract process?

Also, nuanced data analytics can provide insights that can be used in order to quickly prove which party is at fault in case of a payment dispute regarding quality. Likewise, we can make better decisions on *when* and *how* to use an ML algorithm for classification or prediction purposes.

In addition, there are also benefits at the level of logical reasoning. We can define a set of rules for recurring entities, so as to (1) examine which classes are the best candidates for co-dependency influencing such relations and (2) apply advanced reasoning to uncover hidden data or further relations. The value of this inferential reasoning is that it can support automated reasoning for automated dispute resolution.

[19] https://www.marktechpost.com/2023/03/11/understanding-explainable-ai-and-interpretable-ai/.

Contract Automation Applications

In the same way that smart contracts began with cryptocurrencies and are now applied in more use cases, the iContract literature should gradually expand into more directions as well. In the present research, we have made a first attempt in showing how iContracts may apply in a freelance project. Moreover, we expect that further scientific examination of the iContracts concept should help specify their general value for LegalTech, as well as for AI. A valuable addition that iContracts bring in contract automation is that they point in the direction of *monitoring during the contract execution stage*. In fact, it is vital that for a higher degree of automation to be achieved, project data should be connected with iContracts. By expanding the scope of contract automation during the execution phase, the management of risks will also improve. For example, in energy or financial industries, advanced risk frameworks are already applied and there is a higher degree of effectiveness in risk management relative to what can be controlled.

By connecting iContracts with realistic project execution, this higher effectiveness in contract execution can also be achieved. Here PPL, and in particular legal visualisation, can overcome the lack of sufficient frameworks. Adding on that, the ontology can help by standardising data classes while a more harmonised approach can be taken for the classification and collection of such data. To that end, more research in the field of how iContracts can benefit from IoT devices, as well as how they connect more generally with project management, would be useful.

Insurance Applications

One of the main benefits for iContracts automation for complex projects relates with insurance premiums. In general, by having better risk predictions, insurances can be provided with *more accuracy* and the premiums calculated *more realistically*. This has a direct effect on the operational expenses of organisations. It also has an effect on the policy choices they make (e.g., by being able to better measure contract risk for achieving policy-making). Indeed, in such projects where there are often complex contractor and sub-contractor relationships, the main contract ends up bearing the major risks; by improving iContracts from the perspective of risk management, there are added benefits for the main contractors.

Insurance premiums are usually flexible in larger projects. In smaller projects they are calculated on the basis of general market standards. By calculating in greater detail the specific level of risk for each agreement, the opportunity rises to assign a tailored insurance premium for smaller projects. For instance, if an accident occurs (also known as "occurrence" in insurance) a claim is initiated. With iContracts it is possible (1) to locate the case of the occurrence faster and with a higher accuracy and (2) to determine the decision on a claim with a higher degree of validity.

Contract Risk Standardisation

Last but not least, risk frameworks are *not standardised in legal practice* as they are, for example, in the energy or finance sectors. That is potentially because the underlying legal practice is (already) sufficiently complex. iContracts can help as they can create the space for *responsible* risk management based on validated frameworks by abstracting and reducing repetitive workloads. Currently the proactiveness of contracts is not measured, so iContracts can also help with risk *quantification*. Our parallel research [30] shows with the support of relevant literature how to move towards this direction.

Research Benefits

Designing an ontology to automate contracts based on communications and risk data is beneficial for (1) *technological*, (2) *trustworthiness*, and (3) *economic* reasons. First and foremost, the technology will increase the effectivity and scalability of contracting relative to state-of-the-art solutions; whereas more contracts can be executed at a fraction of the time. Second, the focus on risk analysis helps increase stakeholder trustworthiness provided that legal risk is managed explicitly, leading to higher awareness and control over legal consequences to contractors as well as reducing the potential (human) mistakes by legal experts. Third, it is economically sensible given that more contracts can be executed at a fraction of the price, since less resources will be necessary for contracting on a procedural and human capital levels.

Conclusion

The Subsections below provide the answer to the RQ (in "Answer to the RQ") and give further research suggestions (in "Further Research").

Answer to the RQ

The article progresses the state-of-the-art in ontology engineering for the legal domain by providing an approach for contract automation based on communications and risk data. The RQ of this research is:

RQ: *to what extent is it possible to develop an ontology that automates contracts with communications and risk data*

The answer to the RQ is that defining an ontology that *automates* contracts based on communications and risk data to a level comparable with the best experts in the world will be possible for adequate automation as shown with the Onassis Ontology. However, it remains essential to (1) test extensively its validity, (2) to conduct further research to ensure that an adequate level of *trustworthiness* will be reached for any action the legal expert and contractors will be involved in, and (3) to keep a sharp eye on future developments that may have unexpected challenges with the automatically driven programs. This should happen beyond any research we have already conducted.

The finding that *none* of contract automation solutions in the Legalcomplex database simultaneously focusses on both automating contract communications **and** risk data demonstrate a significant omission in the existing solutions. This omission justifies our scientific attention to the subject. The aims for the current research were (1) to bridge the gap between smart contracts and iContracts and (2) to clarify our stance. All in all, we may conclude that automating a contract based on communications and risk processes, which have long been neglected, can prove to be the *missing link* in realising both self-executing contracts and iContracts.

Our research on the market adoption of iContracts with the utilisation of communication and risk data is *in its early stages*. Still, our experiment with the Onassis Ontology as well as our parallel research on EBTO and the prototype of our ontology shows that there is sufficient potential to optimize the contracting process.

Further Research

The key question at this point is: how to best move forward from here? Based on the aforementioned discussion, the *communications and risk processes* need to be examined more deeply. Therefore, our follow-up research will focus (1) on the legal expert-based inputs and outputs, (2) on the contractor-based inputs and outputs and (3) on the experimental validity of the KG in more complex case studies. Through this in-depth examination and validation, our ontology can be improved upon and expanded.

A step in conducting further research is aiming to understand the correlation of the ontology classes. By selecting certain correlated classes, we may conduct specific quantitative or qualitative experiments to further our research (see for example ontology research on class correlation: [57]).

To conclude, this article began by giving you a *promise* but by the end of it, we hope to have provided a *real gift*: a systematic way to study contract automation and to achieve the goal of iContracts.

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Data availability The data supporting all tables are directly available by reading this article.

Declarations

Conflict of Interest Georgios owns stock in Venterp.

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

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