Preventing disputes: preventive logic, law & technology

Stathis, G.

Chapter 3

Contract Risk Management

The Chapter addresses RQ2, which reads:

> **RQ2:** *To what extent is it possible to translate the Bow-Tie Method into a visualisation of an ontology for contract risk management without altering the bow-tie structure?*

Standing at the start of our research we propose a new *visual analysis method* of hazardous events to be used in contract risk management. Our aim is to create an extension of the Onassis Ontology to *manage*, *analyse* and *visualise* risk data. The extension of the Onassis Ontology will be used for the development of *trustworthy* iContracts. The idea is that the implemented extension allows for the creation of *explicit* data out of *implicit* contractual information and legal processes. The creation happens by performing cross-referencing analyses with other collections of data. The ontological model that results from our study will additionally help to disambiguate the information stored in the Bow-Tie Method structure. To achieve this, we use the following methodology. (1) We visualise the Bow-Tie Method in an ontology. (2) We investigate the presence of taxonomic ambiguities or even errors in its structure. (3) The results present an enriched version of bow-tie conceptualisation of information, in which entities and relationships are translated into openly-accessible and *ready-to-use* ontological terms, whereas risk analysis becomes visible.

The current chapter corresponds to the following publication:

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3.1 iContracts and Risk Data

iContracts aim to support end users with drafting legal documents via the adoption of automation techniques [Mason, 2017]. Thus far, *iContracts* have not been designed to include the *editing* and *visualisation* of risk data [Stathis et al., 2023d]. Yet, risk data, which are defined below (see Definition 3.1 [1]), play a fundamental role in contract risk management.

*Definition 3.1 – **Risk Data***

Risk Data denotes a defined set of information (data), in any format (but increasingly in digital form), that is used by an organisation for diverse Risk Management and other business processes.

The main challenges with Risk Data in iContracts is: *how do we structure the risk data and how do we get a grip over them?*

Nowadays, legal experts act as legal risk managers who examine legal risk data in order to safeguard the interests and rights of the parties that are involved in a given agreement. Cross-investigation between different sources (such as databases) may help users quickly identify the risks associated with the (legal) documents that they are drafting [Haapio and Siedel, 2013]. In analytical processes, both visualisation methods and ontologies (i.e., formal representations of knowledge) can be truly beneficial to carry out a conjoint analysis of diverse data sets [Hogan, 2020] and [Dudáš et al., 2018]. They can be used for at least three problem areas: (1) to *reach a deeper understanding* of the risks involved in a certain arrangement, (2) to *design an efficient strategy* to visualise the manifestation of a potential hazardous event, and (3) to *develop remedies* and repair mechanisms prohibiting disastrous events.

Although these three methods may lead towards remarkable analytical results, their potential is at this moment still to be completely unlocked for two reasons. First, there is no unambiguous visual structure that is unanimously used to observe and analyse the core entities of the risk management framework and their relationships [de Ruijter and Guldenmund, 2016]. Second, there is no ready-to-use and openly accessible ontology that has been developed to disambiguate any given reference system [Agrawal, 2016].

Therefore, to offer a contribution to the resolution of the problem areas mentioned in (1), (2), and (3), our research will focus on the creation of an *ontological model* to analyse, visualise, and manage risk data in *iContracts*. In so doing, it will particularly examine and discuss the limitations of the bow-tie visualisation medium to manage and visualise risk data.

[1] https://www.openriskmanual.org/wiki/Risk_Data

3.1.1 Bow-Tie Diagram

In 1979, a diagram to analyse hazards was first presented at the Imperial Chemistry Industry course of the University of Queensland in Australia [2]. The shape of the figure used at the presentation took the form of a bow tie, from which it consequently took the name. Today, the bow-tie diagram [3] is de facto standard used to perform visual legal risk management analysis (see Figure 3.1 which will be discussed in Subsection 3.2.1). The figure mirrors the conceptualisation framed in ISO 31000:2018 that has been developed by the International Standardization Organization (ISO) [4] [Kishchuk et al., 2018, de Ruijter and Guldenmund, 2016]. ISO 31000:2018 is a guideline that provides a generic framework for the management of all types of risks, including legal risks [ISO, 2018]. The bow-tie visualisation system makes the relationships between the entities designated by ISO discernible and explicit. Although attempts have been made, the theoretical structure of both ISO 31000:2018 and the Bow-Tie Method have not yet been translated into the expressivity of a ready-to-use ontology [Agrawal, 2016]. Let us have a closer look, why this is the case?

Ontologies enable, *inter alia*, model-based meta-analysis [Becker and Aloe, 2019] (meta-analysis refers to the systematic review of research studies, data and knowledge sources related to an ontology). Meta-analysis can be applied to conduct different risk management analyses either to infer new pieces of information or to draft more solid clauses related to risks in contracts. Ontologies are designed to reduce ambiguity between the entities and clarify the relationships between them [Nirenburg and Raskin, 2001].

According to Ruijter and Guldenmund, there is no consensus on the specific definition of the bow-tie visualisation system except its shape and core concepts [de Ruijter and Guldenmund, 2016]. The main diverging points may originate from the ambiguity of the relationships among the entities in the bow-tie structure. This may result in subjectivity, in terms of both *interpretation* and *intended use*.

[2] https://www.wolterskluwer.com/en/solutions/enablon/bowtie/expert-insights/barrier-based-risk-management-knowledge-base/the-historie-of-bowtie

[3] https://www.wolterskluwer.com/en/solutions/enablon/bowtie/expert-insights/barrier-based-risk-management-knowledge-base/the-bowtie-method

[4] ISO is an independent, non-governmental international organisation with a membership of 164 national standard bodies, founded in 1947 and headquartered in Geneva, Switzerland. In this concern cf. https://www.iso.org/about-us.html

3.1.2 Ontology Visualisation

To clarify the bow-tie and ISO 31000:2018 structures, and to derive new insights into the method and the standard, we will therefore design an ontology mirroring the relationships portrayed in the bow-tie diagram. We will then test it against taxonomic constraints that lead to the creation phases of ontologies (checking how well it adheres to e.g. rules, guidelines or limitations). The resulting ontological vocabulary will be linked to the Onassis ontology that we previously designed and described in Chapter 2 [Stathis et al., 2023d] [5].

Designing a set of machine-understandable vocabulary terms allowing to monitor and manage risk in relation to the violation of specific contractual clauses means taking the expressiveness of *iContracts* a step further. Moreover, having openly accessible ontological vocabularies for risk management data further allows smaller entities with limited economic availability to implement monitoring strategies to reduce the occurrence of hazardous events in relation to contractual clauses. By including risk data and risk management strategies, *iContracts* will not only serve the purpose of formally describing an agreement between different parties, but will also even monitor and prevent the occurrence of hazardous events connected to legal risk. Thus, the avoidance of dispute consequences becomes possible.

3.1.3 Research Question 2

The contribution of the research with respect to RQ2 is therefore two-folded. First, it explores the limitations of the bow-tie visualisation method to perform large scale analysis with regards to risk analysis. This will simultaneously bring new insights into its structure. Second, it proposes a set of openly-accessible vocabulary terms to structure and manage legal risk data. As a result of the aforementioned information we state RQ2 below.

> **RQ2:** *To what extent is it possible to translate the Bow-Tie Method into a visualisation of an ontology for contract risk management without altering the bow-tie structure?*

3.1.4 Research Contribution

The Chapter showcases to what extent it is possible to structure the process and the relevant data for automating contract risk management. So far, the literature mentions the usefulness of the Bow-Tie Method for contract risk management. However, the explicit application of the Bow-Tie Method for its computational

[5] The Onassis Ontologyis accessible at https://github.com/onassisontology/onassisontology

processing in the legal domain has not been made explicitly. Hence, our contribution is to be seen as a practical tool that may inform the designers and engineers of computational models, in particular for risk management in the legal domain, and within that domain for contracting.

The use of ontology engineering helps delineate a specific vocabulary that is understandable and interpretable by machines. The visualisation contributes to human understanding and interpretation. Risk experts can also leverage visualisations to implement the legal risk ISO frameworks. For legal experts interested in risk management and dispute prevention it may be an additional help. Even though we position the research under iContracts, the relevance is for all processes that relate with risk data, including, for example, compliance automation.

3.1.5 Research Structure

We structure the Chapter as follows. As discussed above, Section 3.1 provides the introduction to contract risk management. In Section 3.2, the relevant literature is reviewed. Section 3.3 presents the methodology of our research. Section 3.4 states the results and Section 3.5 discusses those results. Finally, Section 3.6 answers the RQ2 and provides our chapter conclusion.

3.2 Relevant Literature

In this section, the state-of-the-art literature is presented. Subsection 3.2.1 mentions relevant sources on contract risk management. Subsection 3.2.2 presents the latest research regarding ontologies developed to structure risk management data.

3.2.1 Sources of Contract Risk Management

The most exhaustive academic source on contract risk management, which is targetted to practitioners, is Haapio and Siedel's book, *Guide to Contract Risk* [Haapio and Siedel, 2013]. Contract risk can be identified in multiple domains. Ideally a database of contract risks should exist to help legal experts identify instances more quickly and efficiently, as happens in other domains [Patterson and Neailey, 2002, Kuwahara et al., 2015].

In the industrial, energy and environmental areas, visualisation methods, such as the bow-tie, are often used to manage risk and prevent the occurrence of hazardous events within domain-specific projects (a telling source originates from Chemistry as seen in [Center for Chemical Process Safety, 2018]). A Bow-Tie Method (see Figure 3.1) is used for visualising risk in a holistic manner by taking into consideration proactive and reactive risk measures [6]. A bow-tie diagram helps to visualise and control contract risk [Haapio and Siedel, 2013]. It has been used in a variety of risk analysis environments and for various risk management purposes [Khakzad et al., 2012].The usefulness of the Bow-Tie Method stems from its ability to visualise the complexity of legal risk [Dauer, 2006]. Figure 3.1 shows a representation of the Bow-Tie Method.

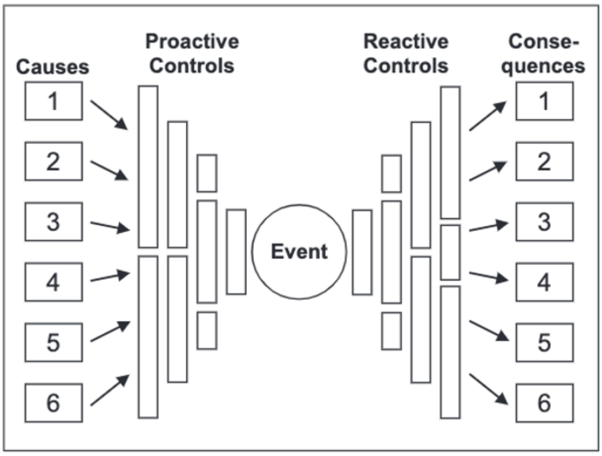

Figure 3.1: Bow-Tie Method

The Bow-Tie Method mirrors, at the level of the entities, the conceptualisation framed in the ISO 31000:2018 standard [ISO, 2018]. The standard defines eight concepts that are considered to be essential to manage risk.

- Risk
- Risk Management
- Stakeholder
- Risk Source
- Event
- Consequence
- Likelihood
- Control

[6] https://www.wolterskluwer.com/en/solutions/enablon/bowtie/expert-insights/barrier-based-risk-management-knowledge-base/the-bowtie-method

In multiple industries, including the legal technology industry, it is also possible to develop a *risk matrix* or risk register after visualising the risk management process via the bow-tie diagram [Leva et al., 2017]. In the risk matrix/register, one may also add six additional concepts [Lu et al., 2015]:

- Impact[7]
- Priority
- Response
- Responsible
- Deadline
- Validation

Consequently, *risk ranking* becomes possible for a quite clear visualisation of the immediate risks requiring risk management as well as a contract risk response. In relation to contract risk, the response mostly relates to two additional aspects, viz. *contract drafting* and *procedural aspects* [Espenschied, 2010, Fox, 2008].

3.2.2 Ontologies for Contract Risk Management

Although ontologies may be a powerful instrument to perform contract risk management analysis, they are not very common in the field. This is mostly due to the scientific immaturity of the domain. However, efforts have been made to build a framework enabling both the *analysis of the risk assessment* process, and the *codification of the relationships* (i.e., roles and responsibilities) between the various entities involved in a risk management organisation. Examples are provided by the Description of a Model Ontology (DOAM) [8], and the Risk Function Ontology (RFO), respectively [9]. Although DOAM and RFO offer great contributions to the field, they still lack the needed level of expressiveness that will allow users to structure risk management data at a processing level while the intelligent agents of the iContract are framing information within the scope of the Bow-Tie Method. A more targeted attempt on the conceptualisation of the ISO standards is evident in the cyber-security domain [Oliveira et al., 2022, Sánchez-Zas et al., 2023] and AI regulation space [Golpayegani et al., 2022]. In particular for cyber-security ontologies, such as the Reference Ontology for Security Engineering (ROSE) [Oliveira et al., 2022], they place significant emphasis on events,

[7] For clarification, we note that impact serves the role of showing the probabilities that a consequence may occur.

[8] https://www.openriskmanual.org/ns/doam/index-en.html

[9] https://www.openriskmanual.org/ns/rfo/index-en.html

event types and anomalies as seen in the context of risk. Surprisingly, some of the work focusses exclusively on the conceptualisation of prevention [Baratella et al., 2022]. Still, regarding ontologies aiming to mirror the implementation phases of the bow-tie process, we could not find any vocabularies designed for this specific purpose either on the Linked Open Vocabularies (LOV) catalogue [10] or the Open Risk Management (ORM) Foundation website [11]. Ultimately, we did observe an attempt to develop an ontology for the ISO risk management standards which did not result in a ready-to-use model [Agrawal, 2016] and another attempt which did result to usable model (see RiskOnto on GitHub [12]).

3.3 Research Methodology

Our research methodology aims to identify (1) the possible presence of violations of taxonomic constraints (this is important for testing the consistency and robustness of the ontology against potential structural omissions in the concepts and relations of the ontology), and (2) ambiguous constructs in the conceptualisation of the bow-tie visualisation medium (this is important for examining the semantic clarity of the ontology in relation to the domain it refers to - abstract use of language is not helpful due to increased risk of misinterpretation). Moreover, it aims to validate the reliability of the ontology. In Subsection 3.3.1, we translate the bow-tie design into the expressiveness of an ontology by mirroring the bow-tie relationships and entities. In Subsection 3.3.2 we introduce three types of taxonomic errors. Subsequently, in Subsection 3.4.1, we check the presence of taxonomic ambiguities and errors by following (a) the best practices for the development of ontologies and (b) the detection of fallacies in the models. Then in Subsection 3.4.2 we arrive at the results aimed at the Enriched Bow-Tie Ontology. The outcomes of our analysis are presented under results in Section 3.4.

3.3.1 Ontology Visualisation of the Bow-Tie Method

As presented in Section 3.2 and discussed by [de Ruijter and Guldenmund, 2016], the entities pictured (see Figure 3.1) in the Bow-Tie Method relate to one another as follows. The explanation of the steps 1 to 5 are given below. Then we describe the steps 6 to 8 (see Figure 3.2).

[10] https://lov.linkeddata.es/dataset/lov
[11] https://www.openriskmanagement.com/
[12] https://github.com/coolharsh55/riskonto

1. The *causes* of a hazardous event are protected by proactive controls.

2. The *proactive controls* relate to a hazardous event. They result from the causes and are designed based on the nature of the hazardous event.

3. The *hazardous event* is contained by both the *proactive* and *reactive* controls (barriers).

4. The *reactive controls* are conceptualised based upon the nature of the hazardous event to marginalise its consequences. They relate to both a hazardous event and its consequences.

5. The *consequences* are limited by the reactive controls to which they relate.

6. The *risk* which is not represented in the bow-tie diagram can be intuitively associated with the hazardous event itself. This is mostly based upon the guidelines of the ISO 31000:2018 standard.

7. The *stakeholder*, who is not represented in the bow-tie diagram, can be intuitively associated with the hazardous event. This can be derived from the guidelines of the ISO 31000:2018 standard.

8. The *likelihood*, which is not represented in the bow-tie diagram, measures the probability of the occurrence of a hazardous event as described in the guidelines of the ISO 31000:2018 standard.

When translating the entities and relationships of the bow-tie diagram into the expressiveness of an ontology, we arrive at the structure presented in Figure 3.2.

The *validity*, *efficiency*, and *consistency* of the ontological structure presented in Figure 3.2 can be tested against the presence of taxonomic errors.

3.3.2 Three Types of Taxonomic Errors

According to literature [Gomez-Perez, 1995, Gómez-Pérez et al., 2004, Gómez-Pérez, 2001, Fahad et al., 2008, Fahad and Qadir, 2008], there are three main types of taxonomic errors. They are *inconsistency* errors, *incompleteness* errors, and *redundancy* errors.

Inconsistency errors may be caused by circulatory errors (i.e., entities defined as sub-entities or super-entities of itself), partition errors (i.e., instances belonging to various disjointed classes), or semantic inconsistency errors (i.e., when ontologists define concepts as sub-classes of concepts to which they do not pertain).

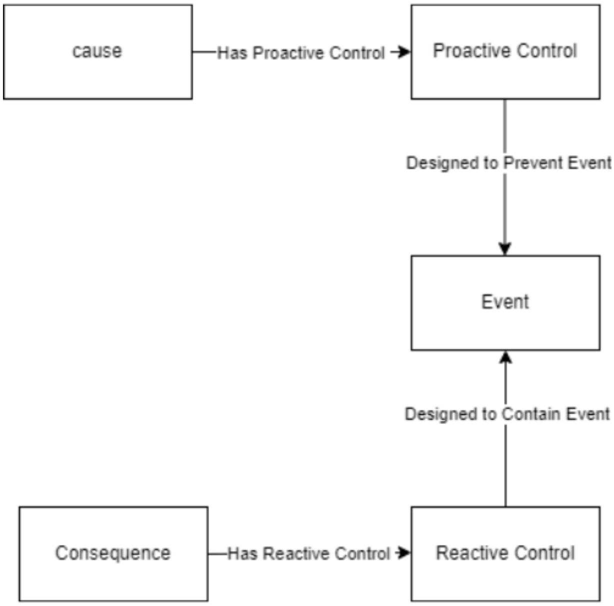

Figure 3.2: Bow-Tie Centred Ontology

Incompleteness errors may be of three types, namely, (a) incomplete concept errors (they occur when concepts and relationships of the domain are overlooked and not defined in the structure), (b) incomplete axiom errors (they occur when ontologists omit important axioms and information about the classification of a concept), or (c) sufficient knowledge emission errors (they take place when concepts have only necessary descriptions). Incompleteness errors lead to ambiguity and create a lack of proper reasoning mechanisms.

Redundancy errors happen when pieces of information are inferred more than once from the relationships, classes, and instances of the ontology. They can be: redundancies of sub-class/sub-property errors (they may occur when classes or relationships directly or indirectly have more than one sub-class/sub-property relationship); identical formal definition of classes, properties and instances (i.e., proprieties, classes and instances have different names but provide the same formal definition); or redundancy of disjoint relationships (i.e., concepts explicitly defined as disjointed from other concepts more than once).

In order to derive more insights into the Bow-Tie Method and to test the actual taxonomic validity of the bow-tie centred ontology displayed in Figure 3.2, we tested this ontology against the three types of taxonomic errors discussed above. Our results are presented in Section 3.4.

3.4 Research Results

The section presents the results of our research. The results concern the taxonomic errors in the ontology visualisation of (3.4.1) the bow-tie centred ontology and (3.4.2) the enriched bow-tie ontology.

3.4.1 Taxonomic Errors in the Bow-Tie Centred Ontology

The bow-tie centred ontology (Figure 3.2) presented in Section 3.3 mirrors the exact relationships that are framed by the Bow-Tie Method (Figure 3.1) and a few of the concepts of ISO 31000:2018. As discussed in Section 3.3, the *risk*, the *stakeholder*, and the *measure of likelihood* are not addressed by the bow-tie analytical medium. This resulted in the absence of their concepts from the bow-tie centred ontology. The same can be remarked for the measure of likelihood regarding the occurrence of a hazardous event. The lack of these concepts in the diagram and ontology causes several *knowledge emission errors*. Other incompleteness errors that can be found in the bow-tie centred ontology are *incomplete concept errors*.

In the bow-tie diagram (Figure 3.1), only four relationships are described.

1. The causes and proactive controls,
2. the proactive controls and hazardous event,
3. the hazardous event and reactive controls, and
4. the reactive controls and consequences.

However, these four relationships may lead to ambiguity when performing a cross-referencing analysis with a bow-tie centred ontology and/or diagram. Below we discuss two types of ambiguities.

First, the problems identified in the bow-tie centred ontology originate from the *ambiguity* in the relationships between the entities that are framed by the bow-tie visualisation method.

Second, the two taxonomic errors that we individualised, namely *incomplete concept errors* and *sufficient knowledge emission errors*, do not only concern the relationships between causes, proactive controls, and the hazardous event (i.e., the left side of the bow-tie visualisation method) but even the relationships between the hazardous event, reactive controls, and consequences.

Ultimately, no other type of taxonomic errors have been detected in the bow-tie centred ontology.

3.4.2 The Enriched Bow-Tie Ontology

To resolve the taxonomic errors identified in the bow-tie centred ontology (Figure 3.2), we shifted the relationships in the previously presented ontological model from a *cause-sequential order* of connected entities to a *node-centred order*. In the resulting version of the model, the cause, proactive control, reactive control, and consequence are directly connected to the hazardous event. We identify the hazardous event as the most core component. The hazardous event is here conceived as a physical occurrence possibly associated with a point in time. Furthermore, we consider the *cause*, *reactive control*, *proactive control*, and *consequence* as human-derived observations rather than actual physical situations. This makes it so that every time a hazardous event is identified by a legal expert, a unique identifier shall be created for it, regardless of whether its nature is similar or identical to another event. Unlike the case of the hazardous event, the identifiers of identical causes, reactive controls, proactive controls, and consequences can be reused across use cases.

As previously discussed, the bow-tie visualisation method (Figure 3.1) does not include the following three relationships: (1) the relationship between the hazardous event and the risk, (2) the relationship between the hazardous event and stakeholders, and (3) the relationship between the measured probability of a hazardous event and the hazardous event itself.

The new vocabulary terms of the Onassis ontology demonstrate the relationships presented above as follows. The risk is connected to a hazardous event that is, in turn, linked to a measure of probability. Based on the structure of the risk matrix analysis, we connected the stakeholder directly to the impact of a hazardous event. The probability and impact measures are then associated with a level of risk which is subsequently linked to the risk itself. Both the probability and the impact measure are connected to a source. Figure 3.3 displays the new vocabulary terms that we added to the Onassis ontology (leading to the Enriched Bow-Tie Ontology) in its simplified visualisation. In Figure 3.4 we present its scientific visualisation.

To conclude, the rationale behind the new classes and properties of the Onassis Ontology can be described as follows.

1. The Risk *involves* a Hazardous Event and a Risk Measure.
2. The Hazardous Event *has* a Cause, Proactive Control, Reactive Control, Impact, and Consequence.
3. The Cause *is contained by* the Proactive Control.
4. The Consequence *is contained by* the Reactive Control.
5. The Impact of a Hazardous Event *affects* an Agent.

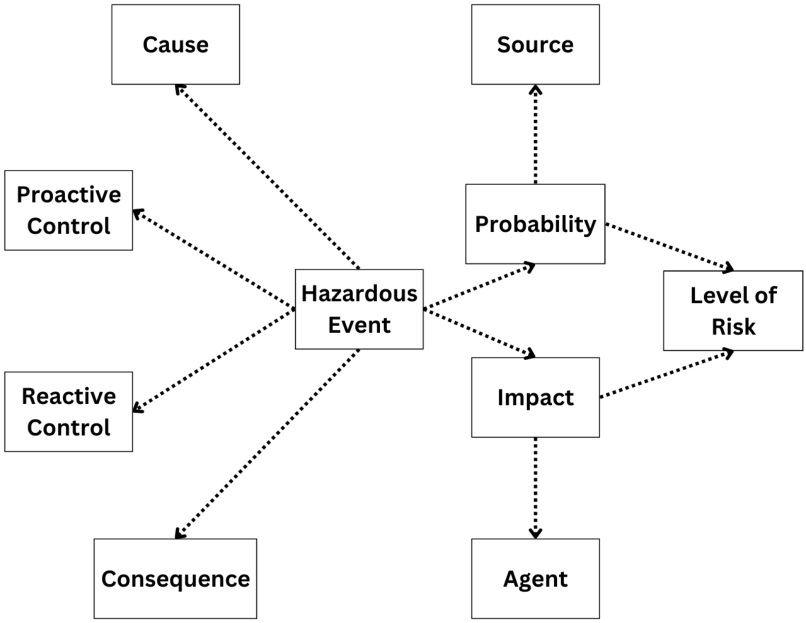

Figure 3.3: Enriched Bow-Tie Ontology (Simplified)

6. The Hazardous Event *has* a Probability number.

7. The numbers of the Probability and Impact *result* in a Level of Risk.

8. They are *based on* a Source.

9. The Level of Risk *is* ultimately *involved* in a Risk.

To design the new vocabulary terms for Onassis, we used the Resource Description Framework Schema (RDF/S) and Ontology Web Language (OWL).

The logical consistency of the new vocabulary terms has been tested via an ontology reasoner [13]. The coherency of the model with domain knowledge has been validated by running competency questions on sample data which are accessible via Github [14]. The competency questions regard questions such as ”what is the cause” or ”what is the proactive control”, based on the sample data that are visible on the visualisation provided on GitHub, with each question referring to a concept identified on the EBTO.

[13]Specifically by launching reasoner Hermit 1.4.3.456 on sample data in the Protégé editor (see https://mvnrepository.com/artifact/net.sourceforge.owlapi/org.semanticweb.hermit/1.4.3.456)
[14]https://github.com/onassisontology/onassisontology/blob/main/img/Visualisation.png

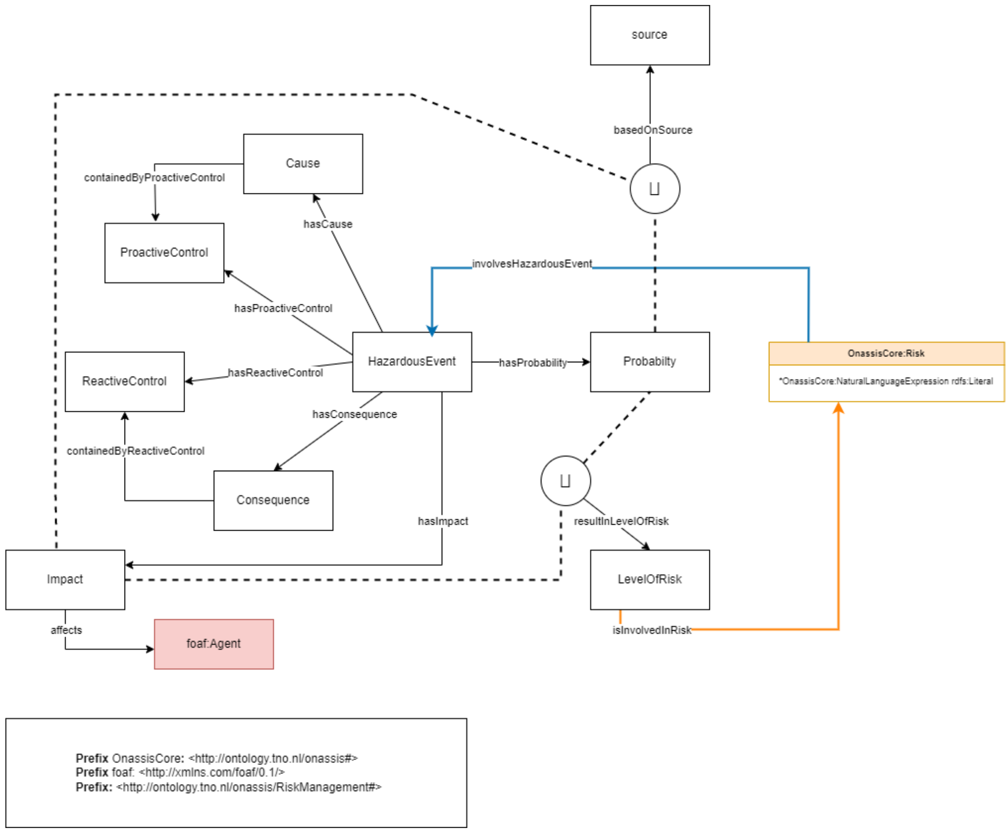

Figure 3.4: Enriched Bow-Tie Ontology (Scientific)

3.5 Discussion

The discussion concentrates on examining three research consequences for (3.5.1) ontology visualisation, (3.5.2) contract risk management, (3.5.3) data interoperability, and (3.5.4) iContracts.

3.5.1 Ontology Visualisation

Visualisation analysis allows users to examine and compare a large amount of data [Dudáš et al., 2018]. However, if some details are omitted, they can mislead the analysts by leading them to erroneous analytical results. Then it is possible to observe, from the application of ontological taxonomic constraints on the bow-tie structure, the bow-tie visualisation system suffers from some limitations. In a large-scale comparative analysis, the Bow-Tie Method can possibly lead to *data ambiguity* due to the lack of direct relationships between the core component (i.e., hazardous event) and related entities (i.e., cause, consequence, proactive and reactive controls). Furthermore, we recognised that the system does not represent all concepts theorised in the ISO 31000:2018 standard to manage risk. To overcome the above mentioned problems, we created an ontological model that embraces the full expressiveness of the ISO 31000:2018 standard. Ultimately, we ensured the presence of connections between all entities described by ISO in order to prevent the occurrence of ambiguity in ontological knowledge representations.

The new vocabulary terms that we designed, did extend the Onassis core ontology that we previously created. Yet, they do not aim to replace the conceptualisation of the entities of the Bow-Tie Method. They focus on enriching it while providing a ready-to-use ontological model to manage and describe risk data in *iContracts*. When visualised, with all improvements, the Enriched Bow-Tie model will take the shape of a more complex and amorphous Figure 3.3 rather than the classical *papillon* (see Figure 3.1). This is due to the granularity of the ontolology.

3.5.2 Contract Risk Management Impact

The presence of openly-accessible vocabulary terms to describe that risk data is vital for (1) an improved analysis and (2) the adequate management of contract risk. In this way we have constructed a legal expert who is able to (1) better define contract risk, (2) improve contract clauses, and (3) better understand the level of risk per contract. An additional benefit is that the open-source nature of our work can help companies exchange risk data to refine the measuring of impact probabilities for improved risk ranking.

Moreover, the research clarifies how is possible to structure risk data for the purposes of contract risk management. It is a novel research scope applying specifically the Bow-Tie Method on legal domain case studies. The result is an examination of how risk data can be structured under the practice of risk management for law, focussed on contracting for the purposes of dispute prevention.

3.5.3 Data Interoperability

One the one hand, we identified some limitations in the conceptualisation of the risk management visualisation framework provided by the Bow-Tie Method. On the other hand, we equally deem that such a structure can play a fundamental role in cross-referencing analysis with different collections of data to manage risk if the potential cause of ambiguity is resolved. Based on this consideration, we decided to enrich the bow-tie by (1) adding more relationships in its structure and (2) translating the *enriched bow-tie* into the expressiveness of an ontology. This will allow interoperability between data sets while hopefully leading to the attainment of new insights for the evaluation of risk in contractual clauses.

The use of ontology engineering facilitates data interoperability with the granular expression of concepts and their relations. For now, provided the analysis of risk is implicit, there is no explicit consensus on the type of definitions, relations and data included in contract risk management. Our ontology clarifies on a granular level such relations with the purpose of assisting multiple parties involved in contract risk management with clarifying related concepts.

Here lies also the importance of developing understandable and interpretable vocabulary terms both for machines and humans. Initially, humans should be able to define the relevant data in their organisational processes. Later on, they should be able to ask machines to process such data. Eventually, humans should again be able to interpret machine outcomes. Having clear vocabulary with granular definitions helps with precisely this purpose.

3.5.4 Intelligent Contracts Impact

Our research shows that risk data are able to contribute to making *iContracts* more responsible. The responsibility mainly derives from the fact that risk data can be explicitly examined thanks to the creation of a set of interlinked metadata (i.e., the extension of the Onassis Ontology that we designed) that can be used to structure information regarding risk. The new vocabulary terms can, in fact, make the usually implicit information about contract risk evident and clear, while fostering the possibility to compare different data collections coming from diverse data sets. As a result, risk management can improve due to the large scale comparative analysis of diverse data records [Haapio and Siedel, 2013].

3.6 Chapter Conclusions

The present Section provides the answer to RQ2 (see 3.6.1), a research novelty (the Enriched Bow-Tie Ontology, see 3.6.2), and a further research suggestion on validating the integration (see 3.6.3).

3.6.1 Answer to RQ2

We repeat RQ2.

> **RQ2:** *To what extent is it possible to translate the Bow-Tie Method into a visualisation of an ontology for contract risk management without altering the bow-tie structure?*

Regarding RQ2, we provide our answer in three statements.

(1) The conversion process of the bow-tie conceptualisation into ontological terms highlighted the presence of missing relationships between entities in the Bow-Tie Method as well missing ISO-specified concepts.

(2) To reduce the possibility of introducing ambiguity into the analytical and management processes of risk data, we searched for and found further relationships between entities in the ontology compared to those that are represented in the bow-tie system.

(3) Ultimately, we incorporated the missing ISO-specified concepts that were not present in the Bow-Tie Method, into the visualisation of Figure 3.4.

3.6.2 Novelty

Our investigation resulted in a new version of the bow-tie visualisation medium as well as an openly-accessible ontological model to manage and describe risk data (the Enriched Bow-Tie Ontology). The research novelty is that we have shown how it is possible to make *explicit* a traditionally implicit process, in such a way that data processing becomes possible. So far, legal experts have not reached consensus on how to *manage* contract risk. Our research shows how it is possible. Moreover, in relation to the Bow-Tie Method, we presented a new theoretical version for it which (1) builds upon the old one, (2) disambiguates some of the bow-tie constructs, and (3) enrich its conceptualisation.

3.6.3 Further Research

In relation to further research, the key question at this point is how to best move forward from here. An essential step in conducting further research is to validate the successful integration of the developed contract risk management ontological framework in iContracts. Chapter 4 will therefore focus on *validating* the integration experimentally.

CRediT Author Statement

Below I would like to give credit to all persons involved.

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