Bookbinding information on the Web: breaking the circle., from pixels to Linked Open Data

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Abstract

Research on historical bookbindings has suffered both for reasons internal to the discipline and external. Internally, the almost exclusive focus on decorated bindings has hindered the development of methodologies to describe any kind of bookbinding, which externally, in turn, has impeded cataloguers from describing these objects—their structures in particular—creating a vicious circle in the production of resources on bookbindings. After having analysed the state of the art of bookbinding resources, we propose that the implementation of semantic web technologies may offer a way to break the bookbinding resource vicious circle.

Keywords: bookbinding, semantic web, catalogues, information silos.

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Running title: Bookbinding information on the web

Bookbinding information on the Web: breaking the circle., from pixels to Linked Open Data

The very essence of the book in codex format—the quintessential book format in Western culture—lays in the technology of its physical structure, which is critical to its function. This technology is so embedded into our society that books are used 'unconsciously' (Frost 1996: 92; Clarkson 1978: 34), to the point that, traditionally, books are not considered as susceptible to archaeological treatment (Adams and Barker 1993: 6). However, books are amongst the most important and numerous human artefacts and their study can progress the knowledge of our civilisation (Adorisio and Federici 1980: 483; Adam and Barker 1993: 7; Foot 1993: 124)

Bookbindings as objects of research

Books, as artefacts, can be studied in a variety of different ways, but looking specifically at their physicality and materiality, one can distinguish two research approaches. A first approach looks at the book as a human artefact, is concerned with the structure and the materials used to construct a binding, and could be seen as mostly focussed on the internal working of the book. A second approach, instead, is focused on externally visible elements, such as the cover and overall appearance of the book, i.e. the material employed in covering the book, its decoration, and the book's furniture (bosses, fastenings, etc.). The former employs methodologies that are typically associated with archaeological studies, whilst the latter can be associated with art history research.

Academic interest in the history of bookbinding can be traced back to the 19th century. Bookbinding historians appear to have first been stimulated by the aesthetic aspects of book covers, and the decoration of bookbindings was the subject of a first wave of scholarly studies, such as those of Arnett (1837), Weale (1898), Schwenke (1898), and others who followed.[1] This trend continued to such an extent that, up to the

[1] For an overview of the development of the history of bookbinding as a discipline see Szirmai 1999: ix-xi and Foot 1993.

1970s, the *history of bookbinding* was essentially a *history of bookbinding decoration* (Clarkson 1978: 34; Foot 1993: 113), and Szirmai (1999: ix), at the end of the 20th century, estimated that no more than 10 per cent of an otherwise sizeable literature on bookbindings was concerned with bookbinding structures and techniques. To date, it is still the case that the great majority of bookbinding research and resources are devoted mostly to fine bindings and bookbinding decoration, and not to the *archaeology of the book*[2] as a whole.[3] Whilst research on decorating tools can indeed yield important information about a binding, sometimes even leading to the identification of a specific bindery and binder,[4] the study of decorating tools should not be the sole remit of research on bookbindings. Decorated bindings, in fact, constitute a small minority of those preserved in libraries and collections across the globe (Pickwoad 2012a: 84), and if all that one can scholarly describe is the decoration, then it becomes impossible to advance a comprehensive history of the bound book in codex format that is able to embrace any item as a source of information. It would be the equivalent of only being able to describe illuminated manuscripts without having any means to consider also the plain parts of the text (let alone manuscripts without any illumination).

A noticeable result of the primacy of decoration as object of research in the history of bookbinding is the fact that, traditionally, plain, undecorated bindings are neglected because researchers have difficulties in distinguishing significant differences between items without the help of tooled decorations (Pickwoad 2014: 233-234). Almost a century ago, Goldschmidt (1928: 112) lamented that, despite the great amount of secondary scientific literature published on bookbindings, 'far fewer people [could] give a reasoned opinion

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[2] For discussions on the remits of research, and definitions of the field of the *archaeology of the book* see Gruijs 1972; Clarkson 1978: 34, 49; Federici 1980: 337-339, 352-353; Federici 1981; Federici 2000: 5-6.

[3] Noteworthy is for example the (somewhat misleadingly named) *Einbanddatenbank* (EDDB –Bookbinding database) funded by the Deutsche Forschungsgemeinschaft: a database of rubbings of bookbinding decoration impressions taken from 15th- and 16th-century bindings belonging to a series of important libraries across Germany.

[4] Perusal of the secondary literature on bookbinding (decoration) brings to light many examples of historical and provenance information locked within binding decoration tools. A number of bindings at the Herzog August Bibliothek in Wolfenbüttel, Germany, have been identified as having been produced in Erfurt by the binder Ulrich Frenckel. These bindings present a typical array of stamps, such as tools representing a barking dog, a pierced heart, a deer, and, most importantly, Frenckel's name stamp. See, for example, the descriptions of *A: 1.6 Juridica 2°* in Petersen 1975: 59-61; Foot 1984: 94, 111; Adler 2010: 87, 104; and Schneider 2012: 93, 95-96, 98. Similarly, a detailed examination of the 1195 tool bindings of the manuscript collection of the Library of the Monastery of St Catherine on Mount Sinai yielded information regarding specific binderies and binders (Sarris 2010).

on the country of origin and the approximate date of an old bookbinding, than a piece of pottery or furniture.' As we have seen, this is still the case, and this is mainly due to the fact that, still today, literature on the structures and materials of bindings represents only a scarce minority of the research that is published (Pickwoad 2012a: 84).

In addition to this, research on bookbindings lacks a shared description methodology and terminology (Szirmai 1999: xi-xii; Pickwoad 2005: 193-194; Velios *in press*). In turn, this has led to a situation in which the literature that is published is very specialised and specific to particular collections or groups of bindings; however, the absence of a common methodological approach and vocabulary means that we are still lacking a comprehensive overview of the evolution of bookbinding structures that could also be used by the uninformed reader as an entry point into the field.[5]

This lack of knowledge, awareness, and data on bookbinding structures has created, and established, a vicious circle (see Figure1) that has been hindering progress in the field (Pollard 1976: 50-51; Pickwoad 2012a: 84-86):

- cataloguers are unable to describe bookbindings because of the lack of published literature (especially general manuals on how to describe bookbindings, and general histories of the evolution of bookbinding structures);
- catalogues ignore binding information (aside from decoration), or provide general information that is of little use to the binding historian;
- in turn, bookbinding historians lack adequate access to bookbindings that may be of interest—possibly with the exception of being granted access to the stacks—since these are not described in the catalogues, and, as we will see, even online records of bookbindings are of little help in identifying possible remits of research and material sources of information;

[5] There are very few exceptions to this trend, e.g. Pollard 1956; Middleton 1996; Szirmai 1999; Bennett 2004; Pearson 2005.

- and finally, general manuals on a comprehensive history of bookbinding cannot be written because of the lack of primary sources readily available for consultation and research, which leads back to cataloguers not being able to include appropriate binding information in their descriptions. And the circle continues.

This vicious circle needs to be broken for scholars to be able to finally advance the state of the art of the archaeology of the book. A possible way to achieve this may lay in the implementation of semantic web technologies in bookbinding descriptions.

[Figure 1 here]

Figure 1. The vicious circle of bookbinding resource production

The significance of bookbindings

A working binding is composed of several structures and structural elements that come together in the complete object. The number of the basic structures and components that make a binding are actually limited. A useful way of looking at the codex as an object and to read the information that is held into its structural make-up is to survey the steps that a binder would have followed to produce it (Sharpe 2000: 103-104). One would then start with the way in which the gatherings are formed (information that is customarily recorded within collation formulas), then look at the endleaf and sewing structures, consider how the edges of the bookblock have been (or not been) treated (i.e. cut, left uncut, decorated, etc.), examine the boards (if present), the shape of the spine and the type of spine lining (if present), look into how the endbands have been worked (if present), and finally examine the cover style and the furniture (i.e. metal pieces added to the cover, such as bosses, corner pieces, and fastenings – if present). The number of these basic structures and components is limited (ten in total), but the number of possible permutations within each structure and different binding seems almost countless.

The reasons behind such a variety is threefold (Pickwoad 1995: 209-210). Firstly, bookbinding processes evolved and were adjusted over time.[6] Secondly, in different geographic locations different solutions and styles were developed for similar binding problems, often employing different materials: critically, some structures were made only in a limited number of countries, some are typical of individual countries or can even be shown as restricted to certain smaller geographical areas (Pickwoad 2014: 234). Lastly, bookbinding was a trade, and was taught as such, so that individual workshops or craftsmen might have developed their own special techniques, which were passed on, possibly as trade secrets, from master to apprentice, restricting their presence to the work of single workshops.

Traditional descriptions of bindings are insufficient to distinguish between undecorated, similar-looking, bindings, and, in order to appreciate the differences one needs to look closely at how these were made, structure by structure (Pickwoad 2014: 233). Following an essentially art historical approach, bindings are traditionally described by general categories and typologies, e.g. limp parchment, Byzantine bindings, *alla greca* bindings, Dutch bindings, etc.

Bindings categories can be of some help, but one should be aware of the shortcomings of general typologies. For instance, Pickwoad (2014: 234) aptly explains how the commonly used description 'limp parchment binding' can actually refer to at least seven distinct structures—stitched, tacketed, longstitch, external support, laced-case, cased, drawn-on—, each of which can in turn be subdivided into a wide range of subcategories. An even vaguer, but unfortunately common description often found in catalogues is 'bound in parchment', which can literally refer to dozens of different structures (Pickwoad 2005: 193).

As demonstrated by the pioneering work of Professor Nicholas Pickwoad, with sufficient knowledge, and detailed information about the structures and materials of original historical bindings, it is possible to glimpse distinct date/location/workshop patterns; this leads to distinguish clearly between different groups

[6] As pointed out by Pickwoad (1995: 209-210), bookbinding development is particularly linked to the increased flow of material to be bound after the introduction of the printing press, when binders had to adapt their techniques to increase output (and lower costs).

of bindings, reducing even the greatest mass of plain bindings into smaller chunks of discrete categories (Pickwoad 1995: 210; Pickwoad 2005: 192; Pickwoad 2014: 234). In turn, such detailed knowledge and identification of patterns in bookbinding survey data can foster our understanding of the history of the book, its trade, and its readership.

As a practical example, we can take into consideration the order in which the gatherings are sewn into a bookblock. One could either start sewing from the first gathering, positioning it on the sewing frame, first page down, with the head of the gathering to the right, thus exposing the number of the last page (if present) or the catchword, allowing the binder to check the correctness of the gathering sequence, before placing the second on top to continue the sewing; otherwise, one could do the opposite and begin sewing from the last gathering, last page down, with the head to the left, and carry on sewing up to the first gathering. Traditionally, most European countries follow the first-to-last gathering pattern (cf. Cockerell 1953: 103); however, binders in German-speaking areas, historically (and the tradition continues even today), start from the latter gathering and finish with the first. Both sequences have their advantages and disadvantages, but, in reality, once one is accustomed with one practice, these are essentially equivalent; an analysis of the sewing sequence[7] alone, however, can sometimes place a sewing structure in a geographical area rather than another.

In recent times, interest in what bindings (and not just their decoration) can tell about the history of books has increased,[8] but the lack of relevant information in the literature, and the misperception that only decorative patterns are worthy of scholarly research inevitably curbs what scholars can do, and what questions can be asked.

Bookbindings on the Web

[7] The sewing sequence can be analysed by looking at the direction of the sewing at the kettlestitch, if exposed, or through other clues, such as the presence of a sewing thread joining knot at the fist gathering, evidence that the sewing did not start there, for example, since one would rarely need to join another thread at the very first gathering to be sewn.
[8] See for example the thread on 'German bookbinding 18th and 19th centuries' that appeared in the Society for the History of Authorship, Reading & Publishing mailing list (SHARP-L) last June (Fraser 2016).

To assert that no information on bookbindings is ever recorded, and that no such information can be gathered from online resources would be deceitful. What is true, however, is that this evidence is scarce and difficult to peruse.

Digitization programs on book materials, for example, increasingly encompass all pages (and not just text-bearing pages), thus including endleaves and blank leaves, as well as left and right covers,[9] pastedowns (or the inner face of boards), and, often, also spine and edges.[10] From these photographs, theoretically, one could collect some (undeniably limited) information on the bindings and their structures without having access to the original object; this could help in the selection of materials and the planning of a visit to a library, lessening, somewhat, the need to meander around the stacks looking for useful materials. There is, however, a significant problem with this potential *modus operandi*: the images are not machine searchable, for no useful metadata is generally recorded, aside from what view of the object is depicted in each image (e.g. cover, spine, fore-edge, etc.). One would then need to either browse all digitized materials, opening each item's photograph set, one at the time, looking for potentially interesting bindings, or, possibly, to write a script to collect from online collections the relevant binding views, and then look in the newly generated image collection for potential bindings of interest.

Computer vision algorithms could, theoretically, be implemented to recognise specific visual patterns in the photographs as clues of specific binding structures, searching for board lacing patterns under pastedowns (or on the inner side of exposed boards), for example, but, to my knowledge, such a methodology has not yet been attempted; it is, however, doubtful that this would lead to a sufficient number of fruitful results to make the methodology worthwhile, since, even to an expert eye, such visual patterns, even on high-resolution images—aside from the case of exposed boards—can be elusive and imprecise.

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[9] We follow here the nomenclature developed by Pickwoad at the Ligatus Research Centre of the University of the Arts London (Cf. Pickwoad and Gullick 2004: 2; Ligatus 2015b and 2015c).

[10] See, for example, the digital collections of the Vatican Library (2016) or e-codices Virtual Manuscript Library of Switzerland (e-codices 2016).

There are also a number of web resources specifically dedicated to bookbindings.[11] These, following the library cataloguing tradition of focussing chiefly (if not exclusively) on the exterior appearance of bindings[12]—result of the vicious circle described above—, deal predominantly with decorated bookbindings.[13] What these resources lack the most is a comprehensive and efficacious description metadata schema that could allow to find and research relevant binding information. The description schema that is used by the great majority of projects (especially for manuscripts) is the Text Encoding Initiative (TEI 2016c), which, in its manuscript description guidelines[14] prescribe the use of the elements **bindingDesc** and **binding** within the physical description module to include at least a summary description of the binding of manuscripts (but this should not be restricted to manuscript material alone). Not surprisingly, the element **binding**, aside free text within paragraphs, allows—once again, focussing on the exterior of the object—more specific information on the material and decoration (**decoNote**) of the binding to be recorded. The Bibliothèque nationale de France (BnF), conscious of these limits of the TEI guidelines, has conducted, in collaboration with the École nationale des chartes (ENC), a research project to enrich the TEI schema to allow a more detailed description of bookbindings. The model produced,[15] valid for manuscripts as well as printed books, considers bindings as its main object of description, taking into account the features of both structure and decoration (Bibliothèque nationale de France 2016a; 2016b). The new schema has been used

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[11] See, for example, British Library 2016.

[12] Nevertheless, there have been noteworthy exceptions to this tendency. Sheppard (2008) mentions that the medievalist Montague Rhode James (1862-1936), as he worked as manuscript cataloguer in Cambridge Libraries, was amongst the first scholars to make systematic records of binding structures in his catalogue entries, rather than concentrating only on decorated bookbindings. In more recent times, see the cataloguing efforts of Federici *et al.* 1988, Federici and Houlis 1988, Federici and Pascalicchio 1993, and Sheppard 2008, which have, however, often remained isolated ventures, not followed or considered by streamline library cataloguers.

[13] A broad list of online bookbinding resources can be found in Bibliothèque nationale de France (2016a). See also, in particular, 'Legature On-Line' (Biblioteca Riccardiana Firenze, 2016), which have a peculiar three-dimensional interface to interact with the images of the bindings; 'Folger Bindings Image Collection' (Folger Shakespeare Library, 2016), remarkable because not focussed only on fine bindings, and because it employs metadata to describe (at least minimally) the structure of the books; and 'Einbanddatenbank' (EDDB) (Deutschen Forschungsgemeinschaft 2013), a very useful database of decoration tools and impressions. For an overview of the content and a general classification of these on-line resources, see Campagnolo (*in press*).

[14] Text Encoding Iniziative P5 (v. 3.0.0.): guidelines for electronic text encoding and interchange, Chapter 10 Manuscripts Description (TEI 2016b).

[15] The revised TEI schema can be downloaded at: http://bibnum.bnf.fr/reliure_20120912/index.html and http://bibnum.bnf.fr/schema/not_20120912/not_20120912.zip (both accessed 22 August 2016).

for the binding descriptions in the library's database of bookbindings (Bibliothèque nationale de France 2015). It is remarkable that the BnF's TEI-based schema has incorporated a description of the structure of the binding through the addition of a new **structure** element to the schema. The content of the new element, however, is loosely defined through the TEI **macro.specialPara**, which essentially gives it the same structure as a paragraph, containing a series of phrase-level and inter-level elements (TEI 2016a). Binding structures are therefore described in a free-text format, without prescribing the internal arrangement or the kind of the information pieces to be included. Typical content found in the database for this element includes the board material, a brief account of the sewing structure, a description of the endleaves, spine, edge treatment, endbands, furniture, and other structural elements; however, these are not systematically described or included, essentially lacking an appropriate modelling of the item to be described. A controlled vocabulary—however not of sufficient granularity—is included in a glossary of technical terms, and, on the webpage, the relevant definition appears when the cursor hovers over a term used in a description. In addition to following the TEI standard, the project has subsequently been constructed in compliance with semantic web standards (W3C 2014b), a novelty in bookbinding resources. The binding descriptions are in fact mapped against an ontology built specifically for this purpose by the BnF,[16] each description is downloadable as a single Resource Description Framework (RDF) file (W3C 2014a), and each binding is given its own Uniform Resource Identifier (URI) (Berners-Lee *et al.* 1998).

The main problem with these resources is their tendency to focus on the exterior of the bindings, both in regard with the selection of the material for their content (most of these in fact cover specifically only fine bindings), and in regard with the descriptive metadata that is included. Some have attempted to cover also, at least partially, the structure of the objects, but never in a systematic manner.

[16] The RDF ontology specification can be downloaded at: http://data.bnf.fr/ontology/bnf-onto/ (accessed 22 August 2016).

Bookbinding descriptions

As pointed out above, and also lamented by Szirmai (1999: xi-xii) and Pickwoad (2005: 192-194), the lack of formal training in describing bookbindings and of a common methodology/terminology has stalled the progress of the research in the field. The Ligatus Research Centre of the University of the Arts London (Ligatus 2016a), under the leadership of Professor Nicholas Pickwoad, has been working towards the establishment of working methodologies and vocabularies that could be used by researchers worldwide to gain, a piece at the time, a comprehensive history of bookbinding. The road to found this gargantuan venture is a tortuous and difficult one, hindered, as predictable, by time and financial concerns. One way to carry out binding research efficiently, and in a manageable manner, would be to integrate it with other work and operations in progress within memory institutions. For example, Ligatus, between 2001 and 2007, led a preservation programme in the Library of the Monastery of Saint Catherine on Mount Sinai (Ligatus 2016b; Pickwoad 2002; Pickwoad 2004a; Pickwoad 2005: 194; Pickwoad 2011; Velios and Pickwoad 2005a and 2005b.) to condition survey the 3,307 bound manuscripts and about 1,000 early printed books. The collection was treated as if it were an archaeological site, recording a description of the structure and material of the bindings, alongside their condition: information necessary for any subsequent conservation treatment. What became clear, though, was that the information thus gathered in the form of text within the database, drawings, and photographs was sufficiently structured and granular to form the basis of a research project focussed on bookbindings alone (Pickwoad 2005: 194).

The Saint Catherine's project developed in two phases. In the first, the manuscript collection was described utilizing paper forms, onto which information was manually recorded, and which were subsequently scanned to acquire the information and log it within a relational database (Pickwoad 2004a; Velios and Pickwoad 2005a and 2005b). In a second phase, dedicated to the description of early printed books, the paper forms were substituted with electronic forms based on an underlining eXtensible Markup Language (XML) schema (Bray *et al.* 2006) developed by Ligatus (Ligatus 2007), so that the recorded information could be input directly into an XML database. The experience accrued during this project

allowed the researchers at Ligatus to develop and perfect an efficacious description methodology[17] capable of recording information on the structure and materials of the bindings with sufficient granularity, and to develop a first hard core vocabulary precise enough to be objectively useful.

The problem of the lack of an efficacious and internationally employed bookbinding description vocabulary shared amongst scholars worldwide was the focus of a series of other projects at Ligatus, recognizing it as a major obstacle to the development of the field. At first, working in parallel with the paper-based manuscript binding survey at Saint Catherine, Ligatus worked towards a 'Bookbinding Glossary' aimed at compiling a definitive bilingual glossary to describe Byzantine/Greek bookbindings, bringing together the existing (partial and conflicting) terminologies, and the new terms required by the St. Catherine's library survey (Ligatus 2004). Eventually, Ligatus realized that the scope of such a glossary had to be expanded to become as comprehensive as possible, to allow the description of any handmade bookbinding: this lead to the development of the 'Language of Bindings' thesaurus, with a new data structure based on semantic web technologies, published in June 2015 (Ligatus 2015a). The core concepts were selected through a series of *thesaurus development sprints* (Velios *et al.* 2014: 2) in London with a large international development team of bookbinding experts, and organized according to the SKOS standard (W3C 2004). Significantly, the thesaurus prescribes internationally agreed-upon concepts, and not terms (or concepts labels), meaning that one could use their preferred terminology (and in their preferred language), as long as each termed used can be mapped to one and only one concept in the thesaurus. The thesaurus is organized hierarchically and in accordance with the CIDOC Conceptual Reference Model (CIDOC-CRM 2016). Each concept is given a preferred label for each language (and sometimes also alternative labels), a scope note that defines it, and, most importantly, a concept specific URI. As it will be seen, the conjunction of the concept thesaurus and the CIDOC-CRM concept relationships can be implemented as powerful and functional bookbinding description tools (Cf. Velios *in press*). A set of guidelines for the description of

[17] The methodology was based also on Pickwoad's decennial experience in the description of bookbinding structures, though on a somewhat more superficial level, due to time constraints during the survey.

bookbindings (Pickwoad *et al.* forthcoming) is also being prepared as companion to the thesaurus, which, utilizing the same hierarchical structure, will guide the reader on how to read and record, structure by structure, historical evidence on bookbindings.

Notwithstanding the somewhat underdeveloped status of bookbinding research, especially if compared with other fields which engage with books, there is a fair amount of information on bookbindings that is produced and published both on paper and on the Web. Evidence from bookbindings is, however, collected mostly on an ad hoc basis by isolated (or small teams of) researchers and professionals, and, furthermore, the raw data habitually remains with the researcher and is then shared, as processed data, in textual (and sometimes pictorial) form, both in print and online (Velios *in press*). Some raw data is published, as noted above, as photographs during digitization ventures, but the lack of metadata makes it usually of little use. Other sources of information that are usually unreachable and completely isolated are conservation reports and databases (Giordano *in press*). It is true that these might not necessarily be useful, correct, or relevant (Pickwoad 2005: 193), but, nonetheless, are sources that are actively generated on a daily basis in conservation laboratories worldwide, and a way to harness these should be welcome and encouraged.

Information silos and Semantic Web technologies

Scholars are left with sets of unrelated (and often digested) data about bookbindings, in various formats, from specialised articles and books, catalogues, online resources, and, sometimes, if access is granted, datasets within databases. Evidence has to be gathered from all these disparate resources, and combined with primary source evidence, a process that requires a lot of time and efforts, and that, given the patchiness of the information so far gathered from bookbindings worldwide, inevitably can lead to speculative assumptions (Velios *in press*). What we need, is a way to enable scholars to promptly correlate evidence (raw data in particular) from all these information silos.

Velios (*in press*) argues that a possible solution to the information silos problem can reside in sharing research data online with the application of semantic web (Berners-Lee 2001) standards and technologies to the description of bookbindings. The first step towards this approach would be the development of a concept thesaurus, and the Language of Binding (LoB) project met this initial requirement. A second step would be to establish a complex relationship network between the concepts to then describe an object; in this manner, one could establish a logical relationship between the concept of a book 'cover' and that of its covering material, e.g. 'parchment', both defined within the LoB thesaurus, and saying for example that the 'cover' of a certain volume 'consists of' 'parchment'. These relationships need to be formalised in such a manner that they can be consistently searched and that they follow the rules of description logic (Baader *et al.* 2008: 135), so that they can be equipped with structured, formal, and well-understood logic-based semantics. In turn, these relationships are also understandable by reasoning machines, which can retrieve, combine, and analyse data within its context, since, data mapped in such manner returns both the *meaning* and the *context* to the things represented in the data.

A way to describe a binding in such a semantically rich manner, and to then publish the data on the Web for it to be searchable and re-usable, is to follow the Resource Description Framework (RDF) guidelines (W3C 2014a), selecting suitable and formally-defined concepts and relationships to describe each resource according to subject-predicate-objects statements, referred to as *triples*, the RDF's building blocks.[18] For these triple to be referenceable and usable within the semantic web, each entity—i.e. the subject or the object—and each relationship need to be identified by a specific URI. Resources described in accordance with these standards create a network, linking actual pieces of information, and not just documents. These information units linked together allow to form a semantically rich layer of functional information that can be merged even from series of unrelated datasets. URIs, in fact, can be used to identify actual real-world resources—e.g.

[18] The description proposition mentioned above, 'cover-consists_of-parchment', is an example of a 'subject-predicate-object' triple.

a person, a location, a manuscript, a part of an object, etc.—so that information on these can be effectively encoded and recorded.

Amongst the semantic frameworks that have been developed,[19] the CIDOC-CRM (CIDOC-CRM 2016.) is a strong candidate, as it was specifically developed for the Cultural Heritage domain for *semantic data harmonization*—i.e. without prescribing conceptual terminologies—, it was built from the bottom up, taking into consideration common practices from an international base of professionals, and it is an ISO standard (ISO 21127:2014). For these reasons, as noted above, the top terms of the LoB were mapped onto CIDOC-CRM concepts, making the implementation of CIDOC relationships for the description of bookbindings seamless and unambiguous.

Towards semantically rich bookbinding descriptions

In February 2016, thanks to a 5-month Digital Humanities Scholarship from the Marbach-Weimar-Wolfenbüttel Research Association, I had the opportunity to run a short pilot project to put these ideas to the test and create a set of semantically rich bookbinding descriptions from the collections of the Herzog August Bibliothek(HAB) in Wolfenbüttel, Germany.

The Herzog August Bibliothek represented an ideal place in which to run such a pilot. The Library's collections are in fact universally known and valued, representative of other library collections, and their bindings have been previously studied by the foremost international experts in bookbinding (Cf. Petersen *et al.* 1975; Foot 1984; Pickwoad 1998; Pickwoad 1999; Szirmai 1999; Pickwoad 2000a; Pickwoad 2000b; Pickwoad 2004b; Adler 2010; Pickwoad 2012a; Pickwoad 2012b; Pickwoad 2012c; Pickwoad 2014). The earlier commitment and interest in bookbinding structures expressed by the Library is also significant, and it shows that a digital resource based on its collections would be put to good use.

[19] Another set of data models are those proposed by Europeana (Europeana 2016).

Perusing the literature (Cf. Petersen *et al.* 1975; Foot 1984; Pickwoad 1998; Pickwoad 1999; Szirmai 1999; Pickwoad 2000a; Pickwoad 2000b; Pickwoad 2004; Adler 2010; Pickwoad 2012a; Pickwoad 2012b; Pickwoad 2014; Schneider 1926; Helwig 1953-1955; Katte 1972; Katte 1978; Corbach 2010; Corbach 2012; Prinsen 2012; Schneider 2012; Corbach 2013), I found information on more than 400 items, between manuscripts and early printed books, ranging from the 13th to the 17th century, and from various geographic areas, whose bindings had been at least partially described: a substantial number, considering the customary lack of information on bookbindings, which confirmed that the HAB was an ideal venue for the research project. Each item could be described in more than one source, with especially interesting bindings appearing in multiple sources. Notably, notwithstanding the abundance of bookbinding evidence recorded—and one could truthfully also say 'locked'—in the literature, very little information on these bindings is actually available in the Library's online catalogues: yet another symptom of the vicious circle described above.

I then analysed the kind of information on the bindings that was recorded in the literature, and assigned it to three general categories, depending on whether it described the structure of the bindings, the decoration, or the furniture; each description could be assigned to more than one category. I also noted the geographic provenance and dating of the binding (as stated in the literature). For those bindings that were particularly decorated, I also checked whether they had been entered into the Einbanddatenbank (EDDB).

Taking into consideration the project's time constraints, I subsequently selected a set of 36 volumes representative of the whole range of information recorded in the literature, and described them according to the Ligatus XML schema developed for the Saint Catherine's project described above. The Ligatus schema, though not perfect, is the only schema that has been developed specifically for the description of bookbinding structures. Having worked extensively with it during my PhD research project (Campagnolo 2015), I was aware of its limitations, but I also knew that it was capable of recording the information that I needed in sufficient details to be usable for the project. Since I did not need to record information on the state of conservation of the books, but only on the binding structure, materials, decoration, and furniture, I modified the description schema to only record the subset of information deemed necessary. On average,

each description took about one hour to be completed, and, at the end of the process, I had a small, but significant, XML dataset of bookbinding descriptions with which to work.

In order to make this information semantically rich, following the methodology touched on above, and described more in detail in Velios (Velios *in press*), I proceeded to map the XML structured information recorded according to the Ligatus schema onto the CIDOC-CRM. The CIDOC-CRM prescribes entities and relationships, and how these can be reasonably and logically related. To learn the workings of the CIDOC data model, I utilized the 3M online open source data mapping system (FORTH-ICS 2016) developed by the Centre for Cultural Informatics of FORTH-ICS (Foundation for Research and Technology, Hellas – Institute of Computer Science),[20] Information Systems Laboratory,[21] and Delving BV.[22] This tool was designed to allow data experts to actively contribute to the generation of Linked Data mapped to the CIDOC Conceptual Reference Model, making superfluous the need to understand XML and other technicalities (ResearchSpace 2016). Registered users can upload a source XML schema or sample XML files from their collections, and utilize the online tool to express that information according to the CIDOC-CRM, as the system guides the user in selecting the appropriate entities and relationships. Because of the high logical level behind the CIDOC-CRM framework, and because much information in existing databases is implied (Velios *in press*), a simple field in a database may have to be mapped to a series of semantic steps within the CRM mapping. Table 1 shows an example of mapping from the Ligatus XML to the CIDOC-CRM.

[Table 1 here]

Table 1. Example of mapping from a sample of a Ligatus XML binding description to the CIDOC-CRM.

The 3M tool, however, is devised in such a way that it separates into a series of successive phases the steps that are necessary to create publishable, semantic-web ready data. To avoid having to map XML files created

[20] https://www.ics.forth.gr (accessed 22 August 2016).
[21] http://isl.stanford.edu (accessed 22 August 2016).
[22] http://www.delving.eu (accessed 22 August 2016).

according to the Ligatus Schema one at the time, and to produce in only one step the RDF, I decided to write my own eXtensible Stylesheet Language Transformation (XLST) script (Clark 1999). When the XSLT script is run on a Ligatus XML file, the information within the file is mapped onto the CIDOC-CRM, typed according to the LoB thesaurus, in the form of a series of RDF files. At the moment of writing, in collaboration with researchers at Ligatus, the XSLT code is being tested for accuracy, and decisions are being made in regard with the URIs that are automatically generated during the transformation.

As mentioned, each binding description is transformed into a series of RDF files. A first file, labelled 'main', describes the object in very general terms—i.e. the binding has endleaves, has endbands, has boards, etc.—but without adding all the other details that are in fact recorded in the original XML descriptions. This 'main' module is followed by a series of RDF files, each describing an element or portion of the volume: its content, textblock, markers, endleaves, sewing, edges, boards, spine, lining, endbands, cover, and furniture. The rationale behind this was twofold: firstly, to be able to quickly see, at the end of the pilot project, which binding structures, on average, required more triples to be described, and secondly, to also be able to count, on average, how many triples would be needed for basic descriptions, i.e. those contained in the 'main' RDF files. Figure 2 shows this data plotted on a chart. Sewing structures were the part of bindings that consistently took larger numbers of triples to be described: with a minimum of 172 triples (for a simpler structure), a maximum of 405, and an average of 289 triples. On average, a basic bookbinding description took 173 triples (with a minimum of 142, and a maximum of 204).

[Figure 2 here]

Figure 2. Chart showing the maximum, minimum, and average number of triples used to describe each section of a binding during the pilot project at the HAB.

At the time of writing, the data generated during the pilot, along with the XSLT code used to generate it, is being checked for consistency. It is hoped that in the coming months, once ready, the data will be

published as an online triple store with SPARQL (W3C SPARQL Working Group 2013) end-points, constituting a first example of semantic-web ready dataset about bookbinding structures.

Conclusions (with an eye towards the future)

As highlighted, research on historical bookbindings has suffered both for reasons internal to the discipline, and external. Internally, the almost exclusive focus on treasure and decorated bindings has, in fact, hindered the development of methodologies to describe and record historical evidence for any kind of bookbinding, which externally, in turn, has impeded cataloguers from describing these objects (and their structures, in particular), thus creating a vicious circle in the production of resources on bookbindings.

Information on bookbindings published in the literature is inevitably fragmented and disjointed, as it is focussed on particular collections, and the 'big picture' on the history of bookbinding is still hazy and uncertain. Researchers, in fact, have had to focus on recording collection-specific bookbinding information, which limits their conclusions—as the data may be non-representative—; often, correspondingly, researchers have had to repeat work done in the past—because access to previous data is impracticable—or accept, without questioning, the unavoidably imperfect conclusions of others: all this hinders the progress of the discipline towards a reliable 'big-picture' model of the history of bookbinding, and obstructs the use of bookbindings as reliable sources of historical evidence (Velios 2014: 5).

It is anticipated that implementation of semantic web technologies—with their unique capability to relate and encode information on real-world resources, and to link evidence accumulated in separate and distinct information silos—may offer a solution to the problem, and a way to break the bookbinding resource vicious circle.

The work being carried out by Ligatus is certainly promising and is creating a fertile substrate onto which many more projects on bookbindings will be able to grow. The guidelines for the description of bookbindings (Pickwoad *et al.* forthcoming) will serve as a first comprehensive manual that will allow the

readers to learn what evidence to look for in the objects and how to record it, thus permitting cataloguers to initiate themselves to the description of bookbindings and begin recording basic but relevant information on bookbindings: a first step towards the breaking of the vicious circle (see Figure 3). The thesaurus, with its concept specific URIs, on the other hand, provides researcher with an applicable model of bookbinding description, and a way to link their datasets, slowly establishing bookbindings as reliable sources of historical evidence.

One resource that has been for the most part ignored by libraries and cataloguers is the expertise of their conservation staff. Conservators across the globe write conservation reports on a daily basis, and, as noted above, these often include information on binding structures (Giordano *in press*). Information recorded on these reports might not be completely relevant or correct (Pickwoad 2005: 193), however, if these records were accessible and the information they contain were to be openly linkable (maybe even through library catalogues), they could prove an invaluable source of raw data on binding structures worldwide.

It is unthinkable that library cataloguers, even thanks to the help of conservators, will be able to instantly start recording bookbinding structures in the detail needed by binding historians. However, even just a limited set of basic, but relevant and accurate data, such as that contained in the 'main' RDF description in the HAB pilot project, would be enough to start building the backbone of more complete and detailed descriptions by part of the scholars; most importantly, this would also make bindings findable through the catalogues.

[Figure 3 here]

Figure 3. A possible bookbinding resource production circle

Whilst the foundation work done by Ligatus will certainly prove invaluable to facilitate these kind of activities, what we need to see in the near future are tools with uncomplicated user interfaces to create and annotate linked open data on bookbindings. Tools of this kind will surely be developed for the general use of

linked open data technologies leading to a Semantic Web 2.0 (i.e. user generated): we need to be thinking about this kind of tools to start building a semantic network of bookbinding related data.

In a similar way to the pilot project run at the HAB, these tools need to allow the description of binding structures in a formalized way that is compatible with the Semantic Web, the mapping onto the CIDOC or other reference model, and the Language of Binding thesaurus concepts. However, the user will not have to necessarily be aware of the technology behind the tools. In turn, the data generated through these tools, that may be of specific interest to the library or the conservation staff, needs also to be easily publishable as linked open data.

A step at a time, linking raw bookbinding data, and providing users with tools for the descriptions of these structures, the vicious circle could finally be broken, comprehensive bookbinding resources could be compiled, also with the assistance of thinking machines to help making sense of larger datasets, and bookbinding structures could establish themselves as additional sources of reliable historical evidence.

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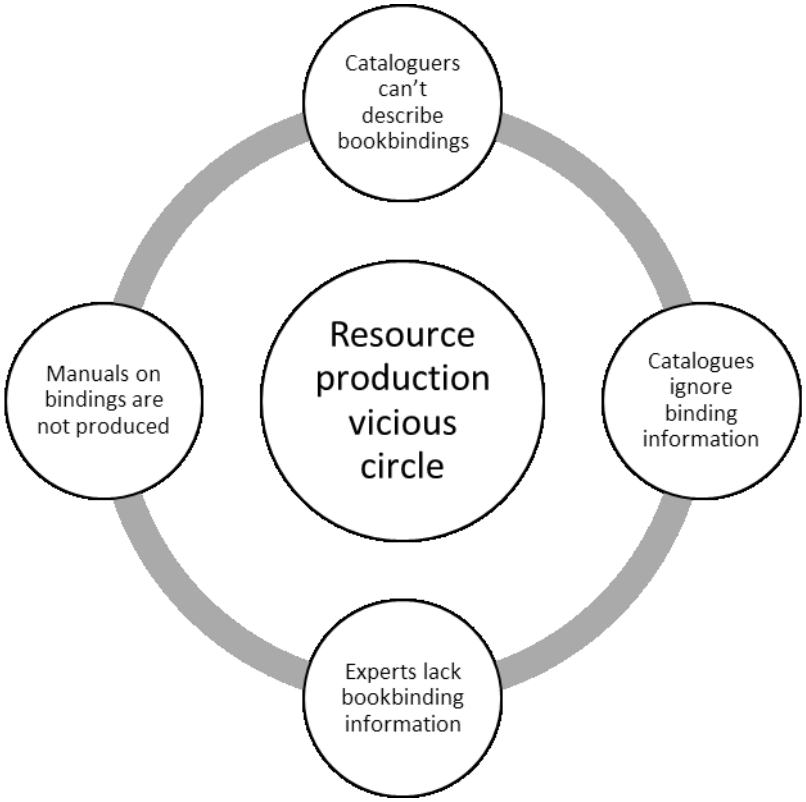

Figure1. The vicious circle of bookbinding resource production

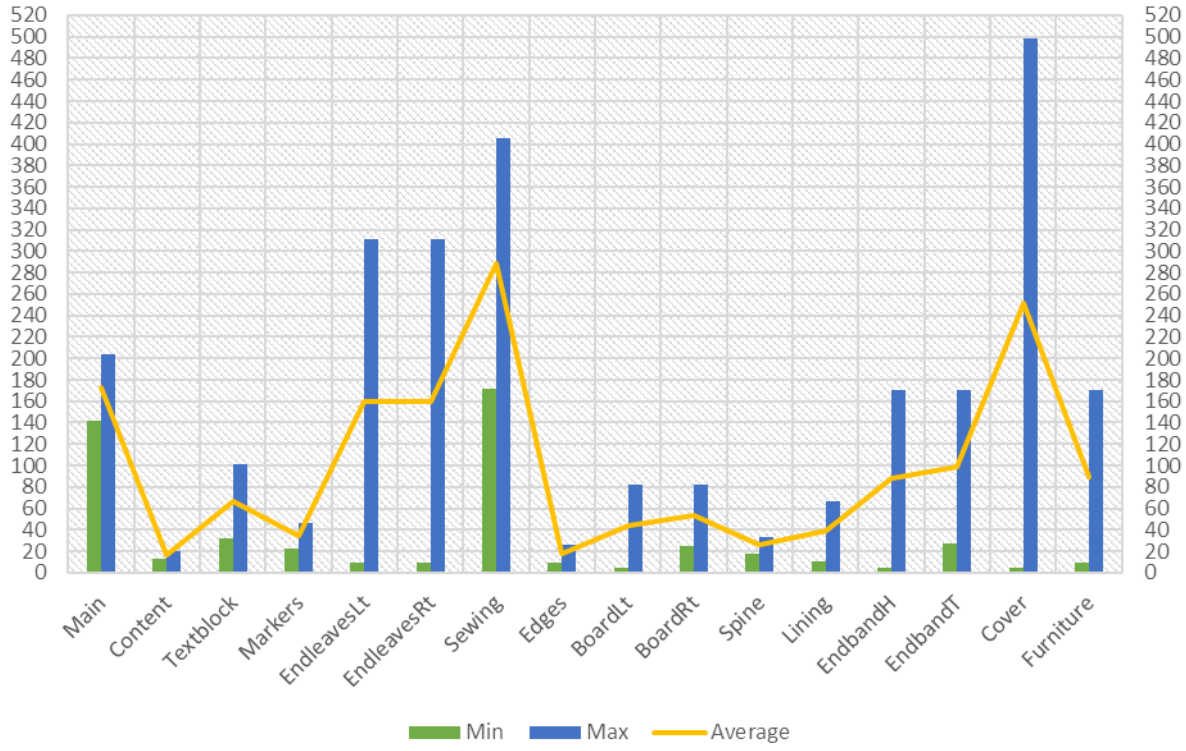

Figure 2. Chart showing the maximum, minimum, and average number of triples used to describe each section of a binding during the pilot project at the HAB.

Ligatus XML	CIDOC-CRM mapping
<book>	crm:E22_Man-Made_Object
	crm:P2_has_type
[...]	crm:E55_Type: codex-form books (LoB: http://w3id.org/lob/concept/4886)
<endleaves>	*crm:P46_is_composed_of*
<left>	crm:E22_Man-Made_Object
<yes>	*crm:P2_has_type*
[...]	crm:E55_Type: endleaves (LoB: http://w3id.org/lob/concept/1317)
</yes>	*crm:P55_has_current_location*
</left>	crm:E53_place
	crm:P2_has_type
	crm:E55_Type: left (LoB: http://w3id.org/lob/concept/2947)
<right>	*crm:P46_is_composed_of*
<yes>	crm:E22_Man-Made_Object
[...]	*crm:P2_has_type*
</yes>	crm:E55_Type: endleaves (LoB: http://w3id.org/lob/concept/1317)
</right>	*crm:P55_has_current_location*
</endleaves>	crm:E53_place
	crm:P2_has_type
[...]	crm:E55_Type: right (LoB: http://w3id.org/lob/concept/3004)
</book>	

Table 1. Example of mapping from a sample of a Ligatus XML binding description to the CIDOC-CRM.

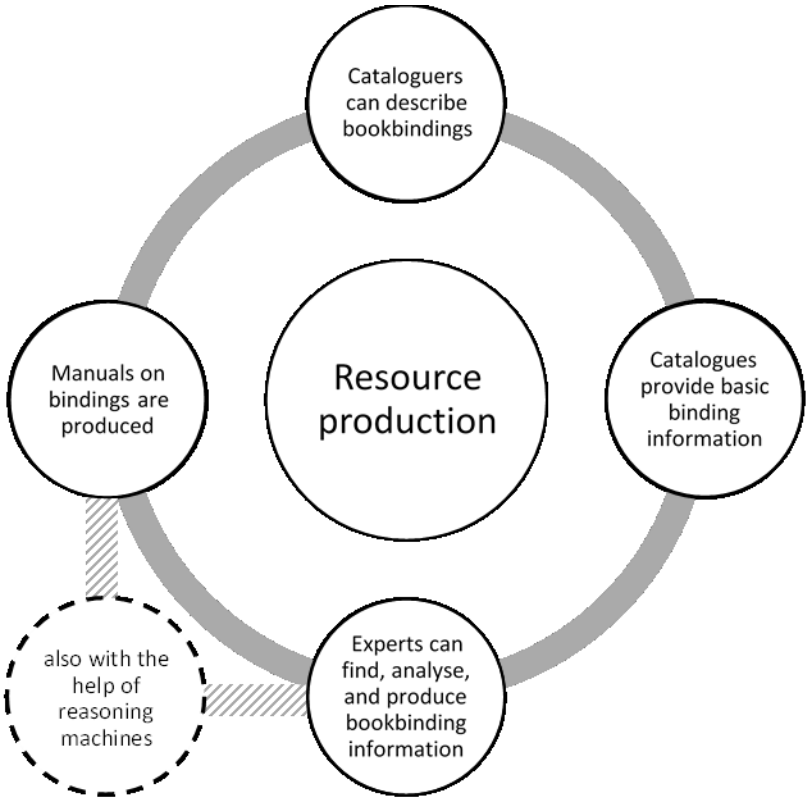

Figure 3. A possible bookbinding resource production circle