The Italian Academic Research System and its Evaluation: a Conceptual Framework Inception

Francesco Bertolotti[1], Angela Locoro[1], Luca Mari[1], Eliana Alessandra Minelli[1],
Aurelio Ravarini[1] and Maria Rucsandra Stan[1]

[1] Università Carlo Cattaneo - LIUC, Castellanza (VA), Italy

`(fbertolotti,alocoro,lmari,eminelli,aravarini,mstan)@liuc.it`

Abstract. In this paper, we introduce the main topics and the initial settings of an Italian PRIN project aimed at investigating how the systematic adoption of systems for the evaluation of research in the Italian academic context may influence research outcomes. We motivate the need to adopt and adapt a conceptual framework, which may identify, define and describe the relevant entities involved in the evaluation process, their measurable properties and relations. We then present the first draft of an ontology derived from an existing ontology about the academic world, namely the VIVO ontology, and the criteria for its design. We report the steps taken to modify the received ontology in order to fit it to our purposes, with an interdisciplinary contribution to the selection and adaptation of entities. Novel considerations about the use of formal conceptual systems and the contribution of our work to the socio-technical view are finally drawn, and some further directions of the project are proposed.

Keywords: Research evaluation systems, Socio-technical model, Ontology design, VIVO ontology, Quality measurement.

1 Introduction and Motivation: The Italian Academic Research Evaluation System

The increasing awareness of the strategic importance of academic research for national and regional development has led many countries to manage research for public policy purposes. Thus, given the complexity of the concept itself of 'quality of scientific research' and the connections between scientific research and public purposes, and given the level of autonomy recently granted to the academic institutions and the system of competitive funding that guarantees some sustainability to the endeavour (Whitley and Gläser, 2007), several countries have implemented and are running a *research evaluation system*.

Such systems within European countries have often been inspired by neo-liberal principles, aimed at simultaneously fostering the steering capabilities of national policy makers and the accountability of the universities for the use of public resources (Neave, 1991; Whitley and Gläser, 2007). In Italy, weaknesses in the policy design together with poor implementation led to unintended consequences in the reform process for the access to public resources, and conflicts

related to the introduction of a research evaluation system (Minelli et al., 2006; Reale and Seeber, 2013; Rebora and Turri, 2013; Capano, Regini and Turri, 2016).

The context of this paper is a publicly-funded project "of national interest" in Italy (PRIN, 2017), titled "The effects of evaluation on academic research: knowledge production and methodological issues". Its general purpose is that of investigating the effects of the research evaluation system implemented so far by the Italian government. The background hypothesis of the project – surely not original – is that this system has effects on the research activity of universities and the production of knowledge: there is some sort of feedback loop between the research system and the system aimed at evaluating the research system. On this basis, the project addresses several research questions, and among them the epistemological and methodological underpinnings of research evaluation systems and their implications for the assessment of the activities of individuals.

Since the 2000s, Italian governments implemented two parallel research assessment frameworks, which had a significant impact on academics' role and work: VQR (*Valutazione della Qualità della Ricerca*, in Italian) and ASN (*Abilitazione Scientifica Nazionale*, in Italian). Even though with some differences, both VQR and ASN aim at assessing the quality of the academic research outputs, using informed peer review and, extensively, either bibliometric indicators (Impact Factor and the number of citations) or a rating of national and international journals based on their quality (the so-called list of top 'A' journals). Both evaluation frameworks define academic quality excellence standards at a national and institutional level, whose achievement grants access to professorship, pushing academics to comply with such evaluation rules and criteria.

The PRIN project mentioned above focuses on the effects of the application of these evaluation frameworks on knowledge production in the Italian academic context, most of which were already pointed out by the relevant literature. Some open questions concern whether research evaluation drives research quality without creating distortions, and how measurable are both the quality of the research and the effects of an external evaluation of the research quality, whereby external research evaluation is intended as a control entity based on an authority who is placed outside (literally detached) the organization being evaluated and independent of it.

Given the complexity of the research process, the methodological aspects of the measurement of its characteristics and the evaluation of its output take on a specific significance. As a first instance of this investigation, it is crucial to rely on a core identification of an appropriate and relevant conceptual framework for this knowledge field.

Thus, the research questions addressed by this paper are related to: the initial identification and definition of the main entities of the Italian research system;

how they relate to each other; whether it is possible to structure this knowledge to share unambiguous notions; and how to support the identification and measurement of the impact that external research evaluation can produce on these entities and research practices in general.

2 Towards a Socio-Technically Aware Ontology

The approach in unfolding the research questions took the perspective of a socio-technical system, i.e., a model defined by four interdependent variables: task, people, technology, and structure, where each of them influences the others (Leavitt, 1965). In brief, the socio-technical perspective implies that all the activities considered under its framework regard both the social subsystems (human and structure) and the technical subsystems (technology and task), and requires that each of these elements is first of all identified, described and carefully considered alone and in interaction with the other ones. We employ a socio-technical approach to the research evaluation issue because we sustain that research products emerge from a network in which social entities, such as scholars and editors, interact with technical components of different complexity, and that the exploitation and the availability of such technical subsystems by social entities influence research quality. By these means, the idea of developing a conceptual framework revolved around the design of an ontology-based conceptualization followed, as already been established in the literature (Pinto, Tempich and Staab, 2004; Kotis and Vouros, 2006; Herrmann, Loser and Jahnke, 2007). This approach involves domain experts and/or end users as central actors. The literature further suggested initiating the development of an ontology not from scratch, but rather reusing already existing ontologies and managing the decision-making process about the ontology construction on consensus. Further advantages in adopting a socio-technical perspective to the development of an ontology were that knowledge sharing was encouraged since the early development phases of its conceptualization (Holsapple and Joshi, 2004).

Research evaluation is intrinsically interdisciplinary in its conception, and its implementation is highly contextual. Hence its definition should go beyond organisations and disciplines. Moreover, as highlighted by Gläser (2007:246), "Scientific communities have their own distinct social order, which extends across all science policy institutions and organisations" and whose impact often prevails over governance practices within universities. These observations called for an effortful and rigorous process of definition, where the measurand of research (Mari, 2003) should be identified, included what and how entities had to be measured in this domain, and how what had to be measured can be provided by an ontology that made measurands explicit and upon which different evaluation practices could be built in accordance with the requirements and the peculiarities of the scientific communities. In this sense, the

conceptualization of an ontology, which can be defined as an "explicit specification of a conceptualization" (Gruber, 1995), seemed to support the analysis of suitable research evaluation practices while formally defining the Italian research system from the point of view of evaluation, and shed light on its complexities and interactions with the evaluation practices.

The literature mainly provided examples of ontologies useful to build taxonomies in specific fields of knowledge, as shown in the following section. Instead, our approach aimed to reconcile interdisciplinarity and purposefulness in order to permit a large application domain. Interdisciplinarity is suited to be studied from a socio-technical perspective because the interaction of social with technical subsystems is transversalto different research areas. This purpose led us to focus on a specific ontology that assured a wide representation of entities and their properties within the Italian research system and thus provided interoperability across analysis methods and perspectives.

3   Background: Ontologies and the Organizational field

In philosophy, the term "ontology" is used to refer to the fundamental studies of entities and their "modes of being" (their characteristics, their relations to other entities, and the like) (see for example Hofweber et al., 2014). As introduced above, an ontology is instead understood in an application context, as a suitably structured system of concepts, typically described by means of a computer-oriented formal language.

Many studies witness the application of ontologies to the field of management. A methodology called "Systematic Literature Network Analysis" (SLNA) (Colicchia and Strozzi, 2012) was implemented to provide an overview of these applications in the following paragraphs.

In the context of organizational studies, until the first decade of 2000, the use of ontologies was limited to the description of organizational goals issues from the point of view of organizational processes, including elements such as sub-goal, task and resources (Fox, Barbuceanu and Gruninger, 1995). Later, ontologies were used to define competencies for learning activities by assessing the ever-changing knowledge needs within an organization (Sicilia, 2005), as well as tools to facilitate the transfer of knowledge across organizations and reduce the learning curve by reusing acquired knowledge (Li and Chang, 2009). Ontologies served also as tools in knowledge management when mapping the competencies of an organization (Zancanaro et al., 2013). Furthermore, ontologies enabled a common understanding of the organizational goals by identifying and evaluating the relevant organizational and social media data to achieve organizational goals, in addition to mapping their relationship with sub-goals, tasks and actions (Izhar et al., 2013; Izhar, Torabi and Ishaq Bhatti, 2017a, 2017b; Izhar and Apduhan, 2018b). The efficiency and effectiveness of an ontology to

act as a support in the decision-making, as well as in enabling the measurement of already achieved goals, resides in capturing data that allows to model relationships and knowledge within an organization, thus reducing irrelevant organizational data (Tengku Izhar, Apduhan and Torabi, 2019). An ontology is, in other words, able to represent the dependency relationships of organizational entities to organizational goals, and used for evaluating the level of organizational goals without affecting the organizational processes (Izhar and Apduhan, 2018a).

Throughout the years, ontologies in the domain of organizations were used for different purposes, including organizational memory management (Paajanen et al., 2006), evaluation (Weinberger, Te'eni and Frank, 2008) and consolidation (Marian, 2009); cross-organization knowledge transfer (Abou-Zeid, 2002; White and Lutters, 2007), retrieval of organizational knowledge (Yao et al., 2013) and compatibility check of cross-organization knowledge (Anjum et al., 2013). They were also used to federate virtual organizations for common goals achievement (Plisson et al., 2007).

3.1 Ontologies as Models for the Research field

In the last twenty years, ontologies have been widely applied to the analysis of scholarly systems and to support activities related to academic research. To the best of our knowledge, it is possible to identify three main streams of research in this area. First, ontologies were used to classify specific research areas into taxonomies. A wide range of fields was characterized and defined through a set of objects and describable relationships among them, for example, computer science (Sanderson and Croft, 1999; Salatino et al., 2018), economics (Cherrier, 2017), biology (Lipscomb, 2000) and physics[1].

Second, generic and wide ontologies were developed to represent the entire domain of academic research. Four main examples can be identified: VIVO, CERIF, SYNAT and FOAF-Academic. VIVO (http://vivo.library.cornell.edu/), a Virtual Life Sciences Library developed at Cornell University, describes the domain of scholars' activities, including not only the agents and the objects that compose it, but also a set of elements – like enterprises, libraries or students – that influence them.

The primary purpose of VIVO is to make a knowledge-based representation of the assortment of actors and activities taking place across the university's world (Caruso et al., 2006) as well as to support scholars' networking (Krafft et al., 2010). CERIF (Common European Research Information Format) describes elementary notions and properties for representing research information as semantic data (Lezcano, Jörg and Sicilia, 2012). SYNAT describes information provided by the research system and covers notions and events related to scholarly work. The purpose of the project is to build comprehensive scientific content storage and sharing platform for anyone interested to use academic

information (Wróblewska et al., 2012). FOAF-Academic (Kalemi and Martiri, 2011) is an extension of the well-known Friend of A Friend[2], an ontology that specifies communications in scholarly communities and academic-related terms.

Third, ontologies were developed to support the evaluation of research, the quality measurement of the academia by aligning all the necessary information (Aminah, Afriyanti and Krisnadhi, 2017), the conceptualization of qualitative factors that influence the performance of faculty members (Bai et al., 2014) and – through the CERIF ontology – the evaluation and the quantitative expression of scientific research results (Grace and Gartner, 2010; Ivanović, Surla and Racković, 2011).

3.2   Interdisciplinarity and Quality: our view

The use of domain ontologies is usually circumscribed within well-defined fields. However, as already stated, research evaluation is intrinsically interdisciplinary in its conception. Consequently, the paper proposes the use of an ontology at an interdisciplinary level (inspired also by the composition of the research group), with the aim of creating a tool that can better connect and support communication and comprehension. In other words, the authors proposed to handle an ontology from a socio-technical perspective, positioning knowledge sharing at the core of the process and putting domain experts and/or end-users at its centre, thus giving the design experience a more pragmatic angle.

Quality has always been relevant for the organizational world, for example in relation to compliance with internal specifications or to customer satisfaction. To this purpose, many tools (including ontology-based ones) were developed since the late 1990s. Ontologies have been used to enable quality problem identification by providing a shared terminology and defining in a precise and unambiguous way semantics for the enterprise (Kim, Fox and Grüninger, 1999). In this sense, the design of an ontology is driven by the interest to answer specific competency questions that characterise the decision-making. The academic research world is no exception to the practices of quality management; on the contrary, quality initiatives should be at the core of scientific endeavours, as this enhances knowledge and skills of humans (Rezeanu, 2011).

4   Management and Adaptation of the VIVO Ontology

The objective of this paper is one of the pillars for the development of the PRIN project introduced in the first Section, whose focus is "the investigation of the effect of research evaluation implemented by the government on the research work and knowledge production" in the Italian universities. Thus, the project

aims at achieving three primary goals. First, the development of a methodological approach designed to measure the effects of evaluation. Second, the identification of the possible consequences of the measurement. Third, the elimination of the ambiguity for the evaluation, assessment and measurement concepts in the area of interest. By looking at the state of art of the literature, two research areas proved to be relevant to our analysis: one related to the specific use of evaluation (distributive, improvement, monitoring) (Molas-Gallart, 2012); the other regarding the influence of neo-liberal approaches on the development of research evaluation reforms in Europe and how the implementation of such reforms has been affected by the institutional factors of the respective country (Gläser and Whitley, 2007; Neave, 2012).

Consequently, the need for mutual understanding among peers as well as among partners in a project (Akyürek and Afacan, 2018) has arisen. To overcome this limit, as well as to set a foundation for the research project, the use of an ontology was put forward. The literature already suggested the use of a domain ontology as a tool for knowledge elicitation (Kaiya and Saeki, 2006). In fact, there was evidence of ontologies being used to support the evaluation of research and the quality measurement of academia (Aminah, Afriyanti and Krisnadhi, 2017) and the conceptualization of qualitative factors influencing the performance of faculty members (Bai et al., 2014) as well as of scientific results (Grace and Gartner, 2010), and to define unambiguously the main elements of a research system (Sure et al., 2005).

Taking into consideration that there are not ontologies able to describe specifically the Italian research system yet, two alternatives were considered: the development of a new ontology from scratch (Wróblewska et al., 2012) or the adaptation of an existing one to fit the project's purposes (Kalemi and Martiri, 2011). The latter choice enabled a solid foundation for the proposed work, as well as the chance to choose from numerous available alternatives. Accordingly, some existing ontologies were analysed, and in particular: VIVO, CERIF, SYNAT and FOAF-Academic. During the selection process two criteria were used: the number of application of each ontology, in other words, the diffusion of the tools; the relevance of the ontology to our goal (the representation of entities and relationships that compose the Italian research system to support the assessment of the impact of evaluation criteria on academic outputs), underlining the preference for constant usage of the same tool through time. No quantitative analysis was developed for this decision, however, the information collected during the literature review was used to assign a qualitative judgment to each option.

As it can be seen in Table 1 and Table 2, the tool that seemed to better fit the goals and purposes of our project was VIVO[1]. For this reason, we adopted this ontology as a starting point of our project.

Table 1. Application of the evaluated ontologies

Ontology	Level	Explanation
VIVO	High	Applied in more than 10 papers indexed on Scopus
CERIF	High	Applied in more than 10 papers indexed on Scopus
SYNAT	Low	Applied in less than 3 papers indexed on Scopus
FOAF-Academic	Low	Applied in less than 3 papers indexed on Scopus

Table 2. Relevance of the evaluated ontologies to our goal

| Ontology	Level	Explanation
VIVO	Medium	Describes most of the entities and relationships we are interested in; needs only slight modifications
CERIF	Low	Describes only a small portion of the entities that are relevant for our goals; needs to be widely integrated
SYNAT	Medium	Describes most of the entities and relationships we are interested in; needs to be compared with VIVO for its redundancies with it.
FOAF-Academic	Low	Describes only a small portion of the entities that are relevant for our goals; needs to be widely integrated

Once we selected VIVO, we defined some criteria to follow during the modification process[2]:

1. we removed entities considered not relevant for the evaluation of the quality of the research (for example, librarians and cities);
2. we removed entities considered not relevant to model the Italian scenario (for example, professor emeritus and US citizen);
3. we added entities considered relevant for the evaluation of the quality of the research, especially in the Italian scenario (for example, the research platforms and the research mindset).

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[1] For documentation please follow the official VIVO link: https://duraspace.org/vivo/, where the last version of the ontology is available. At https://www.w3.org/community/vivo/ the official page of the VIVO as a W3C standard certified project.

[2] Both the inspection and modifications step the VIVO ontology were done by uploading an .owl version of the ontology, available in the VIVO repository, into the Protégé tool, a Java-based specialized knowledge representation and reasoning tool freely available online (at https://protege.stanford.edu/).
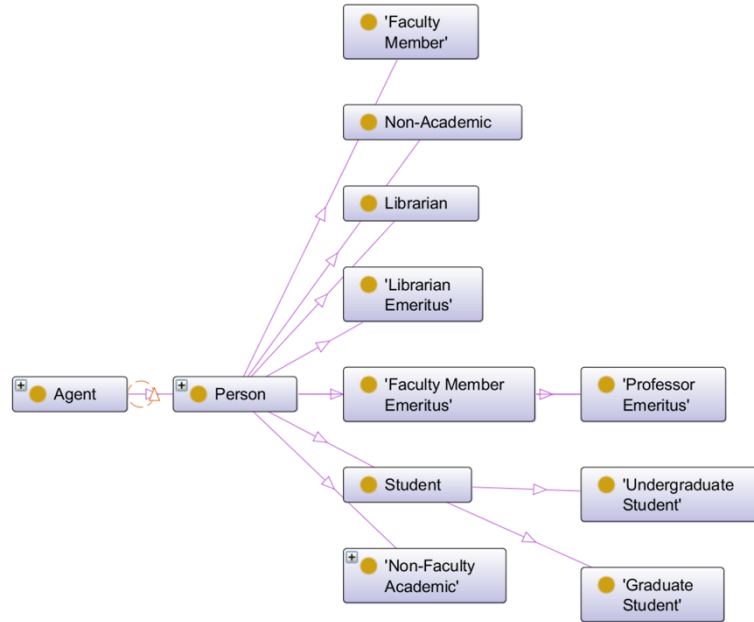
Fig. 1. Excerpt of the original VIVO ontology, with an overview of human entities.
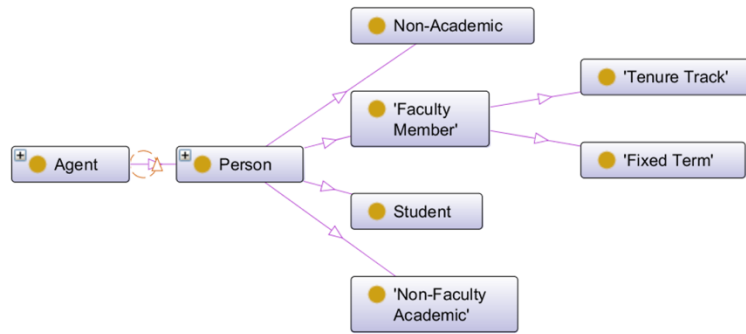
Fig. 2. Excerpt of the customized VIVO ontology, with an overview of human entities.

Subsets of the VIVO entities that were identified at this round are reported in Figure 1 and Figure 2, from both original and customized ontologies. The figures, which exhibit a section of the VIVO before and after our intervention, exemplify how the modification criteria were applied to our work. As VIVO is a multilayer ontology using upper (more abstract) concepts borrowed from upper ontologies to frame proper domain concepts, we maintained the original VIVO structure and mainly worked at the

first and more general domain entity level. In this context, we extended the ontology to include concepts that are peculiar to the description of the Italian academic system and, on the contrary, pruned in width and in depth all those concepts that we deemed out of scope for our purposes or unnecessarily verbose and too detailed. We decided to show the modification criteria and an example of their application instead of reporting a list that includes every change. Thus, we tried to achieve better clarity and efficacy in the description.

5   Discussion

As seen in the literature, it is not news that the academic research system could be analyzed through the lenses of a socio-technical approach (Singh and Han 2005). Our work puts once more in evidence the relationships between the social part of the system (like scholars, research groups and institutions) and the technical one (like laboratories and online platforms). The use of a shared vocabulary to define all entities involved in the evaluation of academic organizations under a sociotechnical perspective was a pragmatic choice. As a matter of fact, this vocabulary circumscribes the scope of the discourse and the horizon within which to observe and validate new routines. Likewise, a second goal was to showcase new approaches to the evaluation of research activities in the academic environment, by opening up to other validation pathways in the evaluation of scholarly practices.

The yielded ontology has the potential to support and help us pursue two goals. On the one hand, this tool could be relevant per se. On the other hand, it could help light up a debate about new ways of evaluating scholars, either inside the project or in the literature, helping other researchers and academic policy makers enrich their vision and take into consideration the existence of different points of view. For example, we already highlighted the introduction of research platforms in our version of VIVO. Nowadays, the score of a scholar on a platform such as ResearchGate[3] is not a discriminating factor in the formal evaluation of its research performance. We are not suggesting that a resort to these platforms should be the only way (let alone the main one) to assess the performance of a researcher. Rather a discussion about the relevance of this specific topic could help expand the boundaries of the debate and involve in the discussion very disparate research fields and traditions.

To conclude, this work gave to our goals a pragmatic attitude. Thus, we do not presume to revolutionize the way in which ontology-based techniques are applied, and neither to develop new theories related to socio-technical systems. Nevertheless, the approach to our research question is original and peculiar. To the best of our knowledge, it was never attempted to use an ontology to gaze to a national research system under a socio-technical perspective, nor to gaze to the effects of evaluation on academic results through a modelling choice. Furthermore, the peculiarity of our approach is given by the interdisciplinary perspective attributed to the design and the use of an ontology. This enables the user, as the creator, to reflect on a given purpose not just from her

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[3] http://www.researchgate.net

point of view, but also by considering all the facets that can be relevant to achieve a defined goal. This experience was also peculiar in the sense that, since the beginning, we tried to fill the inevitable gap between ontologies experts and non-experts by involving both interchangeably as users and designers of the same artifact, in that they were academic people and had a productive role in the project.

6   Conclusions and future work

Coherently with the PRIN commitment, results would first apply to the Italian research system. Nevertheless, a possible next step could be to test other academic systems. In conclusion, our customized version of VIVO could be a support in this process not only for an assessment perspective but also for other purposes.

The development of dynamical models could help to understand the origins and the evolution of complex phenomena that emerged from evaluation activities; the extension of the shared vocabulary towards a thorough examination of entities' measurable properties. This last endeavor is among our future work.

The idea is that of defining entities measurands, their kinds and their measurability. This conceptualization would extend the investigation of the entities defined so far to their measurable relata and their components, such as their algebraic structure and their unit of measure.

Lastly, the application of new-institutional theory to address the evaluation of research in the Italian academic system (Whitley and Gläser, 2007).

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