



Innovation intermediaries and collaboration: Knowledge-based practices and internal value creation



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ABSTRACT

This paper analyses how knowledge-based practices adopted by innovation intermediaries enable them to generate value for themselves when collaborating with their clients. While the literature focuses on value creation for their client organisations, little is known about how innovation intermediaries create internal value even though this is essential for ensuring their long-term survival and sustaining their key facilitating role in the innovation system. This understudied issue is explored using empirical evidence from a sub-set of innovation intermediaries, Research and Technology Organisations (RTOs). The results indicate that by capitalising on existing knowledge vested in employees and collaborators as well as understanding and shaping the knowledge base of the innovation ecosystem, innovation intermediaries generate internal value from their involvement in collaborative innovation, which range from different financial to non-financial types of value. Implications for intermediaries, their collaborators and for policymakers are then discussed.

1. Introduction

This paper investigates how knowledge-based practices adopted by innovation intermediaries enable them to generate internal value for themselves when collaborating with their clients. Innovation has long been seen as a major factor in economic growth and development. In turn, innovation intermediaries have become recognised as key actors in the innovation landscape, improving firms' innovative speed and performance (Knockaert et al., 2014; Lin et al., 2016). Innovation intermediaries, broadly defined as “organisations that provide a supportive role for collaboration between two or more parties during various stages of the innovation process” (Howells, 2006, 721), are therefore seen to be central to creating and maintaining a successful innovation ecosystem (Sieg et al., 2010). The role of innovation intermediaries extends from linking parties for collaboration, to setting up and mediating relationships and bridging a wide array of knowledge, competency and capability gaps (Smedlund, 2006; Klerkx and Leeuwis, 2008a; Klerkx and Leeuwis, 2008b; Edler and Yeow, 2016). Among the varied types of engagement by innovation intermediaries (Howells, 2006) their interaction in collaborative projects represents one of their more complex, enriched and involved roles as they (in addition to developing

and supporting the partnership) engage in co-creative innovative activity with collaborators, in a process of wider co-creation and co-development (Boon et al., 2011).

Whilst past research has extensively discussed the role of innovation intermediaries and how they generate value for their clients (Sawhney et al., 2003; Howells, 2006; Verona et al., 2006; Sapsed et al., 2007; Nambisan and Sawhney, 2007; Arnold et al., 2010; Tran et al., 2011; Landry et al., 2013; Knockaert and Spithoven, 2014), there is a lack of understanding on what enables intermediaries to generate value for themselves in the context of their engagement in collaborative innovation. This is a non-trivial issue as business and innovation move towards more open and networked environments. ‘Who gets what’ in terms of value creation is a crucial issue in modern business dynamics with actors operating in a system in which ‘we move from single-firm revenue generation towards multi-firm control and interface issues’ (Ballon, 2007, 7). How to efficiently capture value for each actor within dispersed networks remains a daunting task, but is essential for the long-term survival of not only businesses (Johnson et al., 2008), but also innovation intermediaries (del Águila-Obra et al., 2007; Lopez and Vanhaverbeke, 2009).

It is this aspect of the *internal value creation* by innovation

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intermediaries, which the literature has not yet been able to adequately address (Krenz et al., 2014), that is the focus of this paper. The *internal value* could be multidimensional comprising both financial and non-financial values. The immediate gain for innovation intermediaries from client engagement can be expected to be from *financial* benefits in terms of: (a) revenues generated by services they provide for clients, or (b) funding secured from research grants. Apart from these financial gains, intermediaries also generate *non-financial* value that consists of *knowledge*, *market* and *network* based benefits. In collaborative projects intermediaries with other partners may develop new knowledge (Mowery et al., 1996; Gulati, 1999; Kale et al., 2000), capabilities required to deploy such knowledge (Hardy et al., 2003; Cepeda and Vera, 2007; Martín-de Castro, 2015), intellectual property (Martín-de Castro 2015), new forms of innovation (Earl, 2001) and useful networks (Nagaoka and Kwon, 2006). Although this, taken to the extreme, might be seen as parasitic or exploitative of their clients, innovation intermediaries need to generate sufficient gains for their long-term survival, without which the generation of value to their clients and their wider systemic benefits would not be possible.

In the ability of innovation intermediaries to generate internal value, the effective development and utilisation of knowledge is a critical component (Wenger and Snyder, 2000; Teece, 2004; Alavi et al., 2005; Knockaert et al., 2014), especially in the context of collaborative innovation (Pisano and Teece 2007; Lichtenthaler and Lichtenthaler, 2009). The knowledge-based view of the firm (Kogut and Zander, 1996; Spender, 1996) as well as the open innovation literature (Chesbrough, 2003; Chesbrough, 2006; Dahlander and Gann, 2010) highlight that valuable knowledge exists not only within organisational boundaries, but also outside the firm. As such, firms' ability to explore, acquire, retain, integrate and exploit knowledge (Grant, 1996), is central to firm value creation (Gold et al., 2001; Klerkx and Leeuwis, 2008c; Lichtenthaler and Lichtenthaler, 2009; Knockaert and Spithoven, 2014).

Where do innovation intermediaries come into this process of knowledge management and coordination? The agency issue and role of cooperation and coordination is complex and not easy to resolve (Holmstrom, 1989), but a number of studies have started to explore the role of intermediaries in the knowledge creation and innovation process. They cover knowledge search, problem solving and connecting and coordinating knowledge between actors (Agogué et al., 2013a; Hargadon and Sutton, 1997) through to commercialising new technologies (Aldrich and von Glönow, 1992). Thus, the successful provision of innovation intermediaries' services involves the handling of complex knowledge (Klerkx and Leeuwis, 2008c; Lichtenthaler and Lichtenthaler, 2009). Innovation intermediaries therefore act as knowledge repositories that introduce new combinations of knowledge and also make knowledge-based contributions when providing solutions to their clients (Hargadon and Sutton, 1997; Howells, 2006). Innovation intermediaries appear to be developing new methods and practices in more unknown knowledge environments where risk and uncertainty are high and where sophisticated management principles have to be developed (Agogué et al., 2013b). Thus, the successful delivery of the intermediation process requires the effective adoption of knowledge-based practices, through which internal value is generated. Even though there is extensive research on investigating how to manage knowledge effectively in collaborative arrangements (Kale et al., 2000; Grant and Baden-Fuller, 2004), the positioning of innovation intermediaries in these studies has been as institutions that help other organisations to manage knowledge and extract value (Lee et al., 2010; Spithoven et al., 2010) rather than on the intermediaries themselves.

Using data from a survey of Research and Technology Organisations (RTOs), an important form of innovation intermediary (Howells, 2006; Oxford Economics, 2008; Arnold et al., 2010; Landry et al., 2013; Miller, 2014), the paper seeks to contribute in three ways to our knowledge of innovation intermediaries and their clients: (1) for innovation intermediaries to more effectively assess and design

knowledge-based practices depending on which type of value they intend to generate; (2) indirectly, by allowing innovation intermediary clients' to better identify and appreciate which aspects of their collaboration intermediaries benefit from the most; and, (3) for policymakers to put in place better measures to support intermediaries as a pathway for wider innovation ecosystem value generation.

The remainder of this paper is organised as follows. The next section outlines a set of hypotheses developed to indicate how different knowledge-based practices may determine an innovation intermediaries' ability to generate both financial and non-financial value. This will be followed by methodology section and the paper then concludes by discussing the results, limitations and future research directions of the study.

2. Background literature

2.1. Internal value generation by innovation intermediaries through collaborative projects

Innovation intermediaries have been characterised as organisations that generate value to other actors within a system of innovation (Sawhney et al., 2003; Verona et al., 2006; Nambisan and Sawhney, 2007; Arnold et al., 2010; Tran et al., 2011). The focus has therefore been on studying how intermediaries enable their clients to leverage external technologies (Howells, 2006), existing design solutions (Hargadon, 2002), the knowledge and experience of customers (Verona et al., 2006), the expertise of external specialists (Tran et al., 2011) and exchange platforms (Lichtenthaler and Ernst, 2008). Nevertheless, in order for innovation intermediaries to successfully perform these tasks they need to generate internal value for themselves from such engagement with clients. 'Internal value' is defined as the sum of both financial and non-financial values generated from their clients by innovation intermediaries. The internal value generated by intermediaries during collaborative projects will be multi-dimensional, comprising both (a) financial and (b) non-financial gains (Huizingh, 2011).

As noted earlier, the immediate gain for innovation intermediaries from client engagement can be expected to be from *financial* benefits, in terms of service revenue generation and funding secured from research grants, but there will also be *non-financial* value generation. Non-financial value, associated with the concept of 'social capital', highlights the central role played by the social network in which actors, such as innovation intermediaries, engage. It is associated with cooperation, reciprocity and information sharing in the value creation process (Tsai and Ghoshal, 1998; Landry et al., 2002; McElroy, 2002; de Felice, 2015). For instance, in collaborative projects intermediaries with other partners may develop new *knowledge* (Mowery et al., 1996; Gulati, 1999; Kale et al., 2000) and technical and operational capabilities required to deploy such knowledge (Hardy et al., 2003; Cepeda and Vera, 2007; Martín-de Castro, 2015). This new knowledge will be important for more effective running of the intermediation process, particularly when new combinations of knowledge are introduced. Innovation intermediaries' engagement in collaborative projects would also enable them to generate 'closer' to *market* benefits. This includes the development and improvement of products, processes (Earl, 2001), services, technologies, equipment and intellectual property (Martín-de Castro, 2015) that provide them with competitive advantage (Gulati et al., 2000b), particularly when bridging technology and market gaps between partners (Lichtenthaler and Ernst, 2008; Nell and Lichtenthaler, 2011; Lichtenthaler, 2013; Melle and Russo-Spena, 2015). Lastly, intermediaries also develop new *networks* of contacts including new markets and distribution channels (Gulati et al., 2000a; Nagaoka and Kwon, 2006; Lichtenthaler, 2007). These are of value when finding partners for collaboration and providing support services, such as introducing new distribution channels to clients and international market access (Arnold et al., 2010).

2.2. The importance of adopting knowledge-based practices

Knowledge-based practices adopted by innovation intermediaries can influence their ability to generate financial and non-financial value from collaborative projects (Wenger and Snyder, 2000; Gold et al., 2001; Alavi et al., 2005; Martín-de Castro, 2015). The knowledge-intensive role of innovation intermediaries (Aldrich and von Glinow, 1992; Klerkx and Leeuwis, 2008a,b; Mount et al., 2015) heightens the need for them to systematically make use of external and internal sources of knowledge, such as employees, clients, collaborators and business (Lin et al., 2012), by integrating these effectively within their organisational and innovation processes (Escribano et al., 2009). Nevertheless, managing knowledge effectively for sustainable value generation is a complex process (Gold et al., 2001) since it requires the adoption of human capital associated knowledge-based practices, recognised as crucial for collaborative innovation success (Gassmann et al., 2010; Sieg et al., 2010; Boari and Riboldazzi, 2014). The recognition of the need for increased knowledge task specialization was noted by Adam Smith (1776) who stressed that the most fundamental aspect of the division of labour was the division of knowledge and the associated combinatorial ways of producing knowledge (Metcalfe, 2002). Invention, in particular, requires individuals (Rosenberg, 1965, 132–133) to draw upon the diverse fields of knowledge and therefore the know-how needed to perform complex tasks can be very divided (Nelson, 2003, 911). Successful knowledge management with regard to innovation must therefore be centred on the individual (Howells, 2012, 1005) as meaning and knowledge is ultimately based within individual minds (Polanyi, 1961; Morton, 1997).

3. Theoretical framework and hypotheses

On the basis of the above discussion, this section proposes six hypotheses to investigate how knowledge-based practices enable innovation intermediaries to generate internal value for themselves. These six knowledge bases practices encompass mechanisms associated with managing knowledge vested in ‘individuals’ within intermediaries and their innovation ecosystem. They are: (1) ‘knowledge capitalisation’ associated with leveraging and recombining *existing* knowledge, both internally and externally between employees, partners and wider networks; (2) ‘knowledge advancement’ related to acquiring new knowledge, absorbing and internalising it; (3) ‘knowledge spanning’ covering the ability of an innovation intermediary to access unrelated knowledge that is non-adjacent to an intermediary’s knowledge base; (4) ‘knowledge worker empowerment’ associated with practices to empower employees engaged in collaboration as to how to use knowledge; (5) ‘innovation ecosystem knowledge access’ is related to the ability of an intermediary to possess knowledge of its wider innovation ecosystem; and, (6) ‘innovation ecosystem knowledge shaping’ is associated with practices and routines aimed at shaping the overarching collaborative framework and institutional form of the innovation system. Each of these hypotheses will now be explored in more detail (Fig. 1).

3.1. Practices for knowledge capitalisation

Leveraging and recombining *existing* knowledge, both internally and externally between employees, partners and wider networks, termed here as ‘knowledge capitalisation’, is found as essential if an organisation, such as an innovation intermediary, is to generate value from collaborative innovation (Davenport et al., 1998; Gold et al., 2001). ‘Knowledge capitalisation’ practices include: retaining experienced staff; having a dedicated team working on specific tasks; capitalising on personal networks of staff and business-to-business relationships; and, engaging with partners with positive working experience (Hobday, 2000; Lichtenthaler and Lichtenthaler, 2009; Dahlander and Gann, 2010).

Capitalising on knowledge accumulated in trustworthy relationships increases the reliability, breadth and depth of tacit and codified knowledge available to an organisation (Nielsen, 2005), improves an organisation’s innovative performance (Martín-de Castro, 2015) and enhances their market advantage (Yli-Renko et al., 2001). Knowledge capitalisation also helps address common causes for failure in collaborative projects by reducing cost and uncertainty (Granovetter, 1985; Vlaar et al., 2007) as well as the ‘psychic’ distance between partners (i.e., the degree of factors that prevent the flow of information between partners; see, for example, Bruneel et al., 2010; Bruneel et al., 2015), whilst increasing trust (Paulraj et al., 2008) which is vital for intermediaries to generate internal value.

Nevertheless, this may not be a wholly positive process; there are a number of negative aspects and problems associated with this focus. Capitalising on *existing* knowledge could increase in-breeding, reducing the innovativeness of an organisation (Saviotti, 1996) and hence the long-term ability to generate value through collaboration (Sethi et al., 2002). A greater reliance on the knowledge of *existing* individuals (whether they are employees or collaborators) also increases the risk of knowledge loss to intermediaries since these individuals could always change their association or, even worse, join competitors (Davenport et al., 2002; Oliver, 2004), diminishing the ability to generate internal value through collaboration. Yet, when considering the role of innovation intermediaries as ‘bridgers’ of knowledge between organisations and those that introduce new combinations of knowledge – which necessitates them to make the most out of their existing trustworthy knowledge – (Hargadon and Sutton, 1997; Howells, 2006), it is possible to suggest that they would benefit from adopting practices for knowledge capitalisation regardless of potential negativities:

H1. The adoption of practices for knowledge capitalisation positively influences the generation of financial and non-financial value for innovation intermediaries in collaborative projects.

3.2. Practices for knowledge advancement

In addition to exploiting current knowledge, acquiring *new* knowledge, absorbing and internalising it (Garud and Nayyar, 1994; Smith et al., 2005; Knockaert et al., 2014) is essential for advancing and developing new business opportunities as well as helping to avoid lock-in (Saviotti, 1996). This capability is termed here as ‘knowledge advancement’. By being able to identify knowledge gaps through mapping current knowledge and having the capability and flexibility to integrate new with existing knowledge are key prerequisites for knowledge advancement (Lichtenthaler and Ernst, 2006). Examples of practices in knowledge advancement include adopting a structured approach towards actively exploring and internalising new knowledge, hiring new staff who possess the required new knowledge (Earl, 2001; Lichtenthaler and Lichtenthaler, 2009) and better team-based learning techniques both within and across organisational boundaries (Scardamalia, 2002). Advancing knowledge is considered critically important for sustainability in an era of short product life cycles, advanced technological developments and considerable economic uncertainty (Bowonder and Miyake, 2000).

However, since innovation intermediaries are mainly involved in handling and integrating knowledge bases of innovation ecosystem actors by exploiting current knowledge (i.e. their positioning as the ‘bridgers’ of basic and applied science; Hales, 2001), it is possible to argue that knowledge advancement will not have significant impacts on their value creation. There are also problems in relation to the extent to which an organisation could correctly identify knowledge gaps and implement an approach to fill them due to the organisation being in a constant state of flux. Still, since innovation intermediaries act as network and knowledge integrators, they need to constantly update and advance their knowledge base (Klerkx and Leeuwis, 2008a,b,c; Lichtenthaler and Lichtenthaler, 2009; Mount et al., 2015), without

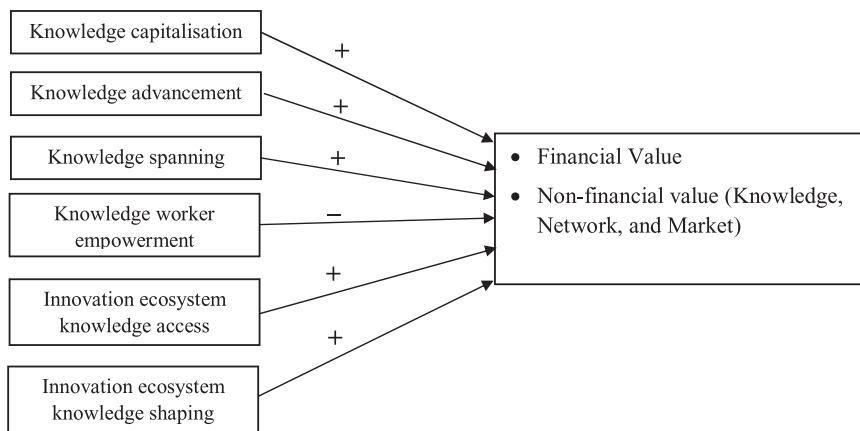


Fig. 1. Influence of knowledge-based practices on internal value creation by intermediaries.

which the identification of opportunities for new knowledge recombination would be impossible. Based on this particular importance and the positive effects of this practice, the second hypothesis is:

H2. The adoption of practices for knowledge advancement positively influences the generation of financial and non-financial value for innovation intermediaries in collaborative projects.

3.3. Practices for knowledge spanning

The ability of an innovation intermediary to access new, unrelated knowledge that is non-adjacent to an intermediary's knowledge base through 'knowledge spanning' is also an important competence for an organisation (Grant and Baden-Fuller, 2004). External unrelated knowledge is often required for a specific project (Earl, 2001), the complexity of which necessitates multi-disciplinary knowledge bases of different parties to be combined (Curley and Salmelin, 2013; Perkmann and Schildt, 2014). Intermediaries often access technical knowledge from universities or other organisations that possess 'unrelated' knowledge bases to achieve common goals for the success of a specific project. Since organisations engage in technical knowledge access are not inclined to internalise partners' knowledge, they remain specialists in their own domains of knowledge (Grant and Baden-Fuller, 1995; Lui, 2009).

Whilst projects that involve integrating 'unrelated' or multi-disciplinary knowledge are found to generate several benefits (Rhoten and Pfirman, 2007), accessing technical knowledge is not been without its challenges. This is due to difficulties faced by being unaware of the knowledge bases of other collaborators, which in turn leads to high transaction costs, uncertainty of outcomes and risk of failure (Zukin and DiMaggio, 1990; Petruzzelli and Rotolo, 2015). Particularly when considering the role of innovation intermediaries, it could be assumed that such challenges would be at a minimum since intermediaries are inherently successful at working with a wide array of actor types. On this basis, the third research hypothesis is:

H3. The adoption of knowledge spanning practices positively influences the generation of financial and non-financial value for innovation intermediaries in collaborative projects.

3.4. Knowledge worker empowerment

There is a danger of having an exclusive emphasis on organisational level factors and disregarding individual level determinants. Since innovation is a multi-level phenomenon (Gupta et al., 2007), the attitudes of individuals/employees engaged in collaboration influence the overall success of the organisation (Gavetti, 2005). Whilst top-down approach ensures the whole organisation to coherently achieving its vision, lack

of employee empowerment on how they develop and use knowledge can lead to employee dissatisfaction and demotivation (Ford and Fottler, 1995). Hence, empowering knowledge workers by adopting practices that engender positively motivated staff (Gold et al., 2001; Lichtenthaler and Ernst, 2006) is seen to be an effective practice for innovation success (Argyris, 1998; Collis and Moonen, 2008).

Nevertheless, there is the danger that employee empowerment could potentially dilute the achievement of organisational outcomes (Jensen 2001). Since intermediaries work with several external organisations, empowering employees may result in coordination problems, as staff adopt individualistic or temporary practices, which do not conform to more standard or transferable rules between individual staff and their team members. This can often lead to a loss of control, thereby inducing opportunism and increased uncertainty (Mils and Ungson, 2003). Hence, while the adoption of these types of practice is important for value creation in collaborative projects, empowerment could also result in the inability of an organisation to coherently achieve intended objectives. This leads to the fourth hypothesis:

H4. The adoption of practices to empower knowledge-based workers negatively influences the generation of financial and non-financial value for intermediaries in collaborative projects

3.5. Practices for access to innovation ecosystem knowledge

A successful intermediation role requires having a better awareness of the needs, resources and competencies of a wide array of actors of a system of innovation and their institutional framework (Howells and Roberts, 2000; Muller and Zenker, 2001; Kauffeld-Monz and Fritsch, 2013), which is termed here as 'innovation ecosystem knowledge'. The practices adopted by innovation intermediaries to access innovation ecosystem knowledge include using digital platforms that have information on the interests, knowledge and competences of potential partners as well as actively developing new relationships with key players (Howells and Roberts, 2000) through which intermediaries could enhance their awareness of the ecosystem. These practices and routines for innovation-ecosystem knowledge access differ from those for knowledge capitalisation (H1) and knowledge advancement (H2). The former involves enhancing awareness of ecosystem through *new* relationship building, whereas the latter involve in making use of knowledge vested in *pre-existing* relationships (H1) and in acquiring 'new' knowledge to advance and fulfil 'knowledge gaps' by recruiting *new* staff (H2), respectively.

Nevertheless, the benefit of accessing the innovation ecosystem knowledge base using external sources and actively attempting to develop new relationships may be questionable as new knowledge/relationships might not be reliable or prove to be successful (Davenport et al., 1998; Dyer and Nobeoka, 2000). Hence, the chances of benefiting

from the time and effort made to access the knowledge of the innovation ecosystem might be low. Yet, developing knowledge about the wider innovation ecosystem is vital to intermediaries in order to identify new opportunities to combine knowledge, mitigate uncertainty about profitability of collaboration, assess the value of available intellectual property and to bring suitable parties together for collaboration (Kodama, 2008). On this basis, the fifth hypothesis is:

H5. The adoption of practices for innovation ecosystem knowledge access positively influences the generation of financial and non-financial value for innovation intermediaries in collaborative projects

3.6. Practices for shaping the innovation ecosystem knowledge base

Collaboration is difficult when partners have diverse interests, goals and motivations. One way of overcoming this is through shaping the interests of actors within an innovation system to increase the chances of reaching a shared understanding and mutuality between the participating actors which is important for successful collaboration (West and Gallagher, 2006; Wallin and von Krogh, 2010; Tjong et al., 2015). Practices and routines aimed at sustaining influence over potential collaborators and influential decision makers are seen as the ‘political’ side of collaboration (Hardy and Phillips, 1998). During this process, innovation intermediaries externalise relevant knowledge to influence actions and interests of potential partners (Arnold et al., 2010). Thus, innovation intermediaries, in collaboration with other actors in the innovation system, often engage in helping to shape the strategic policy direction, which results in convergence around the interests of actors within the region or nation (Bouwen, 2002). Some even argue that developing consensus is one of intermediaries’ key functions (Etzkowitz, 2008; Meyer et al., 2017).

Nevertheless, there is no direct evidence to suggest that shaping the ecosystem would help intermediaries to generate internal value through collaborative projects (see Mazey and Richardson 2006) and indeed they may generate negative impacts by exposing intermediaries’ knowledge too much to external parties, with intermediaries losing their competitive advantage (Dyer and Nobeoka 2000). Yet, considering the specific role of intermediaries as those who bring together partners with different knowledge bases (Agogué et al., 2013a; Hargadon and Sutton, 1997), it could be argued that these practices aimed at shaping the knowledge base of the ecosystem increase the chance of securing projects and finding partners with common interests, thereby leading to value generation. This leads to the final hypothesis:

H6. The adoption of practices that shape the knowledge base of an innovation ecosystem positively influences financial and non-financial value generation by intermediaries in collaborative projects

These six hypotheses were then used in the study to investigate how practices adopted by innovation intermediaries enable them to generate financial and non-financial value. Please note that, considering the exploratory nature of this study, signs are merely preliminary expectations about the causality (Fig. 1).

4. Methodology

4.1. Methodological framework

The empirical base is a study of EU based RTOs that investigated how knowledge-based practices adopted by innovation intermediaries influence the generation of financial and non-financial value during their engagement in EU funded projects, undertaken in collaboration with businesses, universities, public research organisations and RTOs (Andersen and Blanc, 2013). RTOs are a particular form of innovation intermediaries with origins around public ownership and the need to support the transfer of knowledge between science and industry. Hales (2001, p.4) has defined them as “organisations with significant core

government funding which supply services to firms individually or collectively in support of scientific and technological innovation and which devote much of their capability to remaining integrated with the science base”. Most RTOs, such as the Fraunhofer-Gesellschaft, were created to facilitate the transfer of knowledge from the science base to firms and have an applied research focus (van Lente et al., 2003). The majority of RTOs operate between a technical science base, on the one hand, and manufacturing industries, on the other; what they define as “hard intermediary” functions, such as technology testing. However, the functions of RTOs have broadened over time (Miller, 2014) to include more soft forms, such as business service activities around networking and consultancy (EARTO, 2017, 1). Research has highlighted that there is no single ‘ideal type’ RTO, and that each must be tailored to its innovation environment (Miller, 2014). Thus, RTOs are a significant type of innovation intermediary and key actors within the wider European system of innovation. RTOs receive about 30% of their income from government, 30% from competitive public and private grants and the rest from industry as contract income (Martínez-Vela, 2016). RTOs also coordinated a third of all EU research and innovation projects (Arnold et al., 2010) and led some 258 Horizon 2020 projects in 2015 (EARTO, 2017, 7). RTOs engage in a range of tasks in these EU projects, ranging from bringing parties together for collaboration to providing applied research to the consortium. A database of RTOs compiled by the Big Innovation Centre has identified that there are 122 European RTOs in total distributed across the seven EU member states with eight types of organisation (Andersen and Blanc, 2013) was the empirical base for the survey.

A mixed method approach to improve the validity of the overall study (Tashakkori and Teddlie, 1998; Bisbe et al., 2007) was adopted with three main stages: (1) an initial qualitative data gathering stage; (2) an online, quantitative survey; and, (3) a follow-up, in-depth interview phase. The data gathered through initial interviews were checked against theoretical explanations to validate the conceptual framework and to develop the questionnaire survey, which was important since the paper addresses an underexplored topic (Edmondson and Mcmanus, 2007; Autio et al., 2013). A total of 68 responses were received back, of which 59 were then usable after data cleaning, representing a response rate of 48.3%. The non-response bias test revealed that there is no significant difference between respondent RTOs and the full empirical base of 122 RTOs in terms of type of centre [$X^2(5, 179) = 2.217, p = 0.818 > 0.05$], sector of operation of RTOs [$X^2(3, 179) = 1.546, p = 0.672 > 0.05$], turnover of RTOs (i.e. categorised as small medium and large) [$X^2(2, 179) = 3.308, p = 0.191 > 0.05$], and number of employees (i.e. categorised as small medium and large) [$X^2(2, 179) = 1.272, p = 0.529 > 0.05$].

The third phase interviews generated context-specific and in-depth understanding of the causality derived from the survey data (Downward and Mearman, 2007). Finally, a validation event with survey participants and a group of their collaborators, representing the ecosystem, was conducted to further verify the study findings. The adoption of this sequential mixed method design improved the validity and reliability of the overall study.

4.2. Variable construction

The main source of data was derived from the online survey and the findings of in-depth interviews were used to validate the former (Kim and Miner, 2007; Autio et al., 2013). In addition, several control variables capturing the characteristics and innovation approaches of innovation intermediaries were also included in the final model.

4.2.1. Dependent variables

The dependent variables are the four types of internal value innovation intermediaries generate for themselves in collaborative projects, namely, financial value and the three non-financial of knowledge, market and network based value. The variable on financial value was

Table 1
Variable construction of non-financial value: questionnaire items.

Non-financial values	Factor loading
Question: Please tick on a Likert Scale of 1–5 (1- Not at all, 2- Very low, 3- Low, 4- High, and 5- Very high) to indicate the extent to which your organisation generated following benefits (i.e. internal value) when engaging in EU FP 7 projects during last three years.	
Knowledge based internal value (Cronbach's Alpha = 0.731; CR = 0.748; AVE = 0.743)	
Developed new and advanced knowledge	0.820
Developed other disciplinary knowledge	0.745
Developed new research based capabilities required to deploy new knowledge	0.734
Developed new management capabilities required to deploy new knowledge	0.673
Market based internal value (Cronbach's Alpha = 0.824; CR = 0.816; AVE = 0.737)	
Developed new equipment and technologies	0.789
Developed products and services	0.772
Produced intellectual property (e.g. patents)	0.759
Developed capabilities to engage in 'closer' to market research	0.720
Developed capabilities to help industry to pursue their market-oriented goals	0.715
Developed capabilities to help industry to gain commercial knowledge	0.668
Network based internal value (Cronbach's Alpha = 0.645; CR = 0.684; AVE = 0.722)	
Gained access to global markets	0.756
Developed networks of future value	0.793
Developed capabilities to help industry to access international markets	0.617

derived by requesting respondents to state the average annual income generated by their organisation (i.e. with respect to a particular centre, but not the group of centres) through EU Framework programmes (FP) during last three years. Since the data was collected in 2014, the period covered was 2011–13. Similarly, focusing on the same time span, variables for the three non-financial types of value were constructed by requesting respondents to state the extent to which they have generated specific benefits as a result of their engagement in EU projects on a Likert Scale of 1–5. These specific benefits representing each type of non-financial value were identified by checking the findings of initial interviews against the theoretical framework. These responses clearly supported the conceptual development of three non-financial values (Section 2.1), thus used in the questionnaire survey to gather information on internal value creation.

In terms of the reliability and validity of the measures internal consistency and uni-dimensionality were tested to assess the possibility of generating a single score for each non-financial value by aggregating the ratings of different benefits. The factor analysis resulted in generating only one factor with an Eigen value more than 1 for knowledge (2.22, 55.50%), market (3.270, 54.5%) and network (1.581, 52.71%) based value (Table 1). Cronbach's Alpha for knowledge, market and network based values were 0.731, 0.824, and 0.645 respectively, indicating an acceptable level of internal consistency among items (i.e. benefits) used to construct three variables. The Composite Reliability (CR) (Chin, 1988) and Average Variance Extracted (AVE) (Fornell and Larcker, 1981) indices being more than 0.6 and 0.7 respectively further confirms the reliability of the measures and AVE also confirms the convergent validity. All these results indicate the suitability of variables constructed to measure three types of non-financial value.

4.2.2. Independent variables

Independent variables to represent five of the six knowledge-based practices were constructed using 13 practices identified from the literature (Sections 3.1–3.6), validated through initial interviews. During initial interviews it was evident that the practices adopted by RTOs would not drastically change at least during one EU framework programme. Since the data was gathered in 2014, the data on knowledge-

based practices is those adopted during the EU Framework Programme 7 (FP7) ran from 2007 to 2013. These practices were presented to the respondents who were requested to state to what extent they would adopt each practice on a 1–5 Likert scale. In relation to 'innovation ecosystem knowledge influence' it was evident during initial interviews that different RTOs use different routes to shape the knowledge base of the European system of innovation, which may differently influence value creation. A total of 18 such sources were identified and respondents were requested to state the extent of use on a Likert scale of 1–5. The reliability and validity of the measures were further confirmed by empirical evidence. The first five variables of knowledge routines and practices were derived by performing a Principal Component Analysis (PCA) on the 13 practices. Five components with Eigen value ≥ 1 were identified (Table 2). The Kaiser-Meyer-Olkin Measure is 0.655 (> 0.5); indicating that the patterns of correlations are relatively compact and factor analysis should yield distinct and reliable factors. The five components explain 70.25% of variance (i.e. C1–27.8%, C2–14.03%, C3–11.46%, C4–9.4%, C5–7.48%). The CR and AVE indices being more than 0.5 further confirms the reliability of the measures and AVE also confirms the convergent validity (Table 2).

A second PCA was conducted to construct variables for the sixth knowledge-based practice, ecosystem knowledge influence, which resulted in identifying five components with high factor loading (i.e. > 0.5). Kaiser-Meyer-Olkin Measure of Sampling Adequacy was 0.763 and 78.307% variance was explained by the five components. The first component (Table 3) was identified as influencing through active involvements in EU activities and membership-based network organisations (for example, trade associations), the second component represents influence exerted from written media communication, the third component indicates participating in expert advisory groups, the fourth the influence made through collaboration with external bodies (such as EU liaison offices and universities) and the fifth component illustrates the influence felt by the use of media events. It was analysed how the level of use of these five types of routes determine intermediaries' ability to generate financial and non-financial value.

4.2.3. Control variables

Several control variables capturing the characteristics of innovation intermediaries and their innovation approaches were used. The general characteristics of innovation intermediaries may influence value generation in EU projects. Turnover (i.e. average annual turnover during last three years; Hauser, 2010), age (as an indicator of experience; Bruneel et al., 2010), sector of operation, and number of employees engaged in EU activities (Fontana et al., 2006; Kirkels and Duysters 2010), together with variables covering RTOs' FP7 engagement, were all controlled for. Thus, the extent to which innovation intermediaries collaborate with different actors in an ecosystem may determine their ability to generate value through collaboration (Lee et al., 2010). For instance, collaborating with large firms provides innovation intermediaries with more economic advantages compared with universities and small firms (Wright et al., 2008; Huizingh, 2011; Howells et al., 2012) due to large firms' capacity to develop long-term relationships and the size of their resource base (Huizingh, 2011). Nevertheless, large firms may have less need for intermediaries. By contrast, small and medium-sized enterprises (SMEs) and universities may have a higher reliance on innovation intermediaries (Yusuf, 2008; Lee et al., 2010; Howells et al., 2012) due to their need to overcome organisational and cultural issues of dealing with increased external contacts (Van de Vrande et al., 2009). Hence, intermediaries may have a greater chance to interact with SMEs and universities. Past studies on RTOs suggest that RTOs differ in terms of their collaborators. Whilst some RTOs seem to collaborate with large firms to a greater extent, other RTOs seem to focus on developing a stronger network with local small businesses (Albors et al., 2014), which would indeed impact on the type of internal value they generate. Hence, the extent to which innovation intermediaries collaborate with different actors in an EU project was

Table 2
PCA on the use of knowledge-based practices: questionnaire items.

Statements	Component				
	1	2	3	4	5
Knowledge capitalisation (Cronbach's Alpha = 0.794; CR = 0.856; AVE = 0.549)					
1. Capitalise on the personal networks of staff when engaging in EU Framework programmes	0.889	-0.082	0.029	-0.018	-0.023
2. Have a dedicated team working on EU engagements	0.785	-0.008	-0.155	0.289	0.038
3. Make an effort to retain those employees with successful EU experience	0.725	0.334	0.142	0.036	0.056
4. In EU consortia, engage with partners with whom you have good relationships	0.691	0.105	0.171	-0.173	-0.115
5. Capitalise on relationships with local/national government	0.578	-0.060	0.125	0.469	0.259
Knowledge advancement (Cronbach's Alpha = 0.554; CR = 0.616; AVE = 0.802)					
6. Engage in advancing core competences	0.249	0.843	-0.103	-0.095	-0.091
7. Recruit a portfolio of employees with different skills (e.g. basic research, applied research, management, etc.) as a strategy to advance knowledge and skills	-0.136	0.760	0.308	0.205	0.253
Knowledge spanning (Cronbach's Alpha = 0.672; CR = 0.614; AVE = 0.796)					
8. Accessing university knowledge to achieve project outcomes	0.231	-0.111	0.868	0.203	0.022
9. Engage with partners from different disciplines to make use of their knowledge to achieve project outcomes	-0.016	0.339	0.723	-0.081	-0.259
Innovation ecosystem knowledge access (Cronbach's Alpha = 0.591; CR = 0.5870; AVE=0.711)					
10. Use cross EC networks such as ERRIN and other digital platforms to find potential partners and to understand them better	-0.134	-0.036	0.246	0.771	-0.032
11. Develop relationships with key business players and other potential partners in the market	0.283	0.150	-0.215	0.651	-0.252
Knowledge worker empowerment (Cronbach's Alpha = 0.549; CR = 0.553; AVE = 0.618)					
12. Your organisation's staff has freedom of deciding their EU engagements (e.g. what to engage in, with whom to engage in, how to engage in etc.)	-0.069	0.003	-0.218	-0.238	0.722
13. Provide freedom for your employees to work in your member organisations in the form of a placement	0.449	0.270	0.131	0.287	0.514

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 9 iterations.

controlled for.

Second, the innovation strategy adopted by innovation intermediaries may also influence value creation (Kirkels and Duysters 2010). Whilst traditionally innovation intermediaries have been known for adopting 'technology push' approach, there has been an increasing trend towards adopting 'market pull' approach (or a combination of

both the approaches) each of which have different consequences on value creation (Lichtenthaler and Ernst, 2008). Indeed, research by Polzin et al. (2016, 41–42) has shown a key function now of innovation intermediaries is in reducing uncertainty about future market opportunities for new technologies and in niche market development for them. Respondents stated the extent to which they adopt 'technology

Table 3
PCA on the use of sources to influence ecosystem knowledge: questionnaire items.

Statements	Component				
	1	2	3	4	5
Direct EU involvements and memberships (Cronbach's Alpha = 0.910; CR = 0.830; AVE = 0.699)					
1. Meeting EU policy makers	0.750	0.086	0.413	0.102	0.261
2. European Technology Platforms and structures associated with Public Private Partnerships	0.621	0.160	0.385	0.174	0.327
3. Participating in EARTO	0.603	-0.052	0.508	0.282	0.282
4. Participating in membership networks other than EARTO	0.512	0.121	0.604	0.111	0.354
5. Participating in EU investment plan development groups	0.784	0.232	0.160	0.176	0.025
6. Direct tenders from EC – Policy related	0.727	0.193	0.398	0.196	-0.021
7. Through trade associations	0.881	0.127	0.086	0.054	0.067
Written communication (Cronbach's Alpha = 0.883; CR = 0.859; AVE = 0.786)					
8. Through joint publications	-0.018	0.579	0.352	0.146	0.552
9. Through press releases	0.240	0.842	0.077	-0.025	0.328
10. Through newsletters	0.077	0.917	0.095	0.126	0.081
11. Social media (e.g. Twitter, Websites, Blogs, etc.)	0.257	0.805	0.056	0.139	0.211
Expert advisory groups (Cronbach's Alpha = 0.713; CR = 0.618; AVE = 0.805)					
12. Participating in expert panels/workgroups	0.282	0.077	0.764	0.019	0.091
13. Participating in selecting/referee panels	0.279	0.148	0.845	0.033	-0.065
Through external bodies (Cronbach's Alpha = 0.801; CR = 0.712; AVE = 0.825)					
14. Through your business and university network of contacts	0.233	0.126	0.030	0.772	0.148
15. Through connections with local or national governments	0.078	-0.052	-0.028	0.891	-0.073
16. Through EU liaison offices	0.129	0.216	0.183	0.812	0.081
Media events (Cronbach's Alpha = 0.761; CR = 0.620; AVE = 0.816)					
17. Through conferences	0.070	0.320	0.212	0.132	0.796
18. Through industry fares	0.264	0.227	-0.102	-0.040	0.836

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 7 iterations.

push' (develop a technology to a marketable product or service), 'market pull' (project being induced by the market need) and a 'combined approach', when engaging in EU framework programmes using a 1–5 Likert Scale. Another indication of the heterogeneity of their innovation profile is the technology readiness levels of projects, in which the higher levels of readiness indicate closer to the market orientation of the organisation (Mankins, 1995). In order to control for this, respondents were requested to state the highest Technology Readiness Level (TRLs)¹ they engaged in when undertaking EU FP7 programmes. The data revealed the presence of three groups: with those reaching up to TRL 4; those up to TRL 6; with the rest on TRL 7. None worked at TRL 8 or 9. A categorical variable with these three groups was then developed to profile this. Third, the role of innovation intermediaries in collaborative projects could vary from acting as a networking agent and providing associated coordination services (Batterink et al., 2010) to undertaking basic research and delivering associated training (Kodama, 2008) and conducting 'closer' to market research and providing related technology technological services and resources (Tran et al., 2011). As innovation intermediaries may engage in a combination of these activities to a different degree, respondents were requested to rate each types of contributions to indicate the extent to which they provided these in EU FP7 consortia.

4.3. Estimation strategy

The effect of knowledge-based practices adopted by innovation intermediaries on value generation was then analysed. Pearson correlation revealed a significant positive correlation between three dependent variable of non-financial value (for knowledge and marketing $r = 0.510$, $n = 59$, $p = 0.000$: knowledge and networking $r = 0.604$, $n = 59$, $p = 0.000$: marketing and networking $r = 0.524$, $n = 59$, $p = 0.000$). A Multivariate Analysis of Covariance (MANCOVA) was therefore performed that took into account interactions between dependent variables in a context of multiple dependent and independent variables with both fixed variables and covariates (Meyers et al., 2006). There was no theoretical evidence to suggest using different sets of explanatory variables for different dependent variables (i.e. non-financial value), which to justify the use of Seemingly Unrelated Regression (SUR) over MANCOVA model (Zellner, 1962). A separate univariate analysis was then run to investigate the influence of knowledge-based practices on the generation of financial value.

4.4. Robustness checks

Variance Inflation Factors and correlation analysis revealed that there is no evidence of multi-collinearity. Also in relation to MANCOVA, Box's Test of Equality of Covariance Matrices was found not to be significant (Value = 76.968, $p = 0.271 > 0.1$), indicating the ability to pool variance-covariance matrices without any concerns and the normal distribution of the sample. Similarly, Levene's Test of Equality of Error Variances was also not significant (Knowledge $F(11, 47) = 1.297$, $p = 0.256 > 0.05$, Market $F(11, 47) = 1.869$, $p = 0.069 > 0.05$ and Network $F(11, 47) = 1.969$, $p = 0.054 > 0.05$), satisfying MANCOVA assumptions. The plot of residuals further confirms the satisfaction of homogeneity assumption (Knowledge $p = 0.200 > 0.05$, Market $p = 0.091 > 0.05$ and Network $p = 0.200 > 0.05$). Levene's Test of Equality of Error Variances was not significant for the Univariate analysis (i.e. to

investigate the effect of knowledge-based practices on financial value creation) $F(11, 47) = 0.990$, $p = 0.469 > 0.05$, indicating the suitability of the model. The plot of residuals further confirms the satisfaction of homogeneity assumption ($p = 0.051 > 0.05$).

Measures were undertaken to check the problem of endogeneity that could occur when independent variables might not be endogenous (Shadish et al., 2002). Firstly, the sequential mixed method design helped improve both internal and construct validity. Second, as presented in Section 4.1, a non-response bias test revealed that there is no significant difference between respondent RTOs and the full empirical base of 122 RTOs. Third, satisfactorily meeting Cronbach's Alpha, CR, AVE, Kaiser-Meyer-Olkin Measure of Sampling Adequacy and factor loading criteria confirmed the reliability and validity of the chosen constructs, minimising measurement errors. Fourth, measures were taken to avoid reverse causality. Even though the impact of practices on internal value was investigated, it could be argued that reverse causality is possible, where organisations decide to introduce practices if they are not generating enough internal value from their engagements. Nevertheless, initial interviews revealed that since EU framework programmes are long-term, practices were unlikely to be changed over the short term. Thus, the extent to which RTOs adopted a given list of practices during the FP 7 programme was gauged with DV based on value generation over the last three years of the programme (2011–3), increasing the likelihood that the practices adopted cause the values rather than vice versa. This structure therefore provides a good time frame from which to evaluate the influence of specific practices. Fifth, measures were undertaken to address common method bias. Information was cross-validated from secondary information derived from the turnover of each organisation (Y) by multiplying it with the survey data on the percentage of turnover derived from EU projects (Z) in order to reduce common method bias. Additional questions were asked that mixed up independent and dependent variable related questions so that the respondents were unable to know the antecedents and outcome variable. The highest correlation among the constructs was also statistically checked (see Appendix A). The highest value was 0.640 (with a majority less than 0.3), which is low (Bagozzi et al., 1991). Common method variance, using Harman's one-factor analysis (Podsakoff and Organ, 1986) showed that the 10 factors extracted with eigenvalues above 1.0 (74.98% of the total variance) were explained by the first factor, which accounted for only 23.47%. Sixth, since our model combines factor analysis and regression analysis, Structural Equation Modelling (SEM) was conducted for the univariate analysis to further check the model fit (Miles, 2003). The results on the influence of practices on internal value were similar, except for the significant negative effect of two elements relating to innovation ecosystem influence that were not significant in the univariate analysis yet reported a negative influence. This similarity enabled us to use the model fit measures of SEM to further support the findings of the univariate analysis.² Seventh, as many theoretically justified control variables as possible were included to avoid the omitting of a regressor (Rubin, 2008; Shadish et al., 2002), which is recommended despite the cost of reduced efficiency (i.e., higher standard errors; Cameron and Trivedi, 2005). The results of SEM discriminant validity (i.e. measurement model of a construct is free from redundant items) test found no items with high Modification Indices (MI), confirming that our control variables are not redundant (Jöreskog and Sörbom, 1984). This comprehensive approach of robustness checks confirm that the model does not suffer from endogeneity and that the model is robust.

¹ TRL 1 – Concept proposed with scientific validation; TRL 2 – Application and validity of concept validated or demonstrated; TRL 3 – Experimental proof of concept completed; TRL 4 – Production validated in lab environment; TRL 5 – Basic capability demonstrated; TRL 6 – Process optimised for production rate on production equipment; TRL 7 – Capability and rate confirmed; TRL 8 – Full production process qualified for full range of parts; TRL 9 – Full production process qualified for full range of parts and full metrics achieved.

² GIF = 1.00 (> 0.95); AGFI = 0.989 (> 0.95) (Tabachnick and Fidell, 2007); RMSEA = 0.000 (< 0.05), $p = 0.892 (> 0.05)$ (Byrne, 1998); TLI = 1.548 (> 0.95); IFI = 1.001 (> 0.95); CFI = 1.000 (> 0.95) (Tabachnick and Fidell, 2007); GMIN/DF = 0.021 ($p = 0.884$) (< 2) (Carmines and McIver, 1981).

Table 4
Descriptive statistics I

Descriptive Statistics				
	Minimum	Maximum	Mean	Std. Deviation
Dependent variables				
Knowledge based value	1.75	4.75	3.83	0.58
Market based value	2.40	5.00	4.01	0.65
Network based value	2.67	5.00	3.85	0.59
Financial value	0.00	5600000000.00	795820359.32	1276972477.44
Characteristics of RTOs				
Age of RTO	3.00	100.00	42.49	27.93
Number of employees in EU engagement	1.00	800.00	92.75	167.74
Turnover of RTO	400000.00	700000000.00	87896785.63	141815294.21
Nature of contribution by RTOs for EU activities				
Applied research and technology service provision	1.00	4.75	3.36	0.69
Act as a networking agent	2.50	5.00	3.62	0.66
Engage in basic research and training	1.00	4.50	2.86	0.61

Table 5
Descriptive statistics II.

% of respondents responding to each value on the Likert scale – the higher the score the greater the involvement

	1 Never	2 Rarely	3 Sometimes	4 Often	5 Always
The extent to which RTOs adopts different innovation approaches in EU projects					
Technology push	0.0%	5.1%	20.3%	71.2%	3.4%
Market pull	3.4%	11.9%	20.3%	44.1%	20.3%
Combined	1.7%	1.7%	10.2%	54.2%	32.2%
The extent to which RTOs collaborate with different actors in EU projects					
Universities	0.0%	1.7%	10.2%	79.7%	8.5%
Large Firms	0.0%	6.8%	23.7%	55.9%	13.6%
Medium Firms	1.7%	5.1%	33.9%	44.1%	15.3%
Small Firms	5.1%	22%	28.8%	44.1%	0.0%
Micro Firms	13.6%	40.7%	30.5%	13.6%	1.7%
RTO	0.0%	11.9%	20.3%	37.3%	30.5%

5. Results and discussion

The role of RTOs in the projects ranged from engaging in basic research and associated training, acting as a networking agent, engaging in applied research to technology service provision, with a majority mentioning a greater involvement in latter two (Table 4). A majority of RTOs (86.4%) also reported adopting a combination of both ‘technology push’ (i.e. develop a technology to a marketable product or service) and ‘market pull’ (project being induced by the market need) approaches (Table 5), although ‘market pull’ activities came a strong second above that of ‘technology push’ factors (see Polzin et al., 2016). Of the RTOs, a third (33.9%) had engaged in projects up to TRL4, 28.8 percent up to TRL 6 and 37.3 percent up to TRL 7, representing different levels of market readiness levels of project outcomes. The innovation intermediaries were more likely to collaborate with universities, large and medium-sized firms and other RTOs, rather than small or micro firms (Table 5).

Moving on to focus on internal value generation by intermediaries from client interaction, the descriptive statistics also indicated that in addition to financial value generation, innovation intermediaries also generated knowledge (M= 3.83; SD= 0.58), market (M= 4.01; SD= 0.65), and network (M= 3.85; SD= 0.59)³ based value (Table 4). The independent variables constructed using factor scoring indicates that the respondents to a varying degree adopted the six types of knowledge-based practices, further supporting the need to investigate the influence

of the adoption of these practices on value creation. A univariate analysis for financial value and MANCOVA for knowledge, market and network value creation was conducted (Table 6).

The results revealed that different practices influence the generation of different types of value. The only exception here was for practices adopted for knowledge capitalisation, which significantly positively influenced all four types of value creation (Practice 1, Table 6), supporting H1. Since innovation intermediaries extensively interact with several external parties, capitalising on existing trustworthy relationships, minimise the risk of failure and increase their ability to generate new knowledge by combining existing knowledge bases. Innovation intermediary employees engaged in EU projects seem to develop invaluable experience which is tacit and difficult to transfer and RTOs made special efforts to retain them. Indeed, of the six knowledge-based practices, only knowledge capitalisation was found to have a significant positive influence on market value creation. This highlights the need for capitalising proven and established knowledge bases inside innovation intermediaries and/or strong networks to produce marketable products and services.

In relation to the H2, it is evident that practices adopted for knowledge advancement have a significant positive influence only on knowledge and financial value creation (Practice 2, Table 6). In-depth interviews validated this result suggesting that while knowledge advancement improves RTOs’ ability to secure funding, and therefore financial value, there is a lag period for newly recruited staff to generate market or network value. This means that only when new knowledge is appropriately integrated into the existing knowledge base is market and network value generated, which is captured in the H1 as a form of capitalising on existing knowledge.

Interestingly, practices associated with the knowledge-spanning role had no significant positive influence on any type of value, except for the significant negative influence on market value (Practice 3, Table 6), rejecting H3. In-depth interviews revealed that RTOs mainly ‘access’ unrelated knowledge that is non-adjacent to their knowledge base, which they do not intend to acquire and internalise, but use only to achieve project outcomes. Hence, these interactions may not generate additional value other than achieving direct project outcomes. However, it may also be a lag effect in that there are considerable ‘start-up’ costs to create sunk capital in acquiring new knowledge which generate negative impacts over the short term, but may lead to longer-term value generation. RTOs have also highlighted the difficulties they face when interacting with collaborators from different disciplines, whose knowledge is not familiar to RTOs, and thus, unless these players could be of future value, interaction would be limited to achieving specific project outcomes, which may explain the results of the regression analysis. On this basis, therefore, if RTOs perceive that these players

³ The value range from 0 to 5 and the higher the mean, the greater the non-financial value generated.

Table 6
MANCOVA and univariate analysis.

Independent variables	Dependent Variable			
	MANCOVA			Univariate analysis
	Knowledge Value	Market Value	Network Value	Financial Value
R ²	0.904	0.886	0.858	0.930
Adjusted R ²	0.746	0.700	0.627	0.816
Correct model				
Intercept	6.541** (.953)	4.532** (1.167)	6.664** (1.173)	2831804952 (1762828643.2)
Practices adopted				
1. Knowledge capitalisation	0.202** (.078)	0.278** (.095)	0.328** (.096)	327355109.1** (146998770.4)
2. Knowledge advancement	0.214** (.078)	−0.079 (.095)	0.091 (.096)	355049550.3** (153226466.4)
3. Knowledge spanning	−0.016 (.071)	−0.236** (.087)	0.008 (.087)	138094579.6 (132681604.5)
4. Knowledge worker empowerment	−0.227** (.076)	−0.229** (.093)	−0.168* (.093)	−110381422.8 (139300095.5)
5. Innovation ecosystem knowledge access	0.186** (0.067)	0.041 (0.082)	0.357** (0.083)	283902599.8** (128149691.9)
6. Innovation ecosystem knowledge shaping				
Direct EU involvements and memberships	0.200** (0.079)	−0.345** (0.097)	−0.026 (0.098)	−271298400.1 (159128850.1)
Written communication	0.255** (0.111)	−0.457** (0.136)	0.278* (0.137)	−277295774.0 (206814528.8)
Expert advisory groups	0.198** (0.082)	−0.045 (.100)	0.196* (0.101)	−357856699.4** (153641960.4)
Through external bodies	0.319** (0.077)	−0.168* (0.094)	0.208** (0.095)	−180017052.8 (145053505.2)
Media events	−0.194** (0.074)	−0.176* (0.090)	.001 (0.091)	−96286262.4 (134138673.4)

Results after controlling for the characteristics of RTO, and other activities defining their role in EU projects such as the nature of contribution by RTOs, innovation approaches adopted by RTOs, the extent of engagement with different types of actors, sector of operation of RTOs and the extent of commercialisation engagement by RTOs (see Appendix B for full model including control variables).

** *p* < 0.05.

* *p* < 0.1.

from other disciplines would be of future value, they make an effort to strengthen the relationship, the use of the knowledge of whom then becomes capitalising on knowledge vested in close collaborators, captured in the H1.

Practices adopted to empower employees, such as giving freedom for staff to decide what EU projects to work on, with whom and what practices should be involved in such engagements, had significant negative influence on all the non-financial value creation and non-significant, but still negative, influence on financial value creation (Practice 4, Table 6), supporting H4. Interviews revealed that since innovation intermediaries are by their nature outward-looking, having some control over employee engagement is essential. Therefore, there appears to be a dynamic balance between employee empowerment and centralised control by RTOs that enable them to generate value. This is further justified as RTOs engage in EU projects not only as a source of income but also as a source of long-term value creation in knowledge, network and market capability development.

Practices adopted to access innovation ecosystem knowledge (H5) significantly positively influence all the types of value creation apart from market-based value (Practice 5, Table 6). This was mainly associated with the role of RTOs as network builders, in which knowledge of the ecosystem actors enable RTOs to bring together key players for EU projects. This increases the chances of being successful both in terms of securing funding as well as delivering output. Having the opportunity to work with these players enable RTOs to develop new knowledge and network of future value. Not having a positive influence on market value creation might be because of other compatibilities or preconditions needed to be fulfilled (as discussed in relation to H1) to generate marketable products and services.

Innovation-ecosystem knowledge shaping (H6), interestingly, had a significant positive influence on knowledge and network value creation, but not on market or financial value creation (Practice 6, Table 6). All the sources used to influence innovation ecosystem knowledge, except for media events, positively influenced knowledge value creation. Written communication, expert advisory groups and influence made through external bodies have a positive impact on network value

generation. Influencing innovation system ‘architecture’ (Tjong et al., 2015), including EU project calls, enabled RTOs to improve the chances of developing knowledge of value during projects. Such influences have also been made in collaboration with other types of innovation intermediaries and like-minded organisations, which in turn become project collaborators leading to strengthening the network of future value. However, any source used to influence innovation ecosystem knowledge does not seem to positively influence financial or market based value creation.

6. Conclusions

6.1. Key findings and implications

There has been a growing body of knowledge and research surrounding the role and impact that innovation intermediaries have on their client organisations, but little is known about the internal value creation of innovation intermediaries from their interaction with their clients. This is a non-trivial issue because if innovation intermediaries do have an important impact on innovation system and network ‘health’ and on the specific performance and growth of client enterprises and organisations, it is important to understand what helps to sustain and develop their own long-term growth and development. As Knockaert and Spithoven (2014, 1400) have suggested in their analysis of innovation intermediaries and the role of absorptive capacity one needs to understand the capacities of both client firms and technology intermediaries to understand the whole value generation process.

Our results show that it is the knowledge attributes and routines of intermediaries’ staff and their attitudes (Gavetti, 2005; see also Tortoriello et al., 2012, 2014) as well as the support given to them in terms of knowledge capitalisation (but not practices allowing staff more empowerment) that have the most significant impact on value creation within innovation intermediaries. This finding is perhaps not surprising given that ultimately knowledge is held at an individual level. How an innovation intermediary harnesses local personal knowledge and personal knowledge networks (Huber, 2012) is therefore essential for its

long term growth and development. This is also true in terms of the impact of intermediaries on their client enterprises and organisations where the underlying absorptive capacity of both sets of organisations also inherently lies. This is why perhaps knowledge advancement is more limited in its impact, centred on financial and knowledge value creation, as the absorption and internalisation of new knowledge and knowledge practices take time. Knowledge spanning activities appear to be of little (or indeed negative in the case of market value) importance in terms of value generation to intermediaries. This indicates that it is the spanning of market knowledge with their existing technical competence that is important for the intermediaries themselves. Technical knowledge is therefore a condition for their other activities but not an immediate driver for innovation intermediaries.

By contrast, the benefit that innovation intermediaries generate as network integrators and shapers in terms of the architecture of the knowledge and innovation system is one of the most striking results. This is reflected in other studies of intermediaries that are emerging with, for example, the study [Tjong et al. \(2015\)](#) on the role of innovation intermediaries on the development of bicycle technology within the Netherlands and how they helped change the institutional architecture of the national sectoral system. The role of innovation intermediaries as network builders, bridgers ([Caloffi et al., 2015](#)) and innovation system architects ([Klerkx and Leeuwis, 2008b](#)), with no apparent impact on their financial bottom line, but one which enhances their long term capabilities and attraction, is their most significant policy impact. This, together with their direct impact on enhancing the performance of their client enterprises and organisations, is where innovation intermediaries continue to build their presence within the innovation system of nations, regions and sectors.

6.2. Limitations and further research

The study has had to confront a number of issues, which must be acknowledged when reviewing the research, of which two are most significant here. The first set revolve around lag effects and this can be seen on a number of levels. As noted above (Section 5.1) a number of

effects, such as the RTOs knowledge-spanning role are not observed in the data because the time period being considered is too short. In addition, the different value types and their impact on RTOs are also affected by time and periodicity. Thus, as has been seen, shorter term financial value ‘first order’ effects are more prominent but taking a longer term view ‘second order’ effects associated with knowledge, markets and networks could become much more significant. The second set of issues is how the generation of internal value and its variable ‘geometry’ influences the future behaviour and routines of RTOs as a subset of innovation intermediaries. There will be positive and negative feedback loops on RTO behaviours and practices which are not explored here, again in part because of temporal issues. Both these limitations indicate the need for research in this topic. Qualitative data from the RTO survey is available and this may point to further rounds of data collection, especially on a longitudinal basis. More fundamentally, the research points to a lack of the interaction between value generation for both the clients of intermediaries *and* intermediaries themselves and how this shapes the trajectory of the market or the sector and the ‘loosely coupled’ feedback loops between the two groups. This is important in policy terms if we are to understand how innovation intermediaries may be used to leverage benefits for the wider national or regional innovation systems as well as just for their clients.

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Appendix A. Correlation matrices between each IV and DV.

	Annual turnover	tor_Number_C	Staff_Size_EU	Age	TRL_Combinations_C	Tech_Push	Market_Pull	Combined_Inno	Partners_Universities	Partners_Large firms
Annual turnover	1									
Sector_Number_C	0.301	1								
Staff_Size_EU	0.640	0.289	1							
Age	0.432	0.285	0.327	1						
TRL_Combinations_C	0.001	0.260	0.240	0.420	1					
Tech_Push	0.147	0.175	0.169	0.236	0.317	1				
Market_Pull	-0.022	0.223	0.049	0.298	0.402	0.286	1			
Combined_Inno	0.164	0.310	0.229	0.250	0.400	0.289	0.553	1		
Partners_Universities	-0.134	0.059	0.047	-0.069	-0.076	0.066	-0.033	-0.111	1	
Partners_Large firms	0.076	0.179	0.051	0.386	0.432	0.555	0.369	0.416	0.013	1
Partners_Medium firms	0.016	0.150	0.138	0.425	0.533	0.280	0.291	0.368	0.118	0.678
Partners_Small firms	-0.111	-0.019	-0.162	0.339	0.365	0.027	0.255	0.234	-0.024	0.304
Partners_Micro firms	-0.063	-0.121	-0.020	0.186	0.234	0.085	-0.003	-0.089	0.017	0.114
Partners_RTO	0.166	0.288	0.097	0.492	0.415	0.195	0.288	0.198	0.124	0.520
Contri_Ap_Research	0.185	-0.093	0.154	0.398	0.187	0.113	0.204	0.005	0.303	0.213
Contribution_networking	0.050	0.101	0.107	0.262	0.436	0.052	0.398	0.286	-0.144	0.369
Contri_Basic research	-0.173	-0.125	-0.004	-0.194	-0.083	-0.182	-0.152	-0.231	0.114	-0.103
EU_involvements	0.289	0.214	0.177	0.382	0.297	0.102	0.071	0.075	-0.141	0.366
Written com	0.058	-0.067	0.090	0.335	0.263	0.124	0.392	0.269	-0.247	0.363
Expert_advisory	-0.197	0.160	-0.112	-0.058	0.251	0.325	0.161	0.350	-0.137	0.502
External bodies	0.233	0.036	0.259	0.068	0.003	-0.128	-0.211	0.083	0.024	0.058
Influence Media – events	0.157	0.045	0.265	-0.035	0.043	0.047	-0.031	-0.030	0.044	-0.012
Know_Capitalisation	0.090	0.198	0.166	0.328	0.390	0.207	0.323	0.473	0.044	0.485
Know_Advancement	0.164	0.118	0.035	0.132	0.123	0.199	0.302	0.360	0.069	0.164
Tech_Know_Access	-0.119	0.008	-0.014	-0.222	-0.045	-0.394	0.054	-0.025	0.115	-0.387
Eco_Know_Access	0.180	0.132	0.100	0.056	0.066	0.311	0.010	0.084	-0.096	-0.055
Know_Comm_Dev	-0.028	0.085	0.068	-0.150	0.015	-0.096	-0.144	0.130	-0.035	-0.127
Know_Value	0.031	0.138	0.205	0.331	0.494	0.096	0.393	0.510	-0.045	0.244
Market_Value	0.030	0.178	0.034	0.341	0.515	0.316	0.464	0.488	-0.062	0.543
Network_Value	0.007	0.234	0.094	0.174	0.458	0.319	0.301	0.447	-0.045	0.364
Financila_Value	N/A	0.176	0.566	0.402	0.051	0.156	0.099	0.263	-0.157	0.151

	Partners_Medium firms	Partners_Small firms	Partners_Micro firms	Partners_RTO	Contri_Ap_Research	Contribution_networking	Contri_Basic research	EU_involvements	Written com	Expert_advisory	External bodies
Annual turnover											
Sector_Number_C											
Staff_Size_EU											
Age											
TRL_Combinations_C											
Tech_Push											
Market_Pull											
Combined_Inno											
Partners_Universities											

	Influence Media-events	Know_ Capitalisation	Know_ Advancement	Tech_Know_ Access	Eco_Know_ Access	Know_ Comm_ Dev	Know_Value	Know_Value	Know_Value	Know_Value
Partners_Large firms										
Partners_Medium firms	1									
Partners_Small firms	0.545	1								
Partners_Micro firms	0.353	0.633	1							
Partners_RTO	0.550	0.392	0.236	1						
Contri_ Ap_ Research	0.341	0.303	0.289	0.266						
Contribution_networking	0.550	0.394	0.337	0.494	1					
Contri_Basic research	-0.010	-0.094	0.108	-0.132	0.000	1				
EU_involvements	0.315	0.068	-0.022	0.252	-0.090	0.362	1			
Written com	0.429	0.411	0.470	0.441	0.246	0.527	0.000	1		
Expert_advisory	0.177	0.132	-0.008	0.211	-0.055	0.088	0.000	0.000	1	
External bodies	0.107	-0.106	0.090	0.166	-0.013	0.126	0.000	0.000	0.000	1
Influence Media – events	0.043	-0.033	0.069	0.103	0.344	0.181	0.000	0.000	0.000	0.000
Know_Capitalisation	0.531	0.378	0.328	0.574	0.136	0.571	0.000	0.000	0.000	0.000
Know_Advancement	0.202	0.148	-0.086	0.002	0.365	0.075	0.284	0.359	0.328	0.361
Tech_Know_Access	-0.306	0.004	-0.084	-0.091	0.071	0.030	-0.103	0.037	0.160	-0.085
Eco_Know_Access	-0.076	-0.158	0.090	0.109	0.088	-0.092	-0.337	-0.224	0.053	-0.029
Know_Comm_Dev	-0.132	-0.264	-0.280	-0.234	-0.340	0.022	-0.119	0.033	0.084	-0.007
Know_Value	0.338	0.183	0.040	0.274	0.079	0.381	0.214	-0.111	0.018	0.023
Market_Value	0.579	0.300	0.083	0.455	0.311	0.477	0.103	0.288	0.275	0.207
Network_Value	0.296	0.232	0.059	0.360	-0.017	0.401	0.043	0.252	0.323	0.031
Financila_Value	0.055	-0.061	-0.029	0.162	0.196	0.194	0.073	0.244	0.361	0.146
							-0.126	0.094	-0.167	0.171
Annual turnover										
Sector_Number_C										
Staff_Size_EU										
Age										
TRL_Combinations_C										
Tech_Push										
Market_Pull										
Combined_Inno										
Partners_Universities										
Partners_Large firms										
Partners_Medium firms										
Partners_Small firms										
Partners_Micro firms										
Partners_RTO										
Contri_ Ap_ Research										
Contribution_networking										
Contri_Basic research										
EU_involvements										
Written com										
Expert_advisory										
External bodies										
Influence Media – events	1									
Know_Capitalisation	0.065	1								

Know_Advancement	0.112	0.000	1		
Tech_Know_Access	0.128	0.000		1	
Eco_Know_Access	0.290	0.000			1
Know_Comm_Dev	-0.163	0.000		1	
Know_Value	-0.048	0.528	0.089	0.160	0.083
Market_Value	0.143	0.570	-0.038	0.079	-0.259
Network_Value	0.073	0.538	0.078	0.383	0.024
Financila_Value	0.186	0.229	0.178	0.180	-0.028
					1
					N/A
					N/A
					N/A

Appendix B. MANCOVA and univariate analysis: Including control variables

Independent variables	Dependent Variable			Univariate analysis	
	MANCOVA	Network Value	Financial Value	Network Value	Financial Value
Knowledge Value					
R ²	0.904	0.886	0.858	0.858	0.930
Adjusted R ²	0.746	0.700	0.627	0.627	0.816
Correct model					
Intercept	6.541** (.953)	4.532** (1.167)	6.664** (1.173)	6.664** (1.173)	2831804952 (1762828643.2)
Practices adopted					
1. Knowledge capitalisation	.202** (.078)	.278** (.095)	.328** (.096)	.328** (.096)	327355109.1** (146998770.4)
2. Knowledge advancement	.214** (.078)	-0.079 (.095)	.091 (.096)	.091 (.096)	355049550.3** (153226466.4)
3. Knowledge spanning	-0.016 (.071)	-0.236** (.087)	.008 (.087)	.008 (.087)	138094579.6 (132681604.5)
4. Knowledge worker empowerment	-0.227** (.076)	-0.229** (.093)	-0.168* (.093)	-0.168* (.093)	-110381422.8 (139300095.5)
5. Innovation ecosystem knowledge access	.186** (.067)	.041 (.082)	.357** (.083)	.357** (.083)	2839902599.8** (128149691.9)
6. Innovation ecosystem knowledge shaping	.200** (.079)	-0.345** (.097)	-0.026 (.098)	-0.026 (.098)	-271298400.1 (159128850.1)
Direct EU involvements and memberships	.255** (.111)	-0.457** (.136)	.278* (.137)	.278* (.137)	-277295774.0 (206814528.8)
Written communication	.198** (.082)	-0.045 (.100)	.196* (.101)	.196* (.101)	-357856699.4** (153641960.4)
Expert advisory groups	.319** (.077)	-0.168* (.094)	.208** (.095)	.208** (.095)	-180017052.8 (145053505.2)
Through external bodies	-0.194** (.074)	-0.176* (.090)	.001 (.091)	.001 (.091)	-96286262.4 (134138673.4)
Media events					
Control variables					
Characteristics of RTO					
Number of employees in EU engagement	.001* (.000)	.000 (.001)	.000 (.001)	.000 (.001)	941915.6 (923396.5)
Age of RTO	.005* (.003)	.000 (.003)	-0.005 (.003)	-0.005 (.003)	32960554.4** (15601447.6)
Turnover of RTO	-1.743E-9** (6.831E-10)	-8.110E-10 (8.368E-10)	-5.861E-11 (8.415E-10)	-5.861E-11 (8.415E-10)	7.199** (1.283)
Innovation Approach					
Technology push	-0.201* (.114)	-0.101 (.140)	.104 (.141)	.104 (.141)	-381554969.5* (221358273.9)
Market Pull	.073 (.075)	-0.042 (.092)	-0.004 (.092)	-0.004 (.092)	-135241334.6 (142252788.3)
Combined	-0.085 (.135)	.327* (.165)	-0.349** (.166)	-0.349** (.166)	-13720343.1 (255866857.3)
Nature of contribution by RTOs for EU activities					
Applied Research and Technology Service Provision	-0.049 (.089)	.340** (.108)	-0.063 (.109)	-0.063 (.109)	-75016565.7 (172519490.4)
Act as a Networking Agent	.080 (.101)	.417** (.123)	.110 (.124)	.110 (.124)	311947824.3 (189418055.8)
Engage in Basic Research and Training	-0.040 (.060)	-0.004 (.074)	-0.037 (.074)	-0.037 (.074)	124438046.9 (112843119.1)
The extent to which RTOs collaborate with different actors in EU projects					
Universities	.418** (.142)	-0.423 (.174)	.306* (.175)	.306* (.175)	-328883621.8 (267090234.8)

Large Firms	-.0291* (.155)	.139 (.190)	.037 (.191)	809398271.4* (290564911.7)
Medium Firms	-.0148 (.131)	.037 (.161)	-.0283* (.162)	-455080845.7* (247161315.4)
Small Firms	.107 (.093)	-.0158 (.114)	.370** (.115)	-100109312.0 (174080212.0)
Micro Firms	-.0278** (.095)	-.0096 (.117)	-.0446** (.117)	5954792.4 (176315652.6)
RTO	-.0317** (.089)	.092 (.110)	-.0370** (.110)	-229561409.7 (173509405.1)
Sector of operation of RTOs				
Information and Communication Technologies (ICT)				
Bioscience (Agri, Chemical and Env)	-.0490* (.256)	.124 (.314)	-.0097 (.316)	-200079845.7 (484160590.7)
Engineering and Energy	-.0013 (.266)	.212 (.326)	.179 (.327)	-435737278.0 (499194810.5)
Multi-sector	-.0410** (.190)	.157 (.233)	-.0114 (.234)	23648252.9 (350848269.9)
TRL up to 4	0	0	0	0
TRL up to 6	-1.093* (.554)	.148 (.678)	-1.271* (.682)	-1253040670.5 (1060295024.9)
TRL up to 7	-.0464 (.277)	.540 (.339)	-.0512 (.341)	-1221896009.7 (530608710.1)
ICT* TRL up to 4	0	0	0	0
ICT* TRL up to 6	1.355** (.546)	-.0410 (.669)	.597 m(.673)	1779898832.6 (1028946333.2)
ICT* TRL up to 7	.822* (.428)	.365 (.524)	-.0291 (.527)	1131956188.3** (800514957.4)
Bio* TRL up to 4	0	0	0	0
Bio* TRL up to 6	-.0513 (.609)	-.0668 (.746)	-.0097 (.750)	1432962951.4* (1154226347.7)
Bio* TRL up to 7	4.931E-5 (.392)	-.0791 (.480)	-1.284** (.483)	798795159.6 (730543338.8)
Eng* TRL up to 4	0	0	0	0
Eng* TRL up to 6	.779 (.561)	-.0340 (.687)	.885 (.691)	892814888.9 (1107527395.7)
Eng* TRL up to 7	1.047** (.293)	-.0523 (.359)	.380 (.361)	847229529.9 (558033311.6)
Multi* TRL up to 4	0	0	0	0
Multi* TRL up to 6	0	0	0	0
Multi* TRL up to 7	0	0	0	0

**p < 0.05.

*p < 0.1.

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