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The effects of openness on the innovative performance of Research and Technology Organizations (RTOs) and the role of intellectual property appropriation strategy.

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Abstract

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Abstract
State-of-the-art
New paradigms in innovation, such as the Open Innovation (OI) coined by Chesbrough (2003) highlight the benefits of openness and collaboration in R&D. The concept has been accepted with enthusiasm by managers and has received as much attention as criticism from researchers over the last years (Trott and Hartman, 2009). Openness in innovation is not merely relevant to industry though; Research and Technology Organizations (RTOs) are especially concerned with such challenges as they: (i) as their mission is to support the local economies by technology transfer and provision of innovative services (www.earto.org) and (ii) they have to adopt an open approach towards innovation, due to their distinct place in the national innovation systems, positioned between academia and industry and having strong links with government (Arnold et al., 2010). In this perspective they have to manage collaborative R&D projects, to foster and balance the relationships with diverse partners, to focus on technology/knowledge transfer activities and to manage Intellectual Property (IP) issues.
Research gap
Nevertheless RTOs have been studied until now as the partner in the innovation process. There is a significant literature stream on how the innovative services of research organizations (including universities) impact the innovation performance of companies. However, there is, to our knowledge, a scarcity of studies that address the effects of

openness on the innovative performance of RTOs explicitly. This is an issue that deserves attention as the innovative performance of RTOs is essential, in order to fulfill their mission of impact towards industry and society. Moreover, the protection of IP which is one of the major challenges in OI is of particular interest in the case of research organizations, where technology transfer is one of their core activities. The purpose of this project is, therefore, to study the effects of openness on the innovative performance of RTOs, with a special focus on the role of the IP strategy.

Theoretical arguments

Following the work of Laursen and Salter (2006) we are going to study openness in its breadth and depth dimensions. However, we are expanding the concept to not only the external search (relevant to the inbound dimension of OI) but also to the other two dimensions of openness, as defined by Gassman and Enkel (2004), namely the outbound and coupled. We intend to find out whether the inverted-U shape relationship holds for the case of RTOs. Furthermore, we argue that for RTOs the innovative performance cannot be measured only by the innovative products/services sales and thus we create a new construct based on the research institutes core activities (Perkmann and Walsh, 2007; Arnold et al., 2010), as well as the preliminary case studies results. Finally, we will investigate the role of the IP strategy in the relationship between openness and innovative performance of RTOs. For that we will follow Laursen and Salter?s classification (2005; 2013) on appropriation strategies, including an additional dimension, namely the open science model (Dasgupta and David, 1994), which is very relevant in the case of research organizations.

Method

We intend to address our research objectives starting with a thorough literature study and a critical synthesis of the existing theories into a preliminary theoretical framework. The empirical combined qualitative-quantitative approach will follow. More specifically, in the qualitative part, which comprises 2-3 case studies in selected RTOs, we intend to enrich and strengthen our theoretical framework in order to derive a set of robust hypotheses. This is essential as the literature is scarce for the specific case of RTOs. These hypotheses are then going to be tested through survey questionnaires addressed to European RTOs (members of EARTO), in the second quantitative part of the research.

Expected Results

The expected outcomes include theoretical developments of the concepts of OI, IP strategy and technology transfer in OI settings, the contribution to the knowledge about RTOs, as well as managerial implications regarding the management of openness and the development of an effective IP strategy in RTOs and relevant policy implications regarding the role of RTOs in OI ecosystems.

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Abstract

Background: New paradigms in innovation, such as the open innovation paradigm Chesbrough (2003a) highlight the benefits of openness and collaboration in Research and Development (R&D). The open innovation concept has been accepted with enthusiasm by managers and has received as much attention as criticism from researchers over the last years (Trott and Hartman, 2009). Openness in innovation is not merely relevant to industry though; Research and Technology Organizations (RTOs) are especially concerned with such challenges as: (i) their mission is to support local economies by technology transfer and provision of innovative services (www.earto.org) and (ii) they have to adopt an open approach towards innovation, due to their distinct place in national innovation systems, positioned between universities and industry and having strong links with government (Arnold et al., 2010). In this perspective RTOs have to manage collaborative R&D projects, to foster and balance the relationships with diverse partners, to focus on technology/knowledge transfer activities and to efficiently manage their intellectual property in these open and collaborative innovation activities.

Research gap and Research Objectives: Nevertheless RTOs have been studied until now as the partner in the innovation process. There is a significant literature stream on how research organizations (including universities) positively impact the innovation performance of companies. However, there is, to our knowledge, a scarcity of studies that address the effects of openness on the innovative performance of RTOs explicitly. This is an issue that deserves attention, as the innovative performance of RTOs is essential, in order for them to fulfill the impact mission towards industry and society. Moreover, the protection of intellectual property is identified as a major challenge when innovating openly. This is particularly relevant for RTOs where technology transfer is one of their core activities and who strive to balance between profiting from their intellectual property while serving their mission of impact towards science. The purpose of this project is, therefore, to study the effects of openness on the innovative performance of RTOs, with a special focus on the role of the intellectual property appropriation strategy in this relationship.

Theoretical arguments: Following the work of Laursen and Salter (2006) we are going to study openness in its breadth (variety of collaborating actors) and depth (intensity of interactions) dimensions across all the three archetypes of openness (inbound, outbound and coupled (Gassmann and Enkel, 2004)). Furthermore, we argue that the innovative performance of RTOs cannot be measured merely by the innovative products' and/or services' sales -as it is usually done for companies- and thus we create a new construct based on the research institutes core activities (Perkmann and Walsh, 2007; Arnold et al., 2010), as well as the preliminary case studies results. Relevant measures are contractual and competitive research projects, patents and licensing, spin-offs creation and scientific visitors and PhD students. Finally, we will investigate the role of the intellectual property appropriation strategy in the relationship between openness and innovative performance of RTOs. Relevant appropriation strategies include legal and first mover protection mechanisms as well as the open disclosure approach (which we define as including both the open source and the open science dimension).

Method: We intend to address our research objectives starting with a thorough literature study and a critical synthesis of the existing theories into a preliminary theoretical framework. The empirical combined qualitative-quantitative approach will follow. More specifically, the qualitative part, which comprises 2-3 case studies in selected RTOs, will help us to enrich and strengthen our theoretical framework in order to derive a set of robust hypotheses. This is essential as the literature is scarce for the specific case of RTOs. These hypotheses are then going to be tested through survey questionnaires addressed to all European RTOs which are members of EARTO[1], in the second quantitative part of the research.

Expected Results: The expected outcomes include theoretical developments of the concepts of open innovation, intellectual property appropriation strategies and technology transfer in open innovation settings. Moreover we will contribute to the knowledge about RTOs showing that they are more than simple intermediaries in the innovation process. Finally, our work will also raise managerial implications regarding the management of openness and the development of an effective intellectual property strategy in RTOs, as well as relevant policy implications regarding the positioning of RTOs in open innovation ecosystems.

Keywords: open innovation, Research and Technology Organizations, innovative performance, intellectual property

1 Introduction

New paradigms in innovation such as the "open innovation" of Chesbrough (2003b), suggest that openness and collaboration among many actors (e.g. firms, universities, R&D institutions) in R&D has currently become a strategic necessity (Lichtenthaler, 2005). The discussions on collaborative approaches in innovation are not new, neither have they been discussed for the first time when Chesbrough (2003b) coined the term open innovation. The benefits of collaboration in R&D have been widely known long before and have encouraged a number of relevant partnerships in diverse sectors (Hipp, 2010). This is in-line with Dahlander (2010) who, based on an extensive literature review on open innovation, argues that innovation has always been open to some extent, as relying upon external actors for innovation has been a common practice for decades.

New technologies and new knowledge are often generated through the interaction of the firm with its environment and are further developed internally (Hipp, 2010). Teece (1989) argued that firms are likely to require access to capabilities that lie outside their innovating potential and thus they may seek collaboration with other firms, universities and research organizations/centers/institutes. From this perspective, open innovation is not only relevant and beneficial to the industry but to all collaborating actors. Thus, Research and Technology Organizations (RTOs) are also confronted with similar challenges. RTOs focus on innovation as their mission is to support the local economies by providing innovation services (EURAB, 2005). Moreover, they often need to adopt an open approach towards innovation as they have a distinct place in the national innovation systems, being positioned between universities and industry and having strong links with the government (Arnold et al., 2010; Arnold et al., 2007). In this perspective they have to manage collaborative research projects, to foster and balance the relevant relationships with the different actors, to focus on technology/knowledge transfer activities and to be able to respond to Intellectual Property (intellectual property) issues.

Therefore, we could argue that RTOs have a, by definition, open innovation model that is worth studying. Although a vast literature exists on university-industry cooperation for innovation and related knowledge/technology transfer mechanisms such as Technology Transfer Offices (TTOs) (Etzkovitz and Goktepe, 2005; Debackere and Veugelers, 2005), we manifest a scarcity of publications about the role of RTOs in this process (Albors-Garrigos et al., 2010). This is surprising as in open and networked innovation the relations between public research organizations and the industry play an important role in driving the innovation process (Perkmann and Walsh, 2007). Indeed RTOs are engaged in openness and

interactivity, since it is in their mission to support and promote collaborative research and joint innovation projects, as well as technology transfer activities, opposed to companies who may engage in open innovation activities merely sporadically.

To date, the research organizations have been mainly studied together with universities and usually from the partner role; with the majority of the studies focusing on their positive impact on the innovative performance of firms. But it is equally important: first to study RTOs as a separate and distinct, from universities, type of organizations and second to understand what drives their innovative performance. In this perspective we propose to study what is the effect of openness on the innovative performance of RTOs. Understanding this relationship is very important as the RTOs' innovative performance drives their impact towards industry, science and society. Furthermore, the protection of intellectual property which is one of the major challenges in open innovation is of particular interest in the case of RTOs, where technology transfer is one of their core activities. Therefore, special attention will be given to the RTOs intellectual property appropriation strategy in shaping the relationship between openness and innovative performance.

2 Literature Review

2.1 Open Innovation

Innovation models have changed drastically over the years. Under the closed innovation[2] model, firms relied extensively on internal competences for the idea generation and the development of innovation projects and they used the firm's own distribution channels in order to commercialize their innovations (Herzog, 2008). However, the mobility of skilled labor, the increasing presence of venture capital, the emergent high-tech start-ups and the role of university research and its linkages with industry give rise to a more open approach towards innovation (Costello et al., 2007). Even large firms, nowadays, find it difficult to internally produce all the knowledge required to innovate, thus they are increasingly searching for innovation ideas outside their organizational borders rather than investing merely in in-house R&D (Mayer, 2010). In this perspective Chesbrough coined the concept of open innovation as a paradigm in which *"firms commercialize external (as well as internal) ideas* by deploying outside (as well as inside) p*athways to market"* (Chesbrough, 2003b).

[2] Closed innovation Chesbrough (2003) is defined as in contrast to the open innovation paradigm and suggests that there should be control over innovation activities. In this model innovations are conceptualized, developed and commercialized merely by internal to the organization means.

Managers are becoming increasingly interested in the open innovation paradigm (Ramos et al., 2009). Keupp and Gassmann (2009) argue that firms that suffer from more obstacles in innovation (such as structural and strategic rigidities, innovation and cultural related specific issues such as the NIH syndrome and resistance to change) may benefit from adopting the open innovation paradigm to a greater extent than firms that are not confronted with such issues. The authors prove that firms that suffer from information-, capability- and risk- related impediments in innovation are more likely to have increased open innovation activities both in depth and in breadth. This is consistent with Tether (2002) who argues that firms are seeking for cooperation in innovation for two reasons; namely because they lack the internal resources and because they want to reduce the innovation related risk such as knowledge spillovers.

The dimensions of openness

The open innovation paradigm is mainly described by three dimensions; namely the outside-in, the inside-out and the coupled one, and three relevant types of technology transactions: technology acquisition, technology exploitation and a combination of the two. These transactions can take place internally or externally and they represent the main dimensions of a firm's strategic approach to open innovation (Lichtenthaler, 2008b). In the same context Herzog (2008) identifies also the exploration vs. exploitation duality of a firm's innovation strategy and he compares it to the radical vs. incremental innovation dilemma.

(i) Outside-in or inbound open innovation

The outside-in or inbound dimension refers to the absorption of external knowledge and ideas from external partners such as suppliers, customers, competitors, universities and research organizations (OECD, 2008). In this perspective the locus of innovation is not necessarily the locus of knowledge (Enkel et al., 2009). Examples of the inbound approach are in-licensing agreements or strategic alliances (Lichtenthaler, 2008e), however it should be noted that the optimal exploration strategy is often hard and maybe sometimes even impossible to find. Kang and Kang (2009) examine three strategic approaches for technology sourcing; namely information transfer from informal network, R&D collaboration and technology acquisition with their relevant attributes.

Similarly Bessant (2008) argues that firms need to adopt strategies that support their capability to detect and react to early signals about possible technological shifts in their environment. These strategies aim at keeping the firm updated in new technology trends

through external sources such as participation in communities, the use of scouts and technology brokers, supporting internal capabilities of creativity, developing corporate venturing/entrepreneurship capabilities and leveraging creativity tools. Some related practical advices on building an effective external exploitation strategy are also given by Bessant (2008) such as send out scouts who will track down new innovation triggers, detect new trends in online communities and virtual worlds, team up with users to see how they change/develop existing offerings, bring mainstream actors into the product and service development process, use brokers and bridges to connect with other industries, create diverse teams and a diverse workforce (to name but a few).

Dahlander (2010) identifies two different types of inbound processes; namely acquiring and sourcing depending on whether they are driven from pecuniary or non-pecuniary motives respectively. The author defines acquiring as the process of licensing-in and acquiring expertise from the external -to the firm- environment. Sourcing on the other hand refers to the process of using external sources of ideas after searching, assessing and making them fit with internal process. (Dahlander (2010) citing Freeman, 1974)

(ii) Inside-out or outbound open innovation

On the other hand the inside-out or outbound process refers to commercializing technology assets exclusively or in addition to their internal application e.g., by means of out-licensing agreements or strategic alliances (OECD, 2008, Lichtenthaler, 2008). In this approach, the locus of innovation is not the same as the locus of exploitation (Enkel et al., 2009) and the types of technology transactions (markets for technology) include licensing and selling, depending on whether or not patent ownership is transferred (Chiesa et al. 2008; Megantz 2002 as cited in (Jeong et al., 2013)). It has to do with bringing ideas to the market for profit through selling or licensing intellectual property (licensing fees, joint ventures, spinoffs, patenting etc.). The transition to the market is then done faster than it would take to internally develop them (Enkel et al., 2009).

Lichtenthaler (2008a) discusses monetary, strategic motives and challenges for externally commercializing technology. The types of technology transactions in the markets for technology include licensing and selling, depending on whether or not patent ownership is transferred (Chiesa et al. 2008; (Jeong et al., 2013)). Selling involves the transfer of patent ownership from a technology supplier to a buyer while under licensing, a technology supplier grants a licensee the right of exploiting and commercializing the technology protected by the patent; in return, the supplier receives a licensing fee during the contract period. As far as the

revenue of technology suppliers is concerned, licensing provides the technology supplier with various payment options, for instance they can receive a license fee in lump sum or royalty proportional to the sales of the final product/service to which the transferred technology contributed (Jeong et al., 2013).

Dahlander (2010) discusses two forms of the outbound process, namely selling and revealing, again according to the pecuniary or non pecuniary nature respectively. Selling refers to the process of external commercialization of the firm's inventions and technologies through selling or licensing out resources. Revealing on the other hand refers to how firms reveal external resources without immediate financial rewards, but instead seeking indirect benefits.

Previous literature shows that inbound open innovation is more commonly used compared to outbound open innovation. For instance Enkel (2008) argues that generally in-licensing is more often exercised then out-licensing This can be accounted to the fact that outbound activities are more risky and the firm faces the risk of not being able to capture the created value (Schroll and Mild, 2011). Indeed many firms are reluctant to engage in outbound open innovation as they fear that by externally commercializing their innovations they will lose their "corporate crown jewels" (Rivette and Kline, 2000).

(iii) Coupled open innovation

In addition to these two dimensions Gassman and Enkel (2004, as cited in OECD (2008)) propose a third dimension the coupled process which refers to the combination of the inbound and outbound process by working in alliances with complementary knowledge. This approach brings together the two upper mentioned activities. In the coupled process co-creation takes place with partners through alliances, joint ventures and cooperation where give and take is taking place simultaneously (Enkel et al., 2009).

In the coupled process it is important to be able to bridge the two dimensions of open innovation. Harryson (2008) develops a relevant theoretical framework according to which "the balancing act from exploration to exploitation can be seen as an act of transformation from weak to strong ties". Based on network theory, the author defines three networks involved in the process of going from creativity to commercialization: namely creativity, process and transformation networks.

Other strategies concern collaboration with communities (OSS), other companies (alliances) and customers, suppliers, government and universities (Morgan and Finnegan, 2008); all these apply for both exploration and exploitation strategies. Vapola et al. (2008)

explore why and how multinational companies (MNCs) complement their in-house R&D by forming a large number of strategic alliance constellations with small, innovative born globals. The authors argue that MNCs should use a battleship strategy. The parts of this strategy are: an open innovation commercialization strategy, creation of forums for facilitating open innovation and capturing ideas generated externally.

Li (2009) describe Cisco's "mergers and acquisitions" strategy which resulted in an increased number of patents, a complex business ecosystem around the company and an impressive corporate growth. What is interesting to mention is the Cisco's behavior towards the acquired companies; here is no fight to impose their culture, Cisco respects the differences and all the companies co-evolve.

Moreover Waguespack and Fleming (2009) argue that the participation of the startups in open standards communities is a strategy choice that brings benefits (especially liquidity events). Morgan and Finnegan (2008) discuss the Open Source Strategy (OSS) and want to find out what motivates decision makers to adopt an open innovation strategy like the OSS. They conclude that there are several circumstances that motivate firms to embrace an OSS strategy; namely low cost, quality/scalability, staff development, consumer demand, desire of top management, preference for OSS components, reduced risk of being locked-in and new ways to collaborate. There several ways to create value through OSS for the company such as efficiency, knowledge sharing and collaborations etc. as well as for the customers such as improved satisfaction, enhanced products etc. Moreover ways to capture that value for the company include the creation of spin outs, flexibility and access to specialized personnel among others.

The debate around Open Innovation

Since its emergence open innovation has been a rising topic of discussion among scholars who try to define its theoretical elements, but also among practitioners who want to keep up with the revolutionary open paradigm. As a result it has been associated with several things over the years; from user co-creation (Franke and Piller, 2004) to user-centered innovation (Von Hippel, 2005) and from distributed innovation (Sawhney and Prandelli, 2000) to open source (West and Gallagher, 2007), to name a few. For the latter in particular, it is argued that it represents the extreme facet of open innovation as it requires more interactivity and openness from the participating actors (Pénin, 2011). There is, therefore, lack of clarity around the definition of the concept and whether it represents a sound theory or not.

As a result, the open innovation concept has received significant criticism over the last years (Trott and Hartman, 2009). Faems (2008), for instance, expressed the opinion that there is a risk that open innovation is more a managerial fad than a theoretical concept due to the absence of a sound theoretical framework. Others believe that it represents nothing new, stating that collaboration in R&D or the inclusion of customers in the innovation process have been already proposed years before the open innovation concept was coined by Chesbrough (2003b). Moreover, contrasted to open source innovation[3], open innovation has been accused of not being that open since it requires a certain level of secrecy, as the knowledge is only disclosed to the collaborating actors, and not widely (Pénin, 2011). Finally, the linearity of the open innovation funnel has also been criticized (Trott and Hartman, 2009).

If open innovation represents nothing new then why has it been accepted by such enthusiasm by the practitioners as well as a significant part of the researchers' communities? First and most importantly, it is the inside-out approach, the external commercialization of knowledge, that represents the most novel element of the concept (Pénin, 2011). As far as the inbound process is concerned, many researchers have identified the value of external knowledge to innovation before Chesbrough but only in a supplementary role. In the open paradigm, the locus of innovation stops being the internal of the firm.

Thus, it is indeed true that some of the elements that the open innovation paradigm presents are not new, however the concept per se is new in the way that it assigns a single term to a collection of open activities; *"by giving it a label it got a face"* (Huizingh, 2011:3). With open innovation the outside-in and the inside-out approach are gathered under one single concept (Huizingh, 2011). Finally, what is also noteworthy and novel is that Chesbrough, relates open innovation to business models in an attempt to explain how to benefit from open activities (Chesbrough et al., 2006) and for the first time, someone discusses how firms can actually create value from innovation, without necessarily adopting a defensive approach towards their intellectual property.

Openness and the effect on innovative performance

The effects of open innovation on innovative performance had been long debated. Open innovation is often considered to be a complement of internal R&D (Lichtenthaler, 2008b; Lichtenthaler and Ernst, 2009) contributing significantly to the innovative performance of the firm. Following this reasoning, Vanhaverbeke et al. (2007) argue that internal and external

[3] Open source innovation represents the application of the open source model in other sectors that software (Pénin, 2011).

sources should be combined and in this perspective internal R&D is very important to effectively exploit external knowledge. However Laursen and Salter (2006) found that open innovation is a substitute rather than a complement to internal R&D.

Laursen and Slater (2006) also argue that the search for external knowledge in the context of open innovation should be reasonable and that over-search (both in terms of breadth and depth) may hinder innovative performance. As openness comes with a cost companies need to find the right balance in order not to get lost in too many search channels (Laursen and Salter, 2006). Moreover, as far as inside-out innovation is concerned, many firms are reluctant to engage in outbound activities, as they fear that by externally commercializing their innovations they will lose their "corporate crown jewels" (Rivette and Kline, 2000). So one might easily deduct that outbound open innovation may actually harm the innovative performance of firms. In a different perspective however, Lichtenthaler (2009) finds a positive relationship between outbound open innovation and firm performance, rather that innovation performance, and discusses the environmental context and how it affects this relationship.

The intellectual property challenges in the era of open innovation

Until now it is obvious that being open in innovation has significant advantages. Nevertheless, Keupp and Gassmann (2009) mention that there are also significant challenges - open innovation relationships maybe counteracted by the risks and costs of openness such as transaction costs for the search and evaluation of external knowledge and partner interaction, intellectual property issues (spillovers, disputes around jointly developed intellectual property), managerial challenges-leadership, change of mindset etc.

Especially, intellectual property management under the open innovation paradigm represents one of the biggest challenges for managers. "Intellectual property theft is typically identified as the most important risk of global innovation networks." (Backer and Cervantes, 2008: 6). In general, the process of commercializing intellectual property is complex, highly risky, costly and time consuming (Bozeman, 2000). This can be answer to why intellectual property was traditionally managed in a closed and defensive way. For instance patents were used in order to exclude competitors from developing similar technology. This defensive use of intellectual property assets has led to the low utilization of commercialization of new products and services (Backer and Cervantes, 2008). The open innovation paradigm requires rethinking of intellectual property management strategies, with the aim to share and commercialize the more technologies possible (via collaborations, alliances and joint

licensing activities) instead of using them as a defensive mechanisms (Backer and Cervantes, 2008).

For instance patent licensing can bring significant financial benefits for patent holders and cross-licensing agreements and other collaborative mechanisms can facilitate technology collaboration. (Backer and Cervantes, 2008). Indeed most of the discussion until now on intellectual property has been focused around patents, which is very relevant in the case of RTOs. Strong patents promote vertical specialization (Arora, Fosfuri and Gambardella, 2001; Somaya and Teece, 2001; Tepperman, 2001) and by attracting financial capital, they allow inventors to specialize in intellectual assets that are then licensed to users (Lerner, 1994). By reducing transaction costs of negotiating contractual agreements, they encourage users to license patented inputs, rather than to develop their own thus they facilitate and support the open innovation paradigm. Strong patent protection enables disclosure and technology transfer; nevertheless it is still debatable if it can stimulate innovation in general (Gallini, 2002).

More generally, Laursen and Salter (2005) study intellectual property at the firm level in the context of open innovation. In their research work, intellectual property appropriability strategies are classified under two categories; namely legal and first mover. Legal appropriability refers to mechanisms such as patents, trademarks and registration of design. This strategy involves the codification of knowledge and the demonstration of technological novelty of the innovation to the external actors. As far as first mover strategies are concerned Laursen and Salter (2005) include a set of protective mechanisms, such as by being first to the market, maintaining trade secrets and by ensuring the complexity of the product.

Moreover, Young et al. (2008) look at the intellectual property management practices of public research centers and identify three categories namely: the open science-, licensing- and innovation- model. According to the intellectual property science model new knowledge is viewed as a public good and little priority is placed on intellectual property ownership. This is a strategy that is more compliant to a traditional academic mentality. In the licensing model, on the other hand a lot of focus is put on the exploitation of intellectual property, generally through patents and licenses. Finally the innovation model is reflecting the current approach of universities towards intellectual property. More and more universities are trying to develop collaborative projects with the industry investing in applied and research and in this perspective they are willing to share the resulting knowledge from these collaborative activities.

In the context of the open science approach von Hippel and von Krogh (2006) discuss and present the private-collective model (among three different models of innovation incentives according to how innovation gets rewarded). The authors argue that this model is economically beneficial both for the society and the innovators. More specifically, the innovators gain higher profits than free riders from freely-revealed innovations because some sources of profit remain private and society benefits from the creation of public goods at private expense.

Thus, although science is often mentioned as an example of the collective action model, it is evident that nowadays this open disclosure or free revealing model goes beyond science and it can be used as a strategic tool of the company that can lead to profitability. The most prominent example is open source software. Henkel (2009) discusses this issue in his article about open source software and argues that companies should rethink their practices on intellectual and proposes a more positive attitude towards revealing the results of their research in order to better share the benefits of open innovation.

It is worth noting that open source innovation has recently started to be discussed more broadly as to whether it could be potentially applied to other cases than the software one (Huizingh, 2011; Pénin, 2013). Huizingh (2011) defines open source innovation as the case where both the innovation model and the innovation outcome are open. Finally, Pénin (2013) discusses the difference between the open innovation and the open source innovation model, by characterizing the latter as more open, as far as accessibility to knowledge and/or technology is concerned.

RTOs and Open Innovation

Defining RTOs

RTOs[4] represent an important part of the *"extra-university research organizations"* sector, which includes scientific research institutes, the governmental laboratories and applied research institutes or RTOs (Arnold et al., 2007). It is generally acknowledged that it is a challenging task to give a clear definition of RTOs, because of their diverse inherent characteristics (Tann et al., 2002). According to EARTO (European Association of Research and Technology Organizations), RTOs are "organizations which as their predominant activity

[4] According to EARTO's studies: Europe's RTOs have a combined turnover of about €23bn/year, their economic impact is up to €40bn annually, they co-ordinate around one-third of all Framework Programme projects and support some 100,000 companies each year, especially SMEs (http://www.earto.eu/about-rtos/facts-and-figures.html). Some prominent examples of European RTOs include Fraunhofer, Germany, VTT, Finland, TNO, Netherlands, SINTEF, Sweden, INRIA, France etc. For a complete list of European RTOs, as well as more info on the sector, please refer to the official site of EARTO (http://www.earto.eu/).

provide research and development, technology and innovation services to enterprises, governments and other clients…" (EURAB, 2005). Their mission is to help companies (especially Small and Medium Size Enterprises (SMEs)) move "one step beyond" their existing capabilities and reducing the risks associated with innovation to allow a faster rate of economic development (Arnold et al., 2007).

RTOs might be public, semi-public or private; some of them are technology-oriented while others provide services in social sciences or economics. They can do basic or applied research or sometimes both, some offer technology transfer and even implementation support while others deal with certification and standardization (EURAB, 2005; Farina and Preissl, 2000). Regarding their funding, RTOs rely on a mix including public and private sources (Berger and Hofer, 2010). On the one hand, they generate income on the market offering services and capitalizing on know-how just like private enterprises (e.g. KIFs) and on the other hand, they qualify for public funding, because they provide public goods such as basic research and academic publications, as well as support public innovation policy by facilitating technology transfer from science to industry and offering technical support especially to SMEs (Hales 2001 as cited in Berger and Hofer (2010)). Finally, some RTOs operate on a commercial basis, but still, a vast majority adopts a non-for-profit character and usually they hold a certain level of autonomy in their management, while being accountable to government and various stakeholders (Turki and Mention, 2010).

The innovation model of RTOs

The innovation model of RTOs as described by the report of Arnold et al. (2010:10-11) comprises the following stages:

(i) exploratory research and development to develop an area of capability or a technology platform,

(ii) further work to refine and exploit that knowledge, often in collaboration projects with the industry, and

(iii) more routinised exploitation of this knowledge via consulting, licensing and spin-off company creation.

RTOs are therefore performing innovation neither as universities nor as private firms. Thanks to their public funding they can invest in research for developing capabilities that their clients would not pay for, but at the same they need to keep their links to the industry in order to assure the additional funds they need. So in the innovation system their role is quite distinct. However, we cannot really rely on the "three hump" model (Figure 1) according to

which universities do basic research, institutes (like RTOs) do applied research in order to transfer the application of their knowledge to the industry which uses this knowledge for profit (Arnold et al., 2010). This model seems to be oversimplified today and its breakdown shows the overlap of activities between the three actors as illustrated in Figure X The three actors have increasingly overlapping but also complementary roles (firms performing research or universities commercializing their research through Technology Transfer Offices (TTOs)).

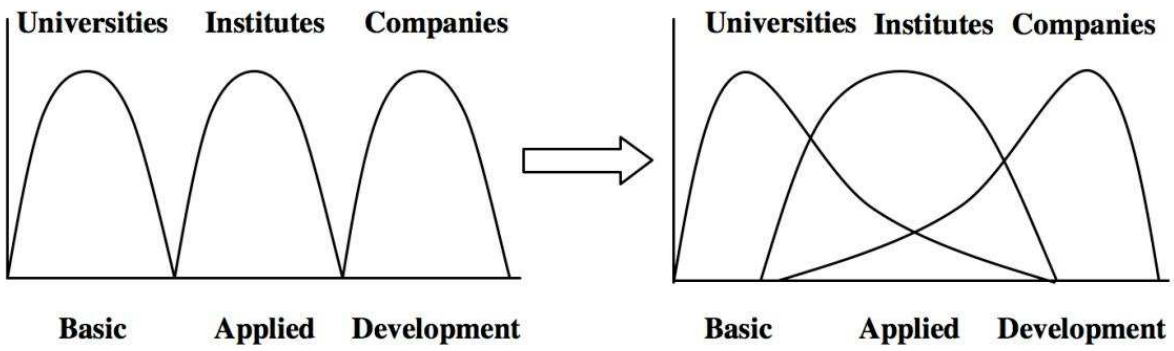

Figure 1: The Breakdown of the "three-hump model". Source Arnold et al. (2010)

The significant role of RTOs in open innovation

Thus the role of RTOs in the innovation system is quite distinct, being the interface between academia and industry. It is evident that the RTOs' innovation models carry a lot of the elements that the open paradigm of Chesbrough dictates, some of them being the management of relationships with different actors, the collaborative innovation projects, the knowledge transfer activities and the subsequent implicit intellectual property management issues.

As a result, we conclude that RTOs can play an important role in the national innovation systems as far as open innovation is concerned. Moreover, their innovation models obviously comply with the open paradigm of Chesbrough, as far as both its dimensions are concerned, with a special emphasis on the outbound innovation though, which represents open innovation's most novel element. Indeed EARTO has identified the important role of RTOs in supporting open innovation and has launched relevant activities such as the Responsible partnering[5] which produced a set of relevant guidelines. To conclude we argue that the innovation model of RTOs is particularly open, as this is their mission, and as a result there would be no place and no reason for them to exist in a closed innovation model. In fact

[5] Responsible Partnering, 2009. Joining forces in a world of open innovation: Guidelines for Collaborative Research and Knowledge Transfer between Science and Industry. EIRMA, EUA, EARTO, PROTON EU (ed.).

we can argue that their role lies even beyond the open paradigm and reaches the boundaries of open source innovation (Pénin, 2011).

Collaborative activities among RTOs and the Industry

The relationships of the academic sector with the industry represent a very important issue as they facilitate technology transfer and innovation. In this perspective Ruiz (2010) identifies two types of technology and knowledge transfer: (i) a simple transaction of intellectual assets in return of some economic benefit (which the author represents as linear process of technology push from universities or research centers) and (ii) a more sophisticated relationship with a series of interactions, collaboration and co-creation (consistent with open innovation paradigm).

In the same perspective Howells et al. (2012) also identifies a difference between universities (and research centers) as simple knowledge providers and as innovation collaborative partners. More specifically he argues that although firms rate them low as source of information (due to high search costs) they value them higher as collaborative partners when the relationships are already established. The authors also identify that the nature of links between academia and industry (formal and informal) does not play any role in terms of their impact in the innovation performance of the firm (Howells et al., 2012).

Instead of simple links Perkmann and Walsh (2007) propose that relationships are more important than simple links in industry university relationships. Note that the authors include public research centers when speaking about universities. Perkmann and Walsh (2007) (based on Williamson (1981) and Schartinger et al. (2002)) define links as: research partnerships, research services, academic entrepreneurship, human resource transfer, informal interaction (conferences and networking), commercialization of property rights and scientific publications. Cohen et al. (1981) acknowledge the significant impact of public research on industrial R&D (in a broad range of industries in different ways though) and identify the following channels for information/knowledge flow between public research and industry: publications/reports, informal interaction, public meetings or conferences, contract research, consulting, joint or cooperative ventures, patents, personnel exchange, licenses, recently hired graduates. The most important among them being: "the decentralized and longstanding channels of publications, conferences, informal exchange and consulting". (Williamson, 1981: pp. 22). These represent channels of open science and they should not be discouraged in the expense of cooperative ventures and technology license which also have significant impact Cohen et al. (1998).

Schartinger et al. (2002) identify 16 types of interaction which they group into four general categories: joint research, contract research, mobility and training. If this is the case for research centers as well, should we not bother to invest in formal strong policies but instead go for simpler collaborative models as Howells et al. (2012) are suggesting? Howells et al. (2012) are also suggesting that universities may not be the end collaborator and that they could assume another role of facilitator in the innovation process, similar to what we are proposing about research centers.

Finally, Perkmann and Walsh (2007) provide also a typology of the upper mentioned channels of university-industry links according to the extent of relational involvement which could potentially apply to RTOs as well (the authors are not clear as to whether they include RTOs also in their work). This typology is detailed in the following Table 1:

Extent of relational involvement		
High: relationships	Medium: mobility	Low: transfer
Research partnerships Research services	Academic entrepreneurship Human resource transfer	Commercialization of intellectual property (e.g. licensing)
Use of scientific publications and informal interaction such as conferences and networking (can accompany all forms)		

Table 1: A typology of university-industry links (source Perkmann and Walsh (2007))

3 Research Objectives and Relevant Hypotheses

Based on the above literature review we can now summarize and present the hypotheses that are going to be investigated by this research project.

We have seen that openness is a very important element of the RTOs innovation process. RTOs can actually perform very few activities in a closed way due to their mission and their special position in the innovation systems. However the degree of openness (both in depth and in breadth) between different RTOs may vary along the three dimensions of openness –i.e. inbound, outbound and couple- as described in the theoretical part. Thus we want to study the effects of the RTOs open approach to innovation on their innovative performance, as this is very important for RTOs to be able to deliver impact towards industry and society in general. We can, therefore, formulate the following hypotheses (each of them including two sub-hypotheses based on the depth and breadth of openness).

Hypothesis 1.1.1/2: The inbound openness (in breadth and depth) of RTOs has an inverted U shape relationship with their innovative performance.

Hypothesis 1.2.1/2: The outbound openness (in breadth and depth) of RTOs has an inverted U shape relationship with their innovative performance.

Hypothesis 1.3.1/2: The coupled openness (in breadth and depth) of RTOs has an inverted U shape relationship with their innovative performance.

Moreover, we have identified intellectual property issues as being focal in the context of open innovation. Intellectual property protection and appropriation remains one of the most important challenges in open activities and most of the times it is one of the reasons that prevent companies from engaging in open innovation. As already discussed Laursen and Salter (2005) have studied the relationship between the intellectual property appropriation strategy of an organization and their innovative performance and they have found an inverse U shape relationship between intellectual property appropriability mechanisms (based both on legal and first mover means) and innovative performance. Moreover, in a later study they have found a complementary relationship between intellectual property appropriation strategy and external collaboration in shaping innovative performance (Laursen and Salter, 2013) showing that the inverse U shape relationship between intellectual property appropriation and innovative performance is moderated by collaboration breadth. Reversing the above statement we want to investigate the role of intellectual property appropriation on the relationship between openness and innovative performance. Based on the above we can formulate the following hypotheses (again two sub-hypotheses are included in each of the following hypotheses according to the breadth and depth dimensions of openness).

Hypothesis 2.1.1/2: The intellectual property appropriation strategy of the RTO moderates *the relationship between the RTO's inbound* openness (breadth and depth) *and the RTO's innovative performance.*

Hypothesis 2.2.1/2: The intellectual property appropriation strategy of the RTO moderates the relationship between t*he RTO's outbound openness* (breadth and depth) *and the RTO's innovative performance.*

Hypothesis 2.3.1/2: The intellectual property appropriation strategy of the RTO moderates the relationship between the RT*O's coupled openness (breadth and* depth) and the R*TO's innovative performance.*

4 Methodology

4.1 Theoretical approach

The proposed research project will start with an exploratory phase, based on a thorough literature review. More specifically, we will perform systematic literature searches on the topics of open innovation, RTOs, university-industry relationships, technology/knowledge transfer, markets for technology, intellectual property appropriation separately but also in a combined way, choosing each time the appropriate keywords. Only peer-reviewed publications will be included and special attention will be given to most cited authors, highranked journals and most recent theoretical and empirical studies. This extensive literature review will result in a critical synthesis of the available publications and relevant theories, in order to construct a preliminary theoretical framework which will serve as a basis for the design of the case studies (first part of empirical study) that will follow.

4.2 Empirical approach

The exploratory phase will not be restricted to the theoretical part; it will be expanded to cover the first part of the empirical study as well. Hence, we will begin with a qualitative approach, in the form of case studies, which are appropriate when studying novel (Eisenhardt, 1989), deep and complex phenomena (Yin, 2009) such as the topics proposed by this PhD project. The exploratory phase; namely the combination of the literature review outcome and the results of the case studies are expected to result in a set of coherent testable hypotheses, that can be tested through a survey by means of questionnaires, in the second quantitative part of the empirical methodology. Indeed the qualitative research can facilitate the quantitative by providing hypotheses, by understanding better the relationships between variables and by aiding measurement (Bryman and Bell, 2003). Besides that, the reasons for which we chose the combinative approach towards methodology for this specific project are twofold: we acknowledge the lack of robust theoretical models in the topic that this project aims at tackling and we want to overcome generalability issues that a qualitative study alone would raise due to the high variance in our sample. Finally, our research field will be European RTOs, that are members of EARTO, both for the qualitative and quantitative part of our research design.

The case studies: The qualitative phase will be based on 2-3 case studies of distinctive RTOs. For the identification of the appropriate case studies we will work with EARTO in order to define the most suitable and distinctive case studies, that present a certain variety in

terms of size, age and range of activities. We will also leverage our knowledge and experience on RTOs from a past research project (SERVICeABLE[6] project) in the sample selection phase. The (relevant to our research objectives) data will be gathered through semi-structured interviews and secondary data sources, such as important organizational documents, annual reports etc. Data analysis will be supported by a software-facilitated iterative coding process, which includes the identification of specific categories or themes defined by our conceptual framework (Miles and Huberman, 1994). Single-case analysis will be followed by cross-validation, where similarities and differences between the cases will be indentified (Yin, 2009). The outcome of the multi-case analysis is expected to enrich our preliminary theoretical framework.

The survey: The second part of the empirical study will be confirmatory and will comprise a survey by means of questionnaires which will be adressed to European RTOs, members of EARTO. EARTO counts 116 members to date, out of which we are going to define a representative sample, according to the total size of the population, available time and cost, heterogeneity of the sample and the expected non-response rate (Bryman and Bell, 2003). The questionnaires will be internet based and we will make sure for an adequate response by assuring a number of recalls to the organizations and by mobilizing EARTO's support (e.g. we will try to assure and official hosting of the questionnaire in EARTOs website). The design of the questionnaire will be based on the hypotheses and variables that were constructed with the exploratory phase of the research. Moreover, a thorough pre-testing of the questionnaires will be ensured (before the official distribution) from a group of experts that can assure both the scientific quality and the practical usability of the survey. Software facilitated analysis of the results will include descriptive and inferential statistics in order to fulfill the different objectives of this research project. Finally, the results of the quantitative phase will be confronted to the initial theoretical framework and the results of the case studies analysis.

[6] Sustainable Development of Services Innovation Capabilities in Luxembourg

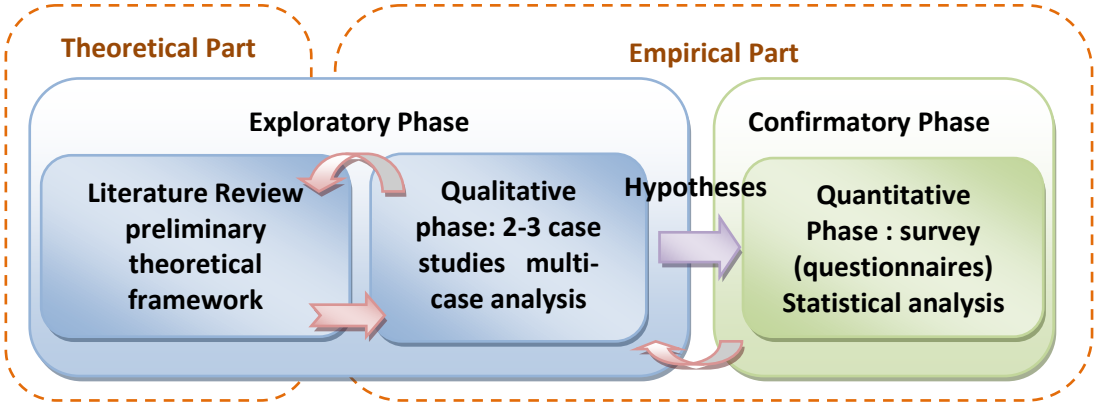

Figure 1: Illustration of proposed research design

Variables definition

RTOs are not for profit organizations thus we cannot measure their innovative performance only by means of sales of innovative products or services (like previous studies do). Instead we define the innovative performance of RTOs based on some commonly used indicators by the research centers and the local governments to measure their performance, which are also compliant with their main activities.

We define an initial set of such indicators as following: contractual research (in millions euro[7]), patents (number), licenses (number) and spin-offs (number) (market related or realized innovation performance) and competitive research (in millions euro[8]), PhDs (number), publications (number), scientific visitors (number) (research related or potential innovation performance).

As far as openness is concerned we will measure it in a similar way like Laursen and Salter (2006) by the openness breadth and depth. The external search breadth refers to the number of external sources or channels that the firm leverages in the context of their innovation activities, while the external search depth refers to the extent to which firms draw deeply from these external sources or channels. However, noticing that Laursen and Salter (2006) were merely focused on the inbound dimension, we will enrich the concept and the measured variable by employing all the three dimensions of open innovation (inbound, outbound and coupled following the three archetypes of open innovation (Gassmann and

[7] Or as percentage of total turnover

[8] Or as percentage of total turnover

Enkel, 2004)). Within each of these dimensions we will then measure breadth and depth according to the number/diversity of partners and the extent of interaction.

Finally, as far as the intellectual property appropriation strategy is concerned we will use the following three measures: legal protection (including patents, registration of design and trademarks), alternative protection (secrecy, complexity, being first at the market), open disclosure (open science, open source). Laursen and Salter (2006) have used the two former appropriation strategies (namely legal and first mover protection) however as we have seen in the theoretical part of this paper the open approach towards IP is widely used nowadays. This open approach towards intellectual property might be adopted either for strategic purposes (open source case) or for supporting the open science model (as we are dealing with research organizations which are most of the times public or semi-public with a mission to support science). We consider this approach to be relevant for RTOs and we name it the open disclosure model, covering both the open source and open science dimensions.

5 Expected Outcomes

The expected outcomes of this research project are twofold; both theoretical and practical.

Theoretical outcomes: With the proposed research we intend to contribute to the building of a more robust theoretical framework around open innovation and how it can be managed and supported, which is a current need according to researchers working on the field (Elmquist et al., 2009). Moreover, we are contributing to the literature about innovation in research organizations which until now has been dominated by university focused research. What is interesting is that we are also contributing to the literature about academia-industry collaboration, studying the RTOs from another persepctive than the partner role in open innovation, as they were traditionally studied until now. This is equally interesting and important as their innovative performance is a crucial element of their impact on industry and society in general. Furthermore, studying the intellectual property appropriation strategies of RTOs can also be beneficial in understanding the relationships between openness, innovative performance and intellectual property protection, in an era where appropriation of intellectual assets is an important concern not only for RTOs but also for universities, as well as firms. Finally, we believe that we can also contribute to the theoretical development of the concept of innovation intermediaries, by showing that RTOs are not simple intermediaries, as it is widely thought. RTOs are disctinctive in the sense that they are not only facilitating open innovation, but they are actually involved in the innovation process. Thus they can, not only

efficiently reduce transaction costs in innovation (like simple intermediaries), but they can also favor the dissemination of tacit knowledge overcoming the challenges that result from the sticky and tacit property of knowledge, which may result in actually accelerating open innovation.

Practical Outcomes: This study has managerial, as well as policy implications. We believe that we can offer valuable insights to other types of innovative organizations that have a similar role to RTOs, such as TTOs and intermediary companies. We hope therefore with the lessons learned from RTOs to be able to provide a set of practical recommendations for the management of collaborative R&D, technology transfer activities and intellectual property management issues. Of course, benefits exist also for other types of firms that are involved in innovative activities, as they will learn more about the open dimensions of innovation; the recommendations will be partly relevant for them as well. Moreover, these companies can also learn what they can achieve by collaborating with RTOs in this process. Finally, we argue that this study wil also raise policy implications as far as supporting and better positioning RTOs in the open innovation ecosystems is concerned, addressing issues of: overlapping activities between RTOs, universities and/or TTOs and other intermediary companies, better supporting SMEs, the open dissemination of scientific knowledge and effective intellectual property regimes, to name but a few.

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