Doctoral Thesis

Scientists in the Principal Investigator Role

Universidad de Cádiz

José Luis Perea Vicente

Departament of Business Management

Supervisors:

PhD. Fernando Martín Alcázar

PhD. María José Foncubierta Rodríguez

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INTRODUCTION

Research and development (R&D) have received an enormous economic support from governments all over the World in the last decades (Kenney & Patton, 2018; Ram & Ronggui, 2018). The United States leads the ranking in funding for R&D with more than half a trillion dollars in 2017, 549 billion dollars to be more exact. China is in a close position, investing 496 billion dollars in 2017. In fact, the United States and China comprised almost half of the world's investment in R&D in 2017 (48% of the global investment in R&D). In 2017 the European Union already invested 430 billion dollars and Japan only 170 billion dollars (National Science Foundation, 2019). This reflects the key role that R&D plays in the development of countries. For instance, around 70% of the economic development of Europe since the beginning of the 21st century is due to R&D and innovation (European Commission, 2018; Azagra-Caro, 2007). Knowledge creation and fostering new technologies are crucial to enhance the development of a region, so they will impact positively in their societies (Wu et al., 2015).

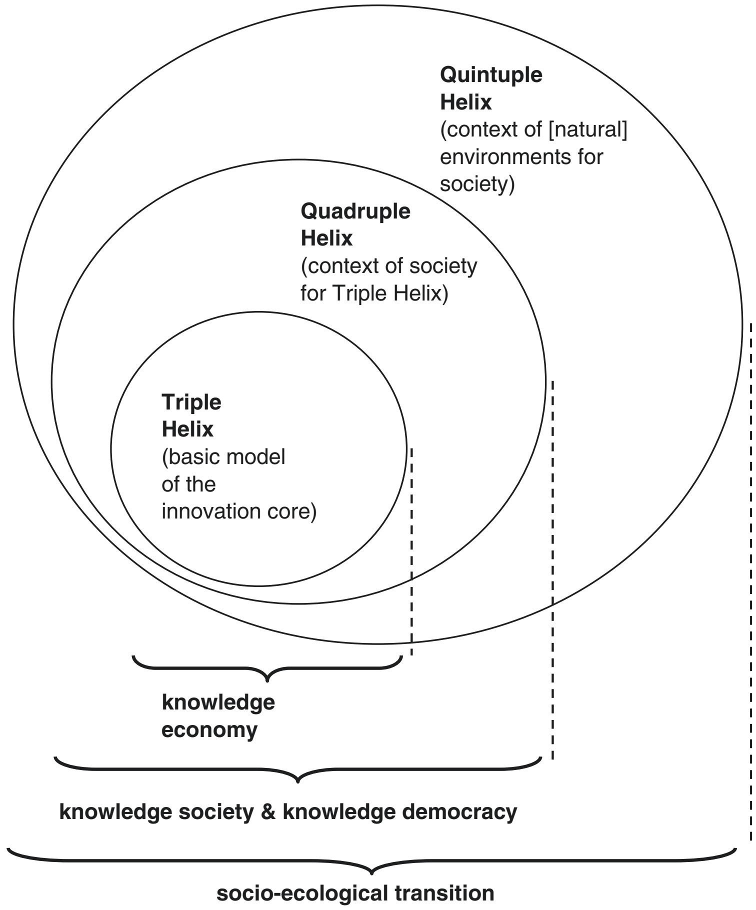
The contribution to the social and economic progress of a region or a country carried out by the technological and scientific development may seem as if it is something current, or limited to the most recent decades (Guimón et al., 2018; Von Zedtwitz et al., 2004). However, this relationship was stablished much earlier. Hall et al. (2001) dated it back to the last half of the nineteenth century in Europe and to the first half of the same century in the USA. At that time, problems that arose in the industry were being solved through scientific advances in a similar way to the progress and studies that are being carried out in science today. Therefore, the emphasis is placed on all those initiatives aimed at generating knowledge and promoting synergies between the different agents involved. Thus, knowledge and its creation are evidently building the foundations of future industrial progress (Carayannis & Campbell, 2009; Etzkowitz & Leydesdorff, 2000). Furthermore, knowledge, acquired or created, is key for companies to achieve a competitive advantage and to retain it (Zhu & Chen, 2016; Coff & Raffiee, 2015). Additionally, it also highlights the relevance of stimulating the transfer of knowledge and its management in environments where interaction, and sharing of objectives and models, favour not only the development of new ideas, but also improvements in the final result, and its subsequent applicability in the market, which is the essence of a country's development (Bergman, 2010; Mazzoleni & Nelson, 2007).

How best to organise innovation is an on-going challenge for firms. Firms source innovations from inside and outside so that they can maintain and enhance their competitive position. This leads to the creation of multiple relationships that can take several forms, such as acquiring knowledge and technology from outside the firms, be it publicly accessible or privately held by other companies, universities or research centres (Fabiano et al., 2020; Skute et al., 2019). This is because these knowledge-intensive organisations contribute more frequently to the creation, development and transfer of knowledge and technology and can provide an array of benefits to individual firms (Scandura, 2016; Cunningham & Link, 2015; Siegel et al., 2003). As part of a company's knowledge, the firm's R&D function is an essential one to pursue internal and external sources of innovation (Chesbrough et al., 2006).

In the last two decades, there has been a growth in firms from different sectors adopting an open innovation strategy (OI). To the extent that the research process is getting more and more complex, it is becoming clear that not all firms have the required competencies to innovate, so pursuing OI becomes essential (Jelinek et al., 2012; Slowinski et al., 2009). This is reflected by the increasing research attention that various aspects of OI are receiving within the innovation domain and cognate fields (Cunningham & Walsh, 2019; Bogers et al., 2017; Chesbrough, 2017; Huizingh, 2011; Gassmann et al., 2010; Enkel et al., 2009; Chesbrough et al., 2006). A core tenet of OI is that innovation does not have to be developed within a company, but rather the opposite. OI is enriched by the interactions and relationships with suppliers, customers, research centres, universities and even competitors, to enhance the scope of innovation. OI represents a means for firms to co-operate with other stakeholders, as part of their strategy to sustain a competitive advantage and for value creation purposes (Reed et al., 2012; Rohrbeck et al., 2009). OI means that organisations collaborate with other talented innovators outside their firm (Chesbrough, 2003) and positively impacts their innovative thinking process (Salter et al., 2015). Competitive advantages can be achieved through the implementation of OI (Vanhaverbeke & Cloodt, 2014). The challenge for firms is how best to organise and support OI, so that is aligned with the firm strategy for current and future competitive conditions.

The R&D function in a firm has become critical to support its long-term competitive sustainability and stability. Moreover, the R&D function is a source and a value-generating factor within a firm (Carpenter et al., 2010). Traditionally, companies used to create R&D departments to house their innovation activities and capabilities in order to improve their productivity and to become more competitive (Grant, 1996). Research can be implemented by companies –private or public–, but it can also be implemented in universities and research centres. Everything that is a result of the research carried out in universities, and especially in public universities, has significance in the global context (Guerrero et al., 2016). This is a result of the key role that universities play in the knowledge creation process and in the knowledge and technology transfer (Kenney & Patton, 2018; Wu et al., 2015). Etzkowitz and Leydesdorff (2000) already studied and highlighted the importance of creating a network of communication and perspectives between universities, the industry and the government, called the Triple Helix model. Such a network is a key piece in the economic, social, and technological evolution and growth of a region (Johnson, 2008), requiring that the relationship among these agents be constant and intense (Roos & Pike, 2011). In order to include the effect of the “media-based and culture-based public” in the knowledge creation and diffusion process, Carayannis & Campbell (2009, p. 206) incorporated it as the fourth helix in the Quadruple Helix model. Carayannis et al. (2012) later proposed the Quintuple Helix model in which, in addition to the knowledge and the know-how, the natural-environment-system is considered with the aim of understanding the link between knowledge and innovation (Figure 1).

Figure 1. *Knowledge production and innovation*



Note: Carayannis et al. (2012)

Since the knowledge economy, the socio-ecological transition was structured to trigger the development of a region, an area or even a country. Due to the inclusion of universities as one of the helixes of the model, it is understood that, apart from teaching and researching, universities have another aim, which is known as Third Mission (Etzkowitz & Leydesdorff, 2000). It consists of developing and sharing knowledge with other organizations, which could be private or public as well. This collaboration is useful for the generation and spreading of knowledge (Arza, 2010), and universities are vital in this process (D'Este & Patel, 2007). Those interactions have been gaining importance over the last years, as a means to promote and develop those areas, regions, countries, or even economic sectors, where knowledge is needed to be fostered (Wright et al., 2008; Etzkowitz & Leydesdorff, 2000), since it offers the opportunity to reach a competitive advantage (Bercovitz & Feldman, 2006).

Since the last decade of the twentieth century, academics have changed the way they carry out research due to the increasing research specialization (Leahey, 2016; Zulueta et al., 1999). Researchers are increasingly interested in collaborating with fellow scholars in the same or different fields of research, in order to be able to develop knowledge (Jeong & Choi, 2015; Bozeman et al., 2013; Lee & Bozeman, 2005). In this sense, a large part of the production that takes place in research is achieved because researchers from heterogeneous areas combine their resources and efforts to contribute to the same purpose (Cummings & Kiesler, 2014). Even though, traditionally, research has been carried out at an individual level, the evolution of knowledge and the development of new research methodologies have impacted the way these issues are approached. Whereas one-person research is decreasing, team-directed research is expanding (Li et al., 2013; Rey-Rocha et al., 2002). This might be explained by the exceptional work that research teams are doing in terms of production of patents and scientific publications (Wutchy et al., 2007) or in their effectiveness and efficacy (Singh & Fleming, 2010; Zulueta et al., 1999) when compared to the solo authors, even in scientific fields that have been traditionally dominated by individual scholars, such as high-impact research. In this sense, an increasing body of articles has been co-authored (Kyvik & Reymert, 2017).

The size and composition of research teams are crucial factors for their collaborations and their scientific publications (Rey-Rocha et al., 2002), not only in terms of quantity but also in their quality (Stankiewicz, 1979). Moreover, the bigger the team becomes, the higher the degree of diversity among team members will be (Van der Vegt & Bunderson, 2005). Consequently, current research is normally developed in research teams which are mainly diverse (De Saa-Perez et al., 2017; Horwitz & Horwitz, 2007). Even though there is no consensus in the literature about the definition of the concept of diversity, it has been frequently used over time in the field of management (Liu & Xia, 2015). While some papers consider personality, education, gender or training, among others, as diversity traits, the definition of diversity could be summarised as those distinctive traits that characterise the researchers of a particular team (Van Dijk et al., 2012; Van Knippenberg & Schippers, 2007).

The diversity of the people who compose the research team can influence the research team's outcomes, because team members will increase the generation of innovative and creative ideas through the impact of the wide variety of experiences, skills, knowledge, or ideas that exist within the research team (Huang & Lin, 2010; López-Fernández & Sánchez-Gardey, 2010). Even though heterogeneous research teams benefit from this strength, which can foster their competitive advantage, this heterogeneity can also have a dark side for the welfare of the research team (Cummings et al., 2013; Martín-Alcázar et al., 2012). The same variables or factors that boost the research team's outcomes, might be the cause of conflicts or lack of collaboration, which may reduce those outcomes (Van Knippenberg et al., 2004). There is still no clear consensus on the impact of diversity of the research team, as there is literature that argues that it provides benefits for the research team (Horwitz & Horwitz, 2007; Williams & O'Reilly, 1998), literature arguing that diversity is a disadvantage (Cummings et al., 2013), as well as literature that states the existence of an inverted U-shaped relationship between them (Martín-Alcázar et al., 2020). As Milliken & Martins (1996) asserted, diversity is a "double-edge sword" (p. 403) as it can represent, on one hand, a chance to increase the creativity, innovation, or production of the group or, on the other hand, it can also be a weakness for the members of the team, since this heterogeneity may result in their not identifying with the group.

Furthermore, doing research as a team carries additional responsibilities as well as certain costs of management, such as planification, organisation and coordination of the team, which can be considered as important as achieving the research team's objective. So, the bigger the team becomes, the more crucial its management will be (Murayama et al., 2015). Stankiewicz (1979) observes that, in large teams, their productivity can be fostered by the leadership experience of the team leader. Therefore, when both advantages and disadvantages can emerge in a diverse research team, what can diminish the weaknesses and enhance the strengths is an effective leadership (Ayoko & Callan, 2010). Managing researchers is not an easy campaign, as a consequence of the complexity of the R&D context (Zhu & Chen, 2016; Stock et al., 2014). Not only in small work teams but also in large work teams, the crucial role that R&D leaders play has been demonstrated (Huzzard, 2015). However, there are some studies in the literature understating the critical role of the R&D leader (Edmondson & Nembhard, 2009; Nippa, 2006). For these reasons and for the call for an effective leader in R&D contexts (Elkins & Keller, 2003), a literature review of the leader and the leadership in the R&D context is carried out in the following section.

Leader and Leadership in the R&D Environment: A Systematic Literature Review

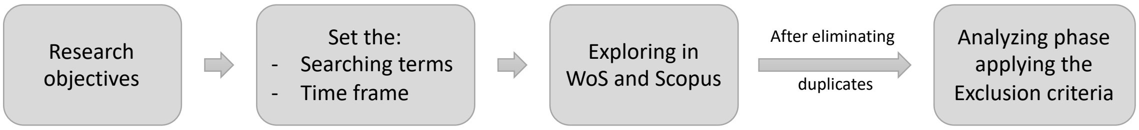
The leader as the responsible of the team (Fiedler, 2006) exerts and essential impact on the internal dynamics (Lin et al., 2016; Zhu & Chen, 2016). Their role is special because of "their direct influence on leading, organizing, rallying, and managing the operations of innovative tasks" (Zheng et al., 2010, p. 265). The leadership style is key to promote creativity and, thus, innovation (Zhou et al., 2018). Leadership style is defined as the attempt to influence the members of a team, project, department or organisation, to do something in a particular way, that they would have done differently otherwise (Huzzard, 2015). Fiedler (2006) defines it as "a problem of wielding influence and power" (p. 371). Strikingly, even though leadership is a research theme that has been heavily studied, its literature is scant in the R&D environment (Gritzo et al., 2017). The R&D environment is a very complex function to organise, a unique type of environmental atmosphere, far more different than other functions in organisations. "Tasks are unstructured and instead of timely and market-sensitive measures of performance, R&D

has a time-lagged, sporadic, and non-market nature to its outputs” (Gupta & Singh, 2015, p. 23).

Chung & Li (2018) highlighted leadership differences in R&D contexts compared to any others (Keller, 2017). In the R&D context, the leader not only has to be empowered, but has to be “a communicator and a coordinator in a horizontal community group, rather than the leader in a hierarchical group” (Chung & Li, 2018, p. 11). Considering the role of leaders and leadership in the R&D context, unexplored avenues for realizing a wide range of organisational objectives are opened. For instance, enhancing the employees’ creativity in the R&D teams or considering the impact of leadership and leaders in the R&D context can be useful to achieve a competitive advantage (Zhou et al., 2018; Gumusluoglu et al., 2017). Adopting team innovative behaviour is another feasible way for the organization to become more competitive, within the team and with other teams (Gumusluoglu et al., 2017), while fostering knowledge sharing (Liao, 2008).

Therefore, even though much of the literature has attempted to explore how R&D improves the performance, productivity and competitiveness of organizations, it is surprising that there has been limited theoretical and empirical focus on the leaders and the leadership style in R&D contexts (Gritzo et al., 2017). Consequently, there is a need for research into leadership implications in R&D environments due to their complexity and differences with other areas (Zheng et al., 2010). In order to have a deeper understanding of leaders and leadership in the R&D context, a systematic literature review was developed, focused on the effects of leaders and leadership styles in a peculiar and sensitive context as R&D. With this, we try to identify which are the key issues that have been dealt with in the literature. This method provides a 'replicable, scientific and transparent process' to achieve a frame of reference that identifies fields and subfields from collective perspectives (Tranfield et al., 2003, p. 209), which was designed as follows (Figure 2).

Figure 2. *Systematic review process*



The first step consisted in setting research objectives for our study (Cacciotti & Hayton, 2015; Ordanini, Rubera & DeFillippi, 2008). In the second step the time frame was defined and a group of keywords was identified to allow us to narrow down target papers. As a consequence, the search terms used were "leader*" AND "R&D team", "leader*" AND "R&D manage*" AND "leader*" AND "R&D project team" in titles, keywords and abstracts, from 1990 to 2019 (both inclusive). Then, the third step is exploring search terms in Web of Science and Scopus databases, as both guarantee high quality papers with high impact (Kullenberg & Kasperowski, 2016). Additionally, those papers that were not published in journals that are at least Q1 or Q2 on Web of Science and/or on Scopus were excluded. This additional step was included to ensure that all selected papers were published in a journal with a wide scope. Moreover, those papers that focused on i) leaders or leadership but not on R&D teams, R&D management, or R&D project teams; ii) R&D teams, R&D management or R&D project teams but not on leader or leadership; iii) on leaders, leadership, R&D teams, R&D management or R&D project teams but those were not an important question of the study and iv) those that focused on leaders' psychological traits, were not considered relevant studies for our literature review (Calabró et al., 2018; Sweeney et al., 2018). Finally, 42 papers comprised the final sample from the review process (Table 1).

Table 1. *Journals compilation*

JOURNAL TITLE	PAPER SELECTED	WoS	SCOPUS
Asia Pacific Business Review	1		Q2
Asia Pacific Journal of Management	1	Q2	Q1
Chinese Management Studies	1		Q2
Creativity and Innovation Management	2		Q1
Drug Discovery Today	1	Q1	Q1
European Journal of Innovation Management	1	Q2	Q2
Human Resource Development International	1		Q2
Humanities & Social Sciences Reviews	1		Q1
Industrial Management & Data Systems	1	Q2	Q1
International Journal of Human Resource Management	3	Q2	Q1
International Journal of Information Management	1	Q1	Q1
International Journal of Innovation Management	2		Q2
International Journal of Manpower	1		Q2
Journal of Business Ethics	1	Q2	Q1
Journal of Engineering and Technology Management	1		Q1
Journal of Leadership & Organizational Studies	2		Q1
Journal of Management	1	Q1	Q1
Journal of Management Development	1		Q1
Journal of Organizational Change Management	3		Q2
Journal of Product Innovation Management	2	Q1	Q1
Leadership and Organization Development Journal	1		Q1
Leadership Quarterly	2	Q1	Q1
Management Research Review	1		Q2
Organization Studies	1	Q1	Q1
R&D Management	4	Q2	Q1
Research-Technology Management	3	Q2	Q1
Technological Forecasting & Social Change	1	Q1	Q1
The Journal of High Technology Management Research	1		Q2

Subsequently, an objective and a detailed reading of those 42 papers was performed in order to identify which key issues are present in the literature. From this, three key issues seem to clearly emerge: (i) the leader characteristics in R&D contexts, (ii) the impact of several leadership styles in R&D contexts, and (iii) the leader behaviours in R&D contexts.

Leaders' Characteristics in R&D Context

The uniqueness of the R&D environment requires certain idiosyncratic leader's characteristics which are different to other leadership positions (Keller, 2017). Concerning the characteristics of the leader, there is a diversity of approaches. McDonough & Barczak (1992) suggested that, instead of basing the selection of the R&D project leader on what they called "gut feel" (p. 51) of the person who is hiring, it should be informed by scientifically contrasted findings in order to narrow down any risk of not selecting the right person for the job. Of all the studies reviewed so far, only seven have focused on the characteristics of the leader.

Among all the studies focused on the features of the R&D leader some common characteristics arise, such as cognitive problem-solving orientation, lead rather than do and encouragement. Cognitive problem-solving orientation is the characteristic highlighted to enhance and speed up the innovation process (McDonough & Barczak, 1992), to influence positively to the innovative R&D team performance (Thamhain, 2003), to improve the R&D team creativity (Zhou et al., 2018) and to become a successful R&D leader (Gritzo et al., 2017; Grosse, 2007). R&D teams are quite different to any other teams because its members usually have high creativity, high technical capacity and great autonomy (Gupta & Singh, 2013; Zheng et al., 2010; Elkins & Keller, 2003). For those reasons, R&D leaders should lead instead of work (Zheng et al., 2010; Grosse, 2007; McDonough & Pearson, 1993), unifying the vision and direction in order to achieve the established goals. Therefore, even though technical skills had traditionally been used as a criteria to select the leader of the R&D teams (Clarke, 2002; Huang & Lin, 2006), that does not seem to be enough (Witzeman et al., 2018). Similarly to what happens with the technical characteristics of the leaders –that they are not enough to be a successful leader in R&D contexts (Witzeman et al., 2018)–, Kim et al. (1999) asserted that the technical expert role is not enough to achieve the R&D project's performance and, thus, other roles must be employed. Human relation skills –giving constructive feedback and appreciation, recognition, etc– need to be considered in the selection process (Gritzo et al., 2017; Thamhain, 2003; McDonough & Pearson, 1993). R&D leaders should encourage and stimulate their team members to be more effective (Huang & Lin, 2006; Thamhain, 2003). They should need more consolidated soft skills: coaching and inspiring, fostering communication inter functions and collaborating in a highly fluid environment (Witzeman et al., 2018).

Grosse (2007) ordered leadership characteristics based on 50 semi-structured interviews with the supervisors (a steering committee member) of the R&D leaders, according to their importance in order to fulfill project success: having knowledge, being creative, being committed, being tolerant of risk, being able to manage conflicts and being accountable. Nonetheless, she also highlighted the understanding of the whole R&D project. Whereas R&D project leader's administrative skills have no impact, their technical skills have a negative impact and their human relation skills have a positive impact on team performance (McDonough & Pearson, 1993). In this sense, Elkins and Keller (2003) asserted that even though technical expertise and leadership skills are reasons to select R&D leaders to be the leader of an R&D project or R&D team, they must be able to resolve any interrelation conflict among team members or project members.

R&D project team leaders ought to demonstrate a high job involvement –means the level of involvement with the project–, need a high degree of self-esteem –means how valuable they think they are– and they ought to be able to manage in uncertain situations, in order to overcome the complexity and drawbacks of the R&D context (Keller, 2017; Grosse, 2007). Keller (2017) also highlighted the moderator role of the type of work, distinguishing between research and development, for a deep understanding of the adequate R&D project team leaders' characteristics.

Besides, a few studies highlighted the negative characteristics that should be avoided by R&D leaders to become successful, such as, not being good dealing with incompetence in the R&D team, being arrogant and not being good at balancing work-life situation (Gritzo et al., 2017; Grosse, 2007; Huang & Lin, 2006), or being narcissistic. However, being narcissistic presents a double-edge sword, since narcissistic leaders can negatively impact on the relationship with their team members, but at the same time, their narcissism could foster team creativity, if the narcissistic leader participates in decision-making process (Zhou et al., 2018).

Impact of Several Leadership Styles in R&D Context

There are unclear conclusions about which leadership style is most effective in R&D environments, as this is a quite particular context (Paulsen et al., 2009). Whereas in the literature is absolutely accepted that the role of the leadership style in innovation processes is crucial (Lenka & Gupta, 2019; Amabile et al., 2004), it is not so much the case regarding to which type of leadership style. From the sample studies reviewed so far that have attempted to address which is the leadership style best suited to achieve team innovation in R&D environments (Denti & Hemlin, 2016; Zhu & Chen, 2016; Paulsen et al., 2009, 2013; Liu & Phillips, 2011; Eisenbeiß & Boerner, 2010) or to enhance team innovation behaviour (Chung & Li, 2018; Gumusluoglu et al., 2017; Stock et al., 2014; Stoker et al., 2001), it could be concluded that they all encourage and facilitate team members to achieve their objectives rather than playing a more autocratic leadership style. Moreover, they achieved similar results applying different leadership styles (Zhu & Chen, 2016; Paulsen et al., 2009) and applying similar leadership styles, they obtained different results (Chung & Li, 2018; Paulsen et al., 2013). Hence, this highlights how complex the R&D environment is.

For instance, some studies focused on transformational leadership style (TFL) have ended up with slightly different conclusions (Paulsen et al., 2013; Liu & Phillips, 2011) and even opposite conclusions (Chung & Li, 2018; Eisenbeiß & Boerner, 2010). Both Paulsen et al. (2013) and Liu & Phillips (2011) asserted a positive direct relationship between TFL and R&D team innovation. However, the former proved that team identification and team member's perception of support for creativity are mediator variables which improve R&D team innovation, while the latter proved R&D team knowledge sharing as another mediator variable in that relationship. In contrast, Chung & Li (2018), and Eisenbeiß & Boerner (2010) stated not a direct relationship but a non-linear relationship, although with opposite conclusions. Eisenbeiß & Boerner (2010) suggested a U-shaped relationship, asserting that “not any level of TFL will result in high team innovation” (p. 369). Hence, team innovation will result higher in those R&D teams with high or low levels of TFL than those R&D teams with moderate levels of TFL. Even though, they demonstrated that the level of intensity of the transformational leaders has a different effect on the R&D team members’ innovative behaviour, the role of TFL is confusing since the team innovation is high both under low and high TFL levels. The poor team innovation results with moderate levels of TFL is due to the high-level needs of intellectual freedom and autonomy to act of the R&D team members in the innovation process, so they perceive TFL as a threat. However, Chung & Li (2018), based on the theory of positive emotions, suggested that both high and low levels of TFL would impact negatively on their team member’s innovation behaviour. In this sense they describe this inverted U-shaped relationship TFL-R&D team innovation as “the dark side of the TFL” (Chung & Li, 2018, p. 11).

Some studies have analysed the effect of leadership styles to enhance team innovation (Gumusluoglu et al., 2017; Denti & Hemlin, 2016; Zhu & Chen, 2016; Stock et al., 2014; Paulsen et al., 2009). Even though they all have demonstrated that several mediated variables –team identification, team cooperation, personal initiative, cross-functional R&D cooperation– can foster R&D team innovation, there are slight differences between those studies and results. In this sense, Gumusluoglu et al. (2017) asserted a positive mediation of team identification to improve team innovative behaviour with a benevolent leadership style, whereas Paulsen et al. (2009) demonstrated a positive relationship between charismatic leadership and team innovation, being team identification as a mediator variable. Therefore, several studies have demonstrated that different leadership styles achieve the same objective through the same mediating variable, and this is due to the cultural context (Gumusluoglu et al. 2017; Paulsen et al. 2009).

In the case of team cooperation as a mediating variable in the relationship between leadership style and team innovation, it has a positive effect by applying both charismatic leadership (Paulsen et al., 2009) and group-focused empowering leadership (Zhu & Chen, 2016). In contrast, when Zhu and Chen (2016) applied differentiated individual-focused empowering leadership, it fostered intra-team competition, but this indirect relationship with team innovation was not significant. They suggested that relationships between intra-team competition and team innovation could be more complex than direct associations, and far more complicated in R&D contexts. Denti & Hemlin (2016) enhanced team innovation applying Leader Member Exchange (LMX) leadership style mediated by fostering team member's personal initiative –recognizing their contributions, encouraging knowledge exchange, developing trust within the team–. In contrast, the direct relationship between LMX leadership style and team innovation and when this relationship is mediated by the intrinsic motivation were non-significant.

Instead of focusing the research question on looking for the best suited leadership style in order to achieve a specific goal, Peng et al. (2019) proposed the study of a leadership style which is prejudicial for team creativity as a warning to the R&D team or research organisation. As a result of the negative effect of self-serving leadership style on team creativity, they proposed what leaders should avoid and some advice to lessen the negative effect of the self-serving leadership style. Psychological safety should be fostered in the R&D team, as well as sharing knowledge and information to decrease the knowledge concealment among the R&D team members.

Knowledge sharing or exchange is defined as that knowledge transferred from one person to another within a team or outside the team (Lee, 2001). Not only sharing knowledge, but also how is it communicated are crucial to increase the innovation team level (Lisak et al., 2016). In this sense, R&D leaders, in order to foster team innovation, can stimulate knowledge sharing by applying a particular leadership style (Zhou et al., 2018). Regarding the studies in this literature review, TFL (Liu & DeFrank, 2013; Liu & Phillips, 2011) and visionary leadership (Zhou et al., 2018) styles can foster an employee's intention to share knowledge. The positive influence of TFL in knowledge sharing has been demonstrated not only as a leadership style (Liu & Phillips, 2011), but also as the climate that this particular leadership style develops in the R&D team, encouraging employees to share knowledge (Liu & DeFrank, 2013). This TFL climate is known to be an indicator of the work team climate. Zhou et al. (2018) achieved the same positive direct results applying the visionary leadership, which is a more autocratic style, more attuned to the Eastern culture where this study was conducted (China). It is based on some characteristics of TFL, but also on other characteristics such as helping team members to perform organizational objectives.

Some of the studies reviewed refer to human resources management systems or practices that might be replaced by leadership styles to accomplish the same objective: knowledge sharing among team members (Chuang et al., 2016; Liu & DeFrank, 2013). Actually, Chuang et al. (2016) asserted that human resources management system for knowledge-intensive teamwork and empowering leadership may replace one another in order to increase team knowledge sharing, because both of them can ensure knowledge sharing within the team and knowledge acquisition from outside of the team. The trusting climate, as Jones and George (1998) defined it, is induced by TFL to foster employee knowledge-exchange behaviours, although this could be nurtured by human resources management systems (Shih et al., 2012). Furthermore, Liu & DeFrank (2013) demonstrated that human resources management practices – team-based job design and knowledge sharing incentives– as well as TFL climate can diminish and mitigate the negative effect that an employee's self-interest can have on knowledge sharing. Hence, developing certain leadership styles might be an opportunity to reduce costs while achieving the same goals (Chuang et al., 2016). In this line, Stock et al. (2014) asserted that innovation-oriented leadership and innovation-oriented rewards, as well as training and development human resources practices enhance cross-functional R&D cooperation, which foster product program innovativeness.

In the last 5 years, most of the studies have been focused in analysing the effect that different cultural environments have on leadership in R&D, mainly conducted in non-western cultural countries such as Taiwan, India, China or Turkey (Gumusluoglu et al., 2017). The reason behind this is that using the traditional leadership styles differentiation (Bass, 1985; Blake & Mouton, 1964) does not provide a conclusive answer. Even though a few existing studies accepted that the leadership theories are culture free (Ishikawa, 2012a; 2012b), several studies have provided a reality check (Zhou et al., 2018; Gumusluoglu et al., 2017).

Zhou et al. (2018) advocated the important role that the cultural context plays on R&D leadership styles. For instance, their study in China, as well as the study of Gumusluoglu et al. (2017) in Turkey –both Eastern cultures– revealed that leaders in R&D contexts, where the collectivistic culture is rewarded and developed, can set autocratic leadership styles more successfully than in Western cultures. Accordingly, Zhou et al. (2018) hallmarked the strongly direct relationship that exists directly between visionary leadership and creativity or, indirectly, through knowledge sharing; and the group-focused empowering leadership is strongly associated with team innovativeness and team performance, both of them positively mediated by intra-team collaboration (Zhu & Chen, 2016). Both studies have in common the advice on the potential response to the special cultural environment of their countries –China and Taiwan, respectively– where people are used to obeying direct orders from their superiors. In this sense, Gumusluoglu et al. (2017) asserted that benevolent leadership has a positive effect on team innovation, enhancing team identification. Moreover, in the Japanese culture, gatekeeping leadership, instead of transformational leadership, has a positive direct impact on team performance (Ishikawa, 2012a). In contrast, shared leadership style can fit in R&D contexts in either Western or Eastern countries or, in other words, regardless of the culture (Ishikawa, 2012b).

Leaders' Behaviours in R&D Context

Leadership behaviours may act as a contextual factor influencing team performance and team innovation, via modifying team processes (Zhu & Chen, 2016). Even though, daily interactions of the leader's behaviours with his or her subordinates can influence the overall performance (Amabile et al., 2004; Stoker et al., 2001), there is a limited and scant literature focused on this relationship (Gupta et al., 2017; Gupta & Singh, 2013). Moreover, the lack of agreement about which are the behaviours that should be studied make the research more difficult (Yukl, 2008). Following the stream of research focused on what leaders do to enhance leadership effectiveness, we are considering as behaviours what leaders in R&D contexts actually do (Gupta & Singh, 2013).

The R&D team leader should not only provide the necessary resources according to the planned program to implement, but also encourage team members to collaborate as a community, avoiding any kind of favoritism towards someone. This favoritism has been demonstrated pernicious to intra-team collaboration. For instance, adapting performance goals to individuals enhances intra-team competition instead of collaboration (Zhu & Chen, 2016). Zheng et al. (2010) suggested individual non-competitive success as a possible variation of that behaviour to improve whole team innovation. The continuous feedback in the R&D team is essential to maintain increasing innovation, and not only to control any deviation, but also to give visibility to the contributions to the client and/or the rest of the organization, and to offer recognition to the team members, which is another important leader's behaviour (Zheng et al., 2010; Zhu & Chen, 2010; Thamhain, 2003).

In the literature, it is assumed that fostering more cooperation within the team, making efforts to enable collective resolutions among team members or enhancing open-innovation –through actions such as mentioning the names of those who suggested a proposal or requesting someone respected by the team members to help to get a proposal accepted–, will improve team innovation (Gupta et al., 2017; Zhu & Chen, 2016; Gupta & Singh, 2013, 2014, 2015). In addition, encouraging and enabling team members to be proactive, in order to undertake some activities, and even to make some individual decisions also has a direct (Gupta et al., 2017; Gupta & Singh, 2013, 2014, 2015) and indirect effect on the team innovativeness (Denti & Hemlin, 2017).

Grosse (2007) suggested that in contrast to the social identity theory there is no correlation between the team identification and the objective of the R&D team leader. Advocating that a too close relationship with the R&D team members might lead to group thinking, and they should balance the organization's, the R&D team members' and their own interests. Conversely, several studies advocated that R&D team leaders who developed the sense of belonging to the team (Gupta & Singh, 2013, 2014, 2015) and who developed caring behaviours to the team members have finally encouraged innovation in the team (Gumusluoglu et al., 2017). Hence, promoting team members' identification such as, enhancing shared efforts, fostering participation in cooperate decisions and collective goals, leaders in R&D environments impact on cooperation in order to achieve team performance, to enhance innovative behaviours within the team or the project team or to foster knowledge sharing (Gumusluoglu et al., 2017, Gupta & Singh, 2013, 2014, 2015; Paulsen et al., 2009, 2013). In addition, not only is clarifying the objective and aligning personal goals with the collective objective crucial to reach team innovativeness (Zheng et al., 2010; Thamhain, 2003) but also to develop employee creativity (Zhou et al., 2018), to fulfill the team performance (Kim et al., 1999; Harris & Lambert, 1998) and to become an effective R&D team leader (Thamhain, 2003).

Moreover, Ishikawa (2012a) asserted that R&D leaders' behaviours to achieve team performance are influenced by cultural context. Actually, in Japan which is a collectivistic culture, behaviours such as, facilitating their needed relationships within the team or outside the team and finding the resources required to achieve their objectives, are much more important R&D leaders' behaviours than those which rely on inspiring, stimulating or encouraging team members to express and contribute to accomplish the team performance.

Therefore, the R&D leader is a critical role in managing the R&D function that comprises multidisciplinary-knowledge workers and their associated teams. It is a pivotal organisational role in the knowledge transfer and creation processes in R&D environments and is key to achieve the organisation's innovative objectives (Edmondson & Nembhard, 2009; Elkins & Keller, 2003). R&D leader's role is also to enhance co-operation between the team members and fostering team members to resolve problems (Gumusluoglu et al., 2017; Lisak et al., 2016). In this sense, Rangus & Černe (2017) demonstrated that leader's behaviours that promote interaction, recognition and visibility of team members creates OI relationships. This fosters intra-team collaboration and collaboration between team members and members outside the team, thereby increasing the team's and the organisation's capacity for innovation and to purse OI. For that reason and because the specific role of the individual actors in leading and managing OI has been overlooked (Ahn et al., 2017; Salter et al., 2015), an analogue literature review was undertaken in the next section, covering the role of R&D leaders in leading and managing OI and OI strategies.

R&D Leader in OI: A Systematic Literature Review[1]

The role of R&D leaders in leading and managing OI is poorly understood. As in the former literature review, an analogous literature review has been carried out in this section, even though the objective and keywords are different. The main question to be addressed in this study is to identify and analyse the main themes and streams with respect to the R&D leader role within an OI R&D environment. To obtain the most extensive number of articles related to the specific field of research, the following

[1] Based on the book: Cunningham, J. A., Foncubierta-Rodríguez, M. J., Martín-Alcázar, F., Perea-Vicente, J. L. (2021). Open Innovation and R&D Managers: A Systematic Literature Review and Future Research Avenues. In Fernandes et al. (eds.), *Managing Collaborative R&D Projects. Leveraging Open Innovation Knowledge-Flows for Co-Creation* (pp. 19-45). Springer.

keywords were used: “OI” AND “R&D leader*”, “OI” AND “R&D manager*”, “OI” AND “R&D environment”, “OI” AND “leader*”, “OI” AND “manager*”. This process was also carried out in the title, abstract and/or keywords. Since Chesbrough's work in 2003 on OI, there has been a growing body of research, hence the period of study is from 2003 to 2019 (both inclusive).

After reading and reviewing each paper considered fit for OI and R&D leaders, the exclusion criteria was applied (Calabró et al., 2018; Sweeney et al., 2018). Those papers that focused on R&D leader or R&D manager or R&D environment or related with leader* or manager* but not in OI, those papers that focused on OI but not in R&D leader or R&D manager or R&D environment or related with leader* or manage* or any article where R&D leader or R&D manager or R&D environment or OI were not an important question of the study were removed from our literature review. After completing this literature review process, a final sample of 18 articles was selected (Table 2).

Table 2. *Literature Review Search Results*

Keywords	**R&D Management**	**Research Policy**	**Technovation**	**Research Technology Management**	**California Management Review**	**Total**
OI and R&D leader*	2	1	0	3	2	**8**
OI and R&D manager*	19	8	9	8	6	**50**
OI and R&D environment	4	3	3	3	0	**13**
OI and leader*	9	8	1	4	2	**24**
OI and manager*	63	41	42	32	26	**204**
Total First Analysis	**97**	**61**	**55**	**50**	**36**	**299**
Total	**6**	**2**	**4**	**5**	**1**	**18**

Based on our literature review, three key themes were identified, namely, OI implementation, fear and firm performance.

OI Implementation

The traditional R&D model in which discovery, research and development, as well as commercialisation could be managed and developed internally for a firm to be successful can be outdated in some sectors. It is becoming clear that all the competencies needed to innovate are not available within a firm, so pursuing OI becomes essential (Jelinek et al., 2012; Slowinski et al., 2009). For this reason, one of the main themes is determining how the OI implementation process should be within a firm. The main themes from our systematic literature concerning the role of the R&D manager concerning OI implementation included their networks, ability to deal with internal barriers and structures, training programmes and their management of relationships.

One of the challenges for firms is embracing open innovation from a closed innovation environment (Chiaroni et al., 2010). We found some papers focused on understanding successful OI implementation process through exploratory research based on different firms (de Araujo et al., 2014; Chiaroni et al., 2010; Sieg et al., 2010; Slowinski et al., 2009), although they do not always have similar results (Christiansen et al., 2013). For example, Sieg et al. (2010) centered their research on seven firms. These firms search for solutions to R&D problems applying OI. The first two phases –problem selection and problem formulation– were conducted inside the firm and the R&D department has the primary responsibility. The next two phases –problem posting and problem-solving– are developed outside the firm through an intermediary innovation company. The final phase is developed inside the firm, which is the solution evaluation. They perform the phases that involve OI outside the firm through an intermediary called InnoCentive (Lee & Shin, 2017; Davis et al., 2015; Slowinski et al., 2009). Furthermore, Slowinski et al. (2009) refer to additional intermediaries such as YourEncore, Yet2come and NineSigma. The main idea of these intermediaries is quite similar to the process described above, in which those responsible for R&D have to specify which innovation the company needs or will need in the future, and a process of searching will be initiated. The range of external sources will depend on the network of the R&D manager (Sieg et al., 2010; Slowinski et al., 2009). Such studies highlight the role of the R&D manager as a facilitator/network broker and in some sense, a guardian of the OI processes within firms. This highlights the need for an R&D manager to have an extensive network within the firm outside the R&D department and with outside firms and knowledge intermediaries and brokers.

Based on a longitudinal study of four different Italian firms Chiaroni et al. (2010, p. 228) asserted that there are three distinctive phases from the closed innovation model to the OI: “unfreezing, moving and institutionalising”. During the first phase, unfreezing, R&D managers play a fundamental role. R&D managers' social networks provide them access to the essential sources of knowledge and technologies to achieve innovation. Making visible to the rest of the firm the advantages of this new way of innovating is one of the essential functions of the managers of these R&D units. The purpose of this is also to justify all the resources that will be invested in the process of opening up the company to external innovation. Furthermore, the authors proposed beginning by applying the OI techniques in pilot projects, so that, later on, the results can be presented as an example of a better way of innovating. A study undertaken at LG Chem Research Park is used to determine whether the firm can apply OI techniques (Lee & Shin, 2017). Throughout the two methods established for the implementation of OI in the firm, Lee and Shin (2017) asserted that R&D managers need to be able to identify any possible internal barriers. When addressing them, they need to be able to overcome them more efficiently, taking advantage of the assets of OI. Also, using social media can enhance the positive impact of OI. R&D managers should use it to reduce any internal barrier, to improve the absorptive capacity of external knowledge and the internal knowledge transfer (Mount & Martinez, 2014).

A further practice to achieve a successful implementation process of OI is that R&D managers promote training programs to overcome any negative attitudes that R&D department employees may have towards OI (de Araujo et al., 2014). There are a few studies focused on determining the OI implementation process, as well as there is a lack of sufficient OI practices for success (Brunswicker & Chesbrough, 2018). Christiansen et al. (2013) proposed some intellectual property processes and incentives systems, although they have not always been proven to be effective. In fact, among the eight projects they examined, just four turned to be positive. Therefore, R&D managers need to be conscious of the practices that better perform in the OI process, not only at the firm level but also at the department level.

A core tenet of OI is that innovation does not have to be developed within a company. Just the opposite is true. OI is enriched by interactions and relationships with suppliers, customers, research centres, universities and even competitors, to enhance the scope of innovation. Therefore, a competence that R&D managers need to have for OI is to manage the interactions that take place between scientists belonging to the firm, but also with those outside the firm (Jelinek et al., 2012; Asakawa et al., 2010).

Fear

In our second theme, two main aspects emerged concerning the fear that OI R&D managers face, based on the papers in our study. Inertia from years of experience doing the same thing is difficult to change. Therefore, the idea and practice of sharing information and knowledge with partners outside the firm goes against the operating principles and firm culture. Thus, one main fear is sharing knowledge with people outside the firm. The other main fear is centred on cultural changes and managing change that is associated with OI.

Undoubtedly, a considerable number of studies that have appeared in this literature review have focused not only on how to deal with the fear of change, but also the fear of sharing knowledge. Building a department that is specifically focused on the implementation of the OI in the company is not enough. There is a need to encourage and foster the new way of innovating by adopting OI such as the internal culture (Christiansen et al., 2013; Asakawa et al., 2010; Chiaroni et al., 2010).

Implementing OI has many advantages (Chesbrough, 2003). However, all these interactions with external actors allow the opportunity to access knowledge and innovations more cost-effectively. The fear is also that they may breed future competitors (Jelinek et al., 2012). R&D managers also have to cope with the application of OI techniques and balance this against their misgivings and beliefs about the potential of adopting an OI strategy and associated practices (Davis et al., 2015; Sieg et al., 2010). R&D managers have to consider the consequence of having external innovation – inbound OI– as this can reduce the available financial and human resources (Slowinski et al., 2009). Furthermore, an extremely compartmentalised structure and an absence of communication between the diverse research projects complicate implementation and the organisational culture that is required for OI to thrive (Lee & Shin, 2017). Inertia can stifle the adoption of OI and R&D managers need to be mindful of this and of the natural fears that arise when collaborating with actors outside their firm.

Conversely, other R&D managers accept the fact that nowadays, innovation takes place globally. As Jelinek et al. (2012, p. 21) stated: "innovation has flown from the central R&D lab to the labs of collaborators around the world". The strategy to be followed by the R&D department will influence the R&D structure that is created within a firm. In OI contexts R&D managers determine the kinds of problems for which they deploy OI strategies and the types of knowledge to be shared in the resultant relationships (Lee & Shin, 2017; Chiaroni et al., 2010). Furthermore, R&D managers should be able to understand that with the implementation of OI, not only should they seek solutions to problems, but one of the changes they are facing is that now they also need to seek solutions through knowledge networks or find those who can provide the answer (Lee & Shin, 2017; Davis et al., 2015; Sieg et al., 2010). Hence, they have to spend significant amounts of time on it. Therefore, the risk and fear are always that the firms and actor R&D managers with whom they finally decide to collaborate with are not the right ones, thus damaging the reputation within their company (Lee & Shin, 2017).

One of the conclusions drawn by de Araujo et al. (2014) in their paper is that the attitude of the members of the R&D department towards OI is crucial. Unless members support the OI implementation process, they could easily cause that knowledge sharing –inbound OI or outbound OI– to end up becoming a failure. The authors were able to identify two different negative attitudes: the attitude against the acquisition and application in the company of external knowledge, called not-invented-here (NIH); and the attitude against exporting the internal knowledge available in the company, called not-shared-here (NSH). For R&D managers, it is essential to recognise those kinds of negative attitudes among their employees, to mitigate them immediately.

Firm Performance

It is not surprising that our third theme to emerge from our study is in respect to firm performance and OI R&D management, which has been studied with some interest (Du et al., 2014; Berchicci, 2013; Hung & Cho, 2013; Asakawa et al., 2010). Such studies have demonstrated the positive impact that can be achieved. Hung & Chou (2013) asserted that inbound OI has a positive effect on firm performance. This relationship is positively moderated by internal R&D. Therefore, as the R&D department is more developed, the firm performance will be higher. This is further supported by Berchicci (2013). In his study, he argues that the impact of the OI in the firm performance depends on the “stock of knowledge” (p. 125) contained in the R&D department. Both studies reached similar conclusions, with samples from high-tech manufactures, although from different continents: Hung & Chou (2013) carried out their study in Taiwan –Asia– and Berchicci (2013) did it in Italy –Europe–. The benefit of this *stock of knowledge* is reflected in the economic side, since it involves fewer costs and less effort. Furthermore, the higher the internal R&D, the fewer the partners with whom the R&D department has to collaborate with in order to achieve the objectives, and only with those who make the company's value increase. Despite both studies reaching similar conclusions, Berchicci (2013) observed the number of external R&D activities undertaken. In his study, he highlights the point at which these external R&D activities can be counterproductive for the firm's innovative performance, as it can be reduced. In essence, the R&D manager's role is to help shape the form of OI adoption and the associated organisation practices and process that contribute to firm-level performance.

R&D managers' attitudes and initiatives promote the use and implementation of OI. Asakawa et al. (2010) suggested that R&D managers should be proactive in the implementation process, not only in the R&D department but across the whole organisation. Also, along with the facilitation of external collaborations, firm performance can be enhanced. Nevertheless, these results may be different depending on the external collaborator. For instance, if the external collaborators are universities or research centres, they will improve the R&D department's research performance.

On the contrary, if they are companies –customers, suppliers, etc– they will boost the R&D department's development performance. Du et al. (2014) also explore the impact of the OI on firm performance. However, they make a distinction in the type of relationships that R&D managers carry out in the different projects, distinguishing between “science-based partnerships” –with research centres and universities– and “market-based partnerships” –with suppliers and clients– (p. 829). Depending on the type of collaboration, how the R&D managers manage the project will have a positive or negative impact on firm performance. In the case of market-based partnerships, the R&D managers should carry out regular control and strictly fulfil the planning initially established to improve firm performance. In contrast, if the R&D managers are less strict and more loosely managing the science-based partnerships, they will also obtain positive results from these relationships. Therefore, the choices that R&D managers make about the type of OI partnership determines firm performance.

R&D is a very complex environment to organise, because it requires higher degrees of autonomy, different working atmosphere, not long in terms of physical conditions, but also the way employees are rewarded and organised. In the literature, it is highlighted that theoretical and empirical studies focused on the leaders in R&D environments are limited. There is a need for future studies to focus on the leaders and managers who have the responsibility for processes, structures and strategy in R&D environments due to its complexity and differences with other areas (Gritzo et al., 2017; Keller, 2017).

Principal Investigator

Drawn from previous discussions in this Doctoral Thesis, we now focus on the Principal Investigator (PI) as the core figure of the research team. In our study, we assume the PI concept by Cunningham et al. (2016) as the person who is the “heart of value creation through development of knowledge that can (…) result in a number of scientific, economic and societal impacts and gains” (p. 780). The role of PIs is crucial for linking academia, universities and the higher education system with the industry, business and the economic system, which form two of the five helixes of the Quintuple Helix model (Mangematin et al., 2014; Carayannis & Campbell, 2009). The literature highlights that the role of the PI is becoming increasingly relevant in a fast-changing research context. Since knowledge is the pivotal pillar on which the knowledge economy and, therefore, the socio-ecological transition, are based (Carayannis et al., 2012), PIs are key in research organizations, research centres and universities, which, following the guidelines of the Third Mission, are becoming increasingly entrepreneurial (O’Kane et al., 2020; Kalar & Antoncic, 2015). From research and, therefore, from its scholars, it is expected that their scientific production becomes the fuel required to initiate an impact, not only within the scientific community, but also to be an extra impulse in the development of the economy and in benefit of the society (Klofsten et al., 2019; Guerrero & Urbano, 2012; Etzkowitz & Leydesdorff, 2000).

While the role of the PI is recognized in the research context, it is also widely considered a significant step in the academic and professional career of a researcher (Cunningham et al., 2019). There are a wide range of roles of PIs identified in the literature, such as, supervisor and mentor, resource manager, knowledge broker, research strategist, researcher, research team leader, project manager, project promotor, stakeholder manager and administrator (Cunningham et al., 2014). In contrast, few papers have been able to deepen the understanding of the responsibilities of PIs (O’Kane et al., 2020; O’Kane et al., 2015).

To accomplish their research purposes, PIs have the responsibility to manage the available resources and make any necessary decisions (Kidwell, 2014). When they are able to combine the resources of academia, industry and government so that all three actors are interacting, they may be able to ensure that they could all benefit from the results of the research projects they undertake. Moreover, acting as a lynchpin between academia and industry, the PI is a knowledge broker and is able to create value by overcoming the distance between them and their different goals (Kidwell, 2013). This liaison role has become so important that, nowadays, it is often considered a requirement for achieving public competitive funding (Mangematin et al., 2014).

The literature highlights the complexity that researchers assumed in the PI role (Casati & Genet, 2014; Kidwell, 2013), since it goes beyond being an excellent researcher, and the demands are actually much more challenging (Cunningham et al., 2016; Menter, 2016). In the academic context, PIs assume a range of responsibilities, including the management of the necessary resources to undertake those research projects, which are aligned with the research team's stream of investigation. Thus, they can efficiently submit to those public funding calls and achieve all the objectives required, and in accordance with the Third Mission (O'Kane et al., 2020). All these responsibilities and functions of PIs can be grouped into four different roles: science networker, research contractor, project manager and entrepreneur (O'Kane et al., 2020). In order to accomplish the Third Mission of universities, PIs must be entrepreneurs. They are meant to bridge the gap between academia and its practical application for the industry, thereby ensuring that research results have a positive impact and improve economic and social development (Baglieri & Lorenzoni, 2014), although it is challenging for PIs as entrepreneurs to establish relationships with the industry. Being boundary spanners, PIs in the role of entrepreneurs are creating value for the research team and other partners who collaborate with the university, such as, the industry, governments or policy makers (Cunningham et al., 2018; Boehm & Hogan, 2014).

PIs also have to be adept and qualified project managers. Since the method of doing research has evolved on a larger scale, the level of bureaucratic activity required is greater and more complex, in addition to the need for other activities such as decentralization, hierarchy or/and division of labour (Murayama et al., 2015). Therefore, not only is the leadership role of PIs recognized, but it is also being acknowledged that PIs need to be responsible managers (Cunningham et al., 2014; Stephan, 2012). Not only do PIs have management responsibilities, such as reporting on the monitoring of research projects in which they are involved, but they also have human-resources responsibilities, such as finding those researchers who have the knowledge necessary to achieve the objectives, as well as integrating and managing multidisciplinarity or any other diversity that exists in the team (Cunningham et al., 2015; O'Kane et al., 2015).

PIs are required to be expert science networkers. PIs have to create, train and lead research teams to be competitive, so the ability of PIs to organize scientific collaborations is key for research productivity (Cunningham et al., 2019; Defazio et al., 2009). Another benefit from having the scientific collaborations professionally organized is that it favors the development of the HC of the team (Bozeman & Mangematin, 2004). Even though experience is one of the characteristics that are regarded positively in a research team, due to all the intangible value that it provides, all the capital that the more novel researchers in the teams provide –consistency, determination, knowledge from more updated training and effort– is also significant (Bozeman et al., 2015). To sum up, PIs need to balance the experience in collaborating of all the members of the research team that is going to undertake the stream of research (O'Kane et al., 2020).

The role of research contractor is related to the PIs' creative way of approaching their research, so that they are able to both embrace and respond to future research avenues (O'Kane et al., 2020; Iden et al., 2017). In addition, PIs aiming to accomplish the strategic vision will manage all those resources they have available to them (Kidwell, 2014). Thus, PIs remain aware of any changes in social, economic, political or scientific development to modify and adequate their objectives and projects so that their scientific visions remain crucial, current and relevant (Cunningham et al., 2015). Therefore, when PIs design and plan their research, they establish objectives to be achieved and foresee how the area of research they have visualized will be developed and its potential (Mangematin et al., 2014).

Notwithstanding that there are some studies that have focused on the PI role in the literature, the knowledge about them is somewhat scant, because there is still a need for a deeper understanding of this crucial actor in R&D environments. In this sense, a fundamental question that remains to be answered is: what makes a PI? In other words: What is the HC needed to become a PI? Which are the characteristics of successful PIs? How could a research center or a university identify the most appropriate scientist to become the PI of a research team? Could a research center or a university base that decision on an HC measurement scale?

In order to answer those questions, it is indispensable to better understand how PIs influence or impact their RTs. This, in turn, poses further questions including, but not limited to: How could the characteristics of the PI influence the performance of the research team? Could the HC of the PI be crucial to achieve key objectives? Would it enhance or diminish the performance of the research team? Does the leadership style of the PI influence the level of conflict within RTs? Does the leadership style of the PI influence the RT performance?

Furthermore, we also think that some issues regarding gender are still in need of a more definite clarification, including the following questions: Is there a gender difference in the PI role in the process to obtain public competitive funds? Is there a gender difference for the researchers in the process of reaching the PI position?

The research work carried out in this Doctoral Thesis aims to address both PIs and their environments. With this research, we will deepen the understanding of what influences PIs and what they have an influence on, since PIs are a key asset in R&D environments. Obviously, a Doctoral Thesis cannot address all the aspects connected to the above questions, so the focus of this Doctoral Thesis had to be narrowed down to some of the issues that are in the core of the influence of PIs on the activities of R&D teams. Therefore, we first focused our research efforts on developing a measurement scale of the PI's HC whose results could allow us to determine whether different PI profiles exist. Then, we focused on studying whether obtaining public competitive funding could be influenced by the PI's priorities or their gender. Subsequently, we focused on the relationship between the level of conflict within an RT and its performance, as well as on the influence that the PI's transformational leadership has on this relationship. In order to address all of the above, this Doctoral Thesis was divided into four different chapters, followed by a closing chapter focusing on the final conclusions, limitations and future research avenues.

Chapter I

In the literature, there are some studies that understate the impact that PIs can have in an R&D environment (Edmondson & Nembhard, 2009; Nippa, 2006). However, the involvement of PIs in research teams has proved to be crucial (Lenka & Gupta, 2019; Huzzard, 2015). Furthermore, research is increasingly carried out in teams, which are often composed mainly of multidiverse scientists, for whom an efficient PI is key (Elkins & Keller, 2003). Therefore, understanding the competences required for those who manage university projects and research teams is crucial (Cunningham & O'Reilly, 2018).

Notwithstanding that leadership is a long-standing area of study, little is known about the characteristics that determine a PI's HC (Käpylä et al., 2010). The purpose in the first chapter is to identify the idiosyncratic features of the PI's HC in order to develop a valid measurement scale for academic PIs' HC, which is essential to successfully lead research teams and large-scale public research programmes (Cunningham et al., 2018).

Data used for this study was collected from PIs belonging to different fields of knowledge with experience as PI of research teams funded in European or national competitive public calls. To increase the response rate and trying to avoid non-responses due to the number of emails that the PIs receive on a daily basis, an email was first sent to both the university vice-rector for research and transfer affairs, and the head of the PI's department, requesting their help in encouraging the PIs to answer the questionnaire. Finally, a total of 242 valid responses were obtained from full professors and professors, who are the RT's PIs of the PAI.

Chapter II

Knowing and being able to identify which are the features that shape the PI's HC could be fundamental to assess any possible influence on the decision making (Cunningham et al., 2018; Käpylä et al., 2010). For that reason and relying on the HC scale of the PI, the aim of the second chapter is to examine whether there are different typologies of RT PIs who might behave differently at leading and managing RTs. Data used for this study was collected from PIs belonging to different fields of knowledge with experience as PI of research teams funded in European or national competitive public calls. To increase the response rate and trying to avoid non-responses due to the number of emails that the PIs receive on a daily basis, an email was first sent to both the university vice-rector for research and transfer affairs, and the head of the PI's department, requesting their help in encouraging the PIs to answer the questionnaire. Our sample was comprised of 224 PIs of RTs from those different scientific fields.

Chapter III

In the third chapter, two different objectives are proposed. Public funding is an unquestionable resource for research centres and public institutions to be able to design sustainable research (Santamaría et al., 2010). Securing competitive public funding is vital for PIs in order to support their current and future line of research, as well as to underpin the RT with which the research will be performed (Cunningham et al., 2014). Therefore, the third chapter proposes a deeper study of the factors that influence the research teams in order to obtain public competitive funding, focusing on how the priorities of the PI influence them.

The other objective is that the debate on whether there are equal opportunities in academia according to gender is still prevalent (Lynn et al., 2019). Even though the number of female scientists has increased, there is still evidence that there are deep gender differences in some features of academia (Lerchenmueller & Sorenson, 2018; Mayer & Rathmann, 2018). Therefore, in the third chapter, it will also be investigated whether there is a gender gap in the acquisition of public competitive funds by examining the moderating effect of the gender of the PI in the relationship between the RT PI's priorities and the public competitive funds received.

To achieve both objectives a different database was used. This study was conducted in R&D teams of Spanish R&D public centres which research is focused in the areas of Biomedicine and Health. It was limited to those R&D teams who had applied for competitive funding projects from national or international programmes from 2011 to 2016. The population was comprised of 68 Spanish R&D public centres. We sent e-mails to the whole population. In fact, emails were sent to every single director of the 68 R&D public centres. In the email we explained in detail the procedure we planned for collecting the data and requested them to inform each of the R&D teams' PIs that existed in their centre that we would be contacting them. Finally, we received answered questionnaires from a total of 47 R&D public centres (69,11%). In these R&D public centres are 128 R&D team's PIs. We received valid answered questionnaire from a total of 97 R&D team's PIs (75,78%), where 23,71% are women. Therefore, the final sample is comprised of 97 R&D team's PIs which research is focused in Biomedicine and Health areas.

Chapter IV

Nowadays, most of the research is developed in RTs (Jeong & Choi, 2015; Bozeman et al., 2013). The bigger the team, the more diversified it is (De Saa-Perez et al., 2017; Van der Vegt & Bunderson, 2005). This multidisciplinarity –i.e., diversity of knowledge, abilities, experiences, skills– fosters the development of ideas and solutions to resolve the problems that the RT may face (Lenka & Gupta, 2019; Martín-Alcázar et al., 2012), even though it may also be a source of conflict within the RT (Zhao et al., 2019; Huang, 2012). Moreover, the complexity of the R&D environment further complicates the management of the scientists who carry out the research (Stock et al., 2014). Thus, the role of the PI managing this RT might be key to leveraging the benefits of the conflict, and to lessening its negative effects.

Therefore, in the fourth chapter an in-depth study will be made on the relationship between team conflict and its performance. Moreover, it is examined whether the PI's transformational leadership moderates this relationship and it is also examined the relationship between the PI’s transformational leadership and team performance. Data used for this study was collected from research team members and PIs from a wide range of fields in Spanish public universities. The unit of analysis in this study are the research teams, which are composed of diversely qualified researchers who, led by the PI, collaborate together towards the achievement of the defined objectives through sharing their knowledge and experience (Hautala & Jauhiainen, 2014; Jiménez-Sáez et al, 2011). In order to obtain the maximum number of surveys answered, we contacted with the Vice-Rectorates for Research of all Spanish public universities, explaining them which the nature of research project was and asked for their collaboration in the dissemination of the questionnaire in their university. As a result, we received a total of 1290 valid responses. Valid responses were considered if the questionnaire allowed us to identify the research team to which the respondent belonged. Then, to identify RTs in our study, we removed those RT do not fulfilled both of two criteria: (i) to have a minimum of three questionnaires and (ii) to represent at least the 50% of the RT members (Chen et al., 2019; Cai et al., 2017). Thus, we finally ended up with 205 RTs.

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CHAPTER ONE

Measuring the Human Capital of Scientists in the Principal Investigator Role

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Abstract

There is an emerging literature on scientists in the principal investigator (PI) role that identifies them as central and key actors in entrepreneurial ecosystems. PIs in leading large-scale public research programmes and teams require an array of skills and abilities to be effective in this role. The purpose of this paper is to propose a human capital (HC) measurement scale that can unearth their competencies at the micro level, since no specific measurement scale specifically for PIs. The proposed model, which was reached through the methodology established in the literature, is composed of 6 PI's HC factors, such as, research knowledge, open-mind research ability, research perform ability, stoic research skill, innovation skill and critical skill. In proposing this, this paper advances micro level understanding of the competencies that PIs require to be effective in the role and answers the call for deeper research on these crucial actors. Shedding light on this issue not only beneficial is for the administrators of the universities, the research centers, or the funding agencies, to obtain further essential information in selecting the best-qualified person, but also to self-evaluate their skills, abilities, and knowledge, so that they can direct their efforts toward improving the weak aspects of their HC. Furthermore, it can be an additional useful criterion for defining the career plans of PIs or their promotion policies.

1. Introduction

When researchers apply for public research funds in both national and international contexts, they more and more frequently encounter minimum requirements regarding the size and composition of the team that will undertake the research. As a bidirectional casual effect, the research process is mainly developed in teams consisting of academics from different disciplines, countries, institutions, universities, etc. (Bozeman et al., 2013). Leading such teams are scientists in the PI role. There is an emerging literature on scientists in the PI role (O'Kane et al., 2017; Cunningham et al., 2014). PIs provide a valuable contribution to science through knowledge and technology transfer and as a boundary spanner creating simmelian ties with the different quadruple helix actors (Cunningham et al., 2018). Since the PI role can be so determinant, studying the competencies of those who lead universities' research projects and teams is crucial (Cunningham et al., 2018; Cunningham & O'Reilly, 2018).

In fact, PIs have been receiving increasing attention in the literature (O'Kane et al., 2017; Cunningham et al., 2016a), as reflected by the number of studies about their influence on the publicly funded research outcomes (Mangematin et al., 2014; Menter, 2016; Cunningham et al., 2018). In this sense, Kidwell (2014) stated that PIs build economic development opportunities through expanding science and knowledge limits. Nevertheless, despite the key role that PIs are playing, there are no studies that focus specifically on identifying the characteristics that determine a PI's HC (Käpylä et al., 2010), which was defined as the group of knowledge, abilities and skills belonging to the individual (Becker, 1964). HC is considered by firms as a resource that contributes not only to enhance efficiency but also to obtain a sustained competitive advantage (Barney, 1991). Moreover, since the beginning of the knowledge-based economy, it has been considered one of the most important resources (Ployhart, 2015) and crucial to reach the competitive advantage (Grant, 1996; Carmeli & Schaubroeck, 2005). The purpose of the paper is the identification of the idiosyncratic characteristics of the PI's HC in order to develop a valid measurement scale for academic PIs' HC, which is essential to successfully lead research teams and large-scale public research programmes (Cunningham et al., 2018; Cunningham & O'Reilly, 2018).

Because of the lack of empirical studies and the absence of such a scale, we developed a two-phase process set in the Spanish public university context, based on a review of the literature on PIs and academic HC. First, an expert study based on the Delphi technique was conducted to identify the dimensions and variables that define a PI's HC. Based on this, a draft questionnaire was designed and pre-tested on a sample of PIs. Next, a quantitative analysis was developed. A self-administered questionnaire was forwarded to PIs based at Spanish public universities and belonging to different disciplines. The data obtained from these questionnaires allowed us to develop an exploratory factor analysis (EFA) to reduce the number of indicators and identify subjacent dimensions, and next a confirmatory factor analysis (CFA) to check the consistency of the EFA's results.

As some studies have analyzed different dimensions of academic researchers' Intellectual Capital (De Frutos-Belizón et al., 2019), none have principally focused on HC, which is one of the dimensions of the Intellectual Capital, of the scientists in the PI role. The main contribution of this paper to the literature of the PI in micro level studies is the PI's HC measurement scale proposal. This can be helpful in the understanding of the "jack of all trades" (Boehm & Hogan, 2014, p. 134) and for science public policy, e.g. selecting the best qualified person for leading the research project or team to ensure that it is capable of delivering broad outcomes.

The remainder of this study is structured in five main sections. Section 2 provides a theoretical background on HC, PIs and micro level perspectives, and PIs and HC factors. In the section 3 the methodology followed to develop, verify and validate the model proposed is detailly described. Moreover, the research limitations are exposed in this section. Before presenting the discussion in section 5, the results are described in section 4. The final section is focused on the conclusions of the study, where some implications for the PIs, for the department, and the universities, the research centers, or the funding agencies where they are working in are described, as well as the future avenues for research.

2. Literature Review

2.1. Human Capital

The concept of HC has been widely developed in the management literature (Velayutham & Rahman, 2018) and has been defined as the group of skills, knowledge and abilities (SKA) of the individual (Becker, 1964). Whereas, there are several empirical studies stating an impact of the organization's HC on the organizational performance (Khanna et al., 2014), the literature about HC in the context of academia is scarce (Käpylä et al., 2010). The research developed in knowledge-intensive organizations, such as universities is becoming more and more collaborative and relies on the HC of the researchers within the research team (Lee & Bozeman, 2005). Researchers' HC has been described as intangible resources characterized by a set of features that they provide to the collaborative research team with, such as degree, experience, field of training, network ties, and/or tacit knowledge (Bozeman et al., 2013). Martin-Sardesai and Guthrie (2018) consider the researchers' individual competencies as an intangible resource. There is a research stream on human capital that states that more is always better, so for the organization the best option is that individuals have more and better knowledge, skills and abilities (Ployhart, 2015). However, this statement also has limitations as a result of the disadvantages of having an excess of human capital, rather than having an adequate combination of skills, abilities and knowledge to achieve the objectives (Garcia-Carbonell et al., 2018).

2.2. PIs and Micro Level Perspectives

PI is considered the nexus who engage in a micro level the triple helix actor, especially in the university-industry link (Cunningham et al., 2016b; Menter, 2016; O'Kane, 2018), where there are many enablers and barriers for the technology transfer (O'Reilly & Cunningham, 2017). PIs are becoming crucial in social or economic changes in knowledge-based economy (Mangematin et al., 2014; McAdam et al., 2010). Actually, it is defined as:

> A heart of value creation through development of knowledge that can be appropriated and utilized by other triple helix actors. This PI driven value creation can result in a number of scientific, economic and societal impacts and gains that contribute to a joint production motivation of the triple helix (Cunningham et al., 2016a, p. 780).

PI requires a set of capabilities to do this such as research leadership; envisioning, strategizing and value creation; managerial responsiveness; boundary spanning and relationship building; research excellence; and resource acquisition (Cunningham et al., 2019). However, PIs face several factors that either inhibit or discourage them from undertaking certain activities such as, commercialization activities (O'Kane et al., 2017).

The literature conceptualizes the PI as the "lead researchers" (O'Kane et al., 2017, p. 217) or the research team leader or research group leader (Goel & Göktepe, 2018). The PI is crucial to the R&D team's internal dynamics (Lin et al., 2016), and is key in scientific fields and for the publicly funded research (O'Kane et al., 2017). There is a consensus recognizing the core contribution of the PI to enhancing knowledge and technology transfers within and outside the research team (Cunningham et al., 2016a). Based on their strategic posture and funding conformance PIs adapt four different strategic behaviours to achieve their research performance (O'Kane et al., 2015). Despite scholars' increasing interest in the role played by PIs in publicly funded research (Dolan et al., 2019; O'Kane et al., 2017), there is a lack of knowledge on what happens at the micro level, specifically in identifying those characteristics that could define an adequate profile for those individuals best suited the job of PI (Cunningham & O'Reilly, 2018; Menter, 2016).

2.3. PIs and HC Factors

The PI leads those collaborative research teams and is the light that guides team members; s/he is also responsible for their level of performance. As researchers become PIs, they take on a range of new responsibilities and become influential actors. It is therefore necessary to understand the specifics of their HC (Cunningham et al., 2018). Based on the above, the HC definition for the PIs will be specified and categorized based on the three well-known SKA dimensions: Skills, Knowledge and Abilities (Velayutham & Rahman, 2018; Ployhart, 2015).

Skills. It is defined as those factors—such as communication, leadership, or management—that enable an improved research outcome (McNie et al., 2016). The productivity of the research and of individual scientists is influenced by how time is allocated and managed in the planning of publicly funded research (Cunningham et al., 2016b). Creativity is another skill that empowers the researcher, so that accommodating and being flexible to the potential modifications that the research may undergo during its development can influence the results (Bazeley, 2010; Marie, 2008).

Knowledge. Lovitts (2005) asserted that researchers' future outcomes are based on their academic knowledge as well as how this knowledge is influenced by their postdoctoral education (Su, 2014). Education has been used as a measure of researchers' knowledge (Carmeli & Schaubroeck, 2005), although varieties in educational background should be kept in mind (Bozeman et al., 2001). Several authors have considered experience as part of researchers' knowledge (Hitt et al., 2001). An in-depth understanding of the issue being researched constitutes capital for becoming a top researcher. Moreover, without that deep knowledge, the study might be rejected (Bazeley, 2010).

Ability. It is concerned with the particular qualities of the researcher that are appropriate to his/her specific field of study (Lindberg & Rantatalo, 2015). McNie et al. (2016) argue that any scientist should satisfy some characteristics, such as scientific rigor, the capacity to define research questions, and the facility to communicate his/her research results (De Frutos-Belizón et al., 2019). In addition to previous studies, other research has highlighted a set of additional abilities, such as the ability to enhance scientific cooperation and teamwork among members of the research or project team (Bozeman et al., 2013) and the ability to analyze the information acquired from the research (Marie, 2008).

3. Methodology

Notwithstanding the key role played by the PI, there are no studies specifically focused on identifying the characteristics that determine the PI's HC (Käpylä et al., 2010). Therefore, it is necessary to define a measurement scale to allow researchers to assess those key HC characteristics that PIs need to successfully lead research teams (Cunningham et al., 2018; Cunningham & O'Reilly, 2018). To accomplish this aim, a two-phase process was developed (Hinkin, 1998). The first phase (qualitative analysis) consisted of an expert analysis based on the Delphi methodology (Landeta, 2006) and aimed at designing a questionnaire to develop the survey analysis further down the road. The second phase (quantitative analysis) was developed from the previous and was based on a survey analysis; it consisted of an EFA and then a CFA to finally obtain the measurement scale of PIs' HC (De Frutos-Belizón et al., 2019).

3.1. First Phase: Qualitative Analysis

To identify the factors that integrate the HC of a PI, an expert method based on the Delphi technique was developed, due to the absence of a measuring scale of the PI's HC. The Delphi method consists of an iterative structure in which experts anonymously share their opinions with each other while looking for consensus (Landeta, 2006; Okoli & Pawlowski, 2004). First, the experts of the panel were identified subjected to two conditions: (i) the experts had to be PIs of research teams that obtained funding in competitive public calls, and (ii) the experts had to belong to different fields of science, to avoid biases of response and restrictions derived from the subjectivity involved in this kind of techniques (Okoli & Pawlowski, 2004). From the Andalusian Research Plan (PAI), 134 RTs were identified in the university context. Although we were only able to contact 62 experts (Table 1).

Table 1. *Experts description*

Variable	Descriptive statistics	Percentage
Gender	Male	77,42%
	Female	22,58%
Academic rank	Full professor	66,13%
	Professor	33,87%
Research Area	Arts and Humanities	32,26%
	Science	27,42%
	Engineering	16,13%
	Social and Legal Science	9,68%
	Health Science	14,52%

The second step was to define questions that would stimulate discussion, in order to reach consensus among the experts. This would help to identify the most significant items for each of the open-ended questions on the HC of PIs that were proposed (Okoli & Pawlowski, 2004). An eight open questions questionnaire was sent to the panel of 62 experts. 40 HC items were drawn from the first response of the experts. After several rounds in which all the experts were given back the conclusions reached from their previous responses to be shared towards a general agreement, a consensus was reached. As a result, 22 items were identified that potentially compose PIs' HC.

Drawing on the above, an initial questionnaire was developed that we sent to the panel to be pre-tested. All items were coded using a 5-point Likert-type scale (1 = total disagreement, 5 = total agreement), including a blank space to receive comments and suggestions about the item. Based on the experts' comments, the questionnaire's items and instructions were improved to be more concise and understandable, some items were rewording reducing any complications in the answering process. So, the final questionnaire was designed.

3.2. Second Phase: Quantitative Analysis

The questionnaire was sent to those PIs belonging to different fields of knowledge with experience as PI of research teams funded in European or national competitive public calls. To increase the response rate and trying to avoid non-responses due to the number of emails that the PIs receive on a daily basis, an email was first sent to both the university vice-rector for research and transfer affairs, and the head of the PI's department, requesting their help in encouraging the PIs to answer the questionnaire. Finally, a total of 242 valid responses were obtained from full professors and professors, who are the RT's PIs of the PAI (Table 2).

Table 2. *Sample description*

Variable	Descriptive statistics	Percentage
Gender	Male	65,70%
	Female	33,06%
Research Area	Arts and Humanities	22,72%
	Science	20,66%
	Engineering	18,59%
	Social and Legal Science	15,70%
	Health Science	11,98%

Notwithstanding the contributions of the measurement scale mentioned above, some limitations should be pointed out. First, the development of this study was carried out using data from Spanish universities, so there is a contextual limitation. For this reason, it would be advisable to apply the scale in universities located in other countries and in different cultures (Zhou et al., 2018) to confirm its validity in different institutional contexts. Moreover, because of the internal heterogeneity of the scientific context, the proposed measurement scale should be validated in research contexts located outside universities (e.g., firms, organizations, etc.), but also in specifics fields of research that have very specials needs while conducting their tasks, such as teams researching in conditions of prolonged isolation, physical risk, etc.

4. Results

An EFA and a CFA were applied consecutively to verify the validity and appropriateness of the scale that was derived from the experts' analysis. To do this, the sample was randomly divided into two different subsamples (Lloret-Segura et al., 2015). One was used to empirically validate the measurement scale using the EFA; this methodology explains the largest amount of data with the smallest group of dimensions (Hair et al., 2010). For this purpose, IBM SPSS 21 was utilized.

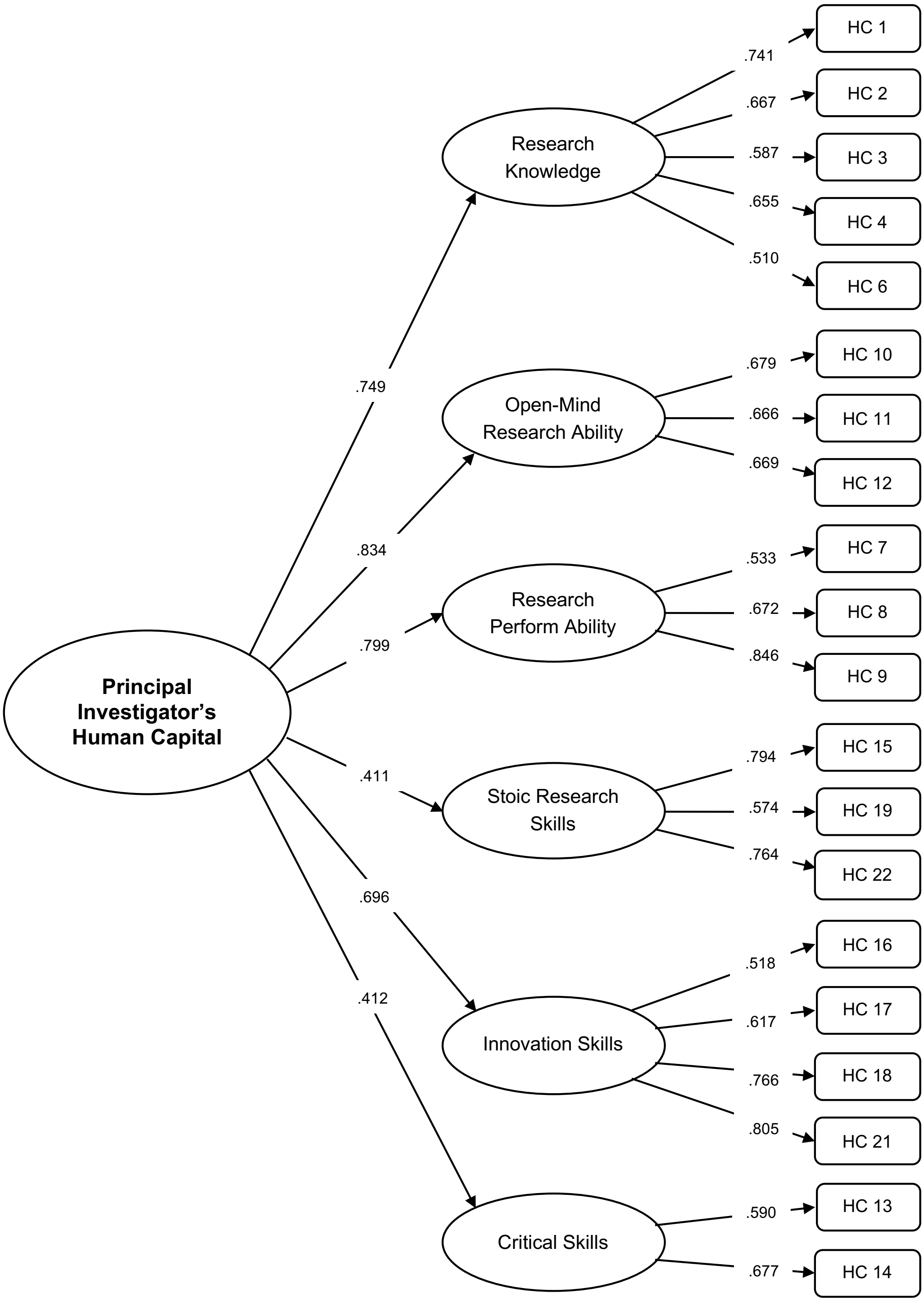
Responses to the 22 survey items were factorially analyzed applying the principal components extraction method. In this process, item HC20 (Altruistic) and item HC5 (I master the language usually used in journals/books and in scientific meetings in my academic field) were successively eliminated, as they had no statistical significance. Finally, 6 factors were extracted meeting the conditions required by the literature (Hair et al., 2010) and representing 68,402% of the total variance. Cronbach's alpha value was high (α=0,850), which means that all elements correlate with each other and, therefore, that the scale is reliable (George & Mallery, 2003). We decided to use Varimax orthogonal criterion since it is the most recommended in the literature and the most used in our research area (Lloret-Segura et al., 2014; Sass & Schmitt, 2010; Hinkin, 1998). Results are displayed in Table 3.

Table 3. *PIs' HC EFA*

Items	Factor 1	2	3	4	5	6
HC1: I have the theoretical training necessary to research in my scientific field	0.830					
HC2: I have the necessary training in research methodologies and techniques	0.766					
HC6: I am able to identify research topics in my research context	0.712					
HC4: I have the required capacity to obtain and manage the information necessary for the research	0.611					
HC3: I know the most relevant publications in my scientific field	0.517					
HC11: I have the ability to interact fluently with other researchers		0.815				
HC12: I am able to adapt to changes in my research results		0.731				
HC10: I can expose and communicate my research results		0.585				
HC9: I know how to conduct research (thesis, research projects, etc.)			0.758			
HC8: I can autonomously develop research			0.707			
HC7: I can relate the observed facts to the results obtained and draw conclusions			0.588			
HC22: I consider myself a disciplined person				0.871		
HC15: I consider myself an organized person				0.865		
HC19: I consider myself a persevering person				0.690		
HC18: I consider myself a creative person					0.816	
HC21: I consider myself a person with initiative					0.756	
HC16: I consider myself an observer					0.625	
HC17: I consider myself a person motivated by research					0.569	
HC13: I consider myself a self-critical person						0.839
HC14: I consider myself a person with the ability to accept criticism from others						0.781
Eigenvalues	5.866	2.370	1.678	1.433	1.256	1.078
Variance explained by each factor	29.331	11.848	8.389	7.167	6.278	5.388
Kaiser–Meyer–Olkin: 0.798						
Bartlett test of sphericity: Chi-square: 907.707						
Degrees of freedom: 190						
Signification level: 0.000						

To confirm the factors that were extracted in the previous phase, a second-order reflective model was constructed and tested with the second sub-sample (Lloret-Segura et al., 2015). A maximum-likelihood estimation was conducted. For this purpose, we used the EQS 6.3 statistics software. The appropriateness of the model has been evaluated examining a variety of fit indices. All indices in this model have shown a good fit for the data (Tabachnick & Fidell, 2007). Examples include absolute fit indices such as the root mean square error of approximation (RMSEA), which is 0.07, and the chi-square test (χ^2), which is 265.917, with 164 degrees of freedom, $p<0.05$ and $\chi^2/df=1.62$. Moreover, we used incremental fit indices such as the Non-Normed Fit Index (NNFI) and the comparative fit index (CFI), which are above 0.90. All 6 factors' items (20 in total) were well loaded; they were all significant ($p<0.05$). Moreover, the 6 factors were loaded into a second-order factor that comprised "PIs' HC." In addition, the scale's reliability was validated by two high reliability coefficients results, such as Cronbach's alpha and the correlation coefficient rho, which were 0.855 and 0.892, respectively (Figure 1).

Figure 1. *PI's HC CFA*



As a result, a HC's PI measurement scale is proposed. Table 4 describes every item comprising each of the 6 labelled factors.

Table 4. *PI's HC measurement scale (definitive items)*

Research Knowledge:
o I have the theoretical training necessary to research in my scientific field (HC1)
o I have the necessary training in research methodologies and techniques (HC2)
o I know the most relevant publications in my scientific field (HC3)
o I have the required capacity to obtain and manage the information necessary for the research (HC4)
o I am able to identify research topics in my research context (HC6)
Open-Mind Research Ability:
o I have the ability to interact fluently with other researchers (HC11)
o I am able to adapt to changes in my research results (HC12)
o I can expound and communicate my research results (HC10)
Research Perform Ability:
o I know how to conduct research (thesis, research projects, etc.) (HC9)
o I can autonomously develop research (HC8)
o I can relate the observed facts to the results obtained and draw conclusions (HC7)
Stoic Research Skills:
o I consider myself a disciplined person (HC22)
o I consider myself an organized person (HC15)
o I consider myself a persevering person (HC19)
Innovation Skills:
o I consider myself a creative person (HC18)
o I consider myself a person with initiative (HC21)
o I consider myself an observer (HC16)
o I consider myself a person motivated by research (HC17)
Critical Skills:
o I consider myself a self-critical person (HC13)
o I consider myself a person with the ability to accept criticism from others (HC14)

5. Discussion

Scientists who play the role of PIs in research teams or research projects are actively involved in research improvement. Through their boundary spanning activities, PIs engage with a wide range of stakeholders outside the university in an attempt to improve research and social and economic impact (Baglieri & Lorenzoni, 2014; Casati & Genet, 2014). PIs are crucial in scientific fields and for the publicly funded research (O'Kane et al., 2017) and studying the competencies of those who lead universities' research projects and teams is crucial (Cunningham et al., 2018; Cunningham & O'Reilly, 2018). In this sense, this study represents a breakthrough in the study of the PIs at the microlevel. However, the literature review led us to initially expect that PIs' HC was integrated on 3 SKA dimensions (Ployhart, 2015), our results identify a PI's HC scale as slightly different. It comprises 6 factors, because the skill and ability dimensions are divided into 3 and 2 factors, respectively, and the knowledge dimension has only 1 (Table 5). This may be explained by the fact that for PIs, both abilities and skills need to be studied more specifically, because they are notably distinctive and empower them to manage any situation (Myers et al., 2004).

Table 5. *PI's HC measurement scale comparison*

SKA dimensions (Ployhart, 2015)	HC's PIs measurement scale proposed
Skills	Stoic Research Skills Innovation Skills Critical Skills
Knowledge	Research Knowledge
Abilities	Open-Mind Research Ability Research Perform Ability

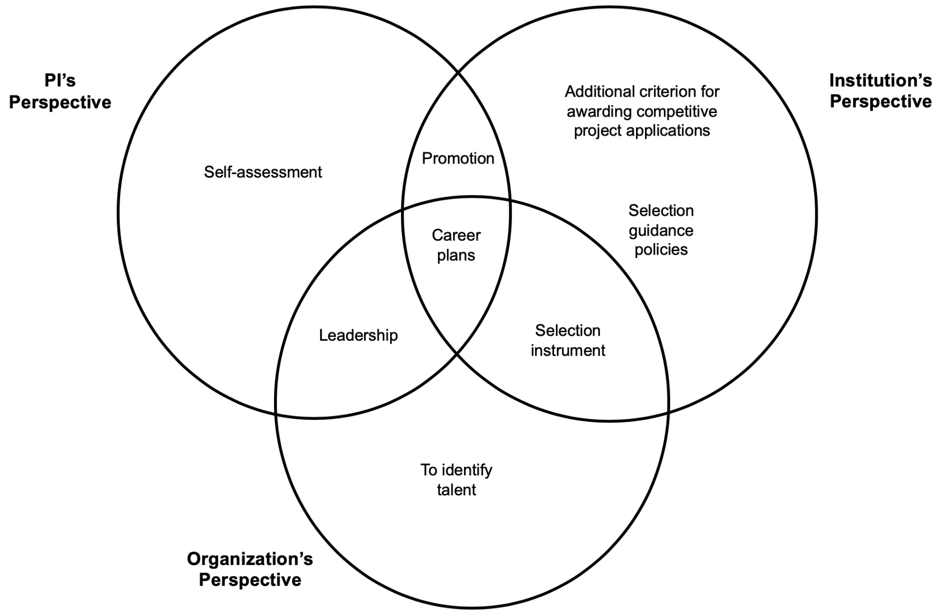
As stated in the literature, the PI role is more complex and demanding, and their managerial responsibilities are beyond their traditional challenges (Cunningham & O'Reilly, 2018; Cunningham et al., 2015), so this fragmentation can help to unearth the role complexity and the PI's HC needed. Strikingly, even though the ability to express one's opinion fluently in a language different to one's mother tongue is an important ability in the literature (Wang et al., 2006), because often the receptor and the source in the knowledge and technology transfer speak different languages (Rogers, 2002), it was suppressed in the EFA.

6. Conclusion and Future Avenues for Research

The crucial role of the PI is highlighted in the literature review performed in this study (O'Kane et al., 2017; Menter, 2016). However, there is still no scale to measure PIs' HC. Throughout this analysis, the PIs' HC measurement scale had to confirm 4 criteria (Claes et al., 2010). The understanding criterion was fulfilled during the qualitative analysis, since it ensured that the meaning of the items was understood by both interviewers and interviewees. The robustness criterion was met as well, based on the reliability of the scale and the psychometric characteristics obtained. In recent years, there has been an increasing need to deepen the understanding of the PIs within the academic context (Cunningham et al., 2015), so the relevance criterion was met, since the purpose of this study is to contribute to literature on PI development. The fourth criterion, denominated "utility," is also considered as met, as will be explained in the following paragraphs. In essence, this is because the PI is key in scientific fields and publicly funded research (Cunningham et al., 2014).

As shown in Figure 2, these are the micro level implications of our study. The PI's HC measurement scale can be used in the service of several goals, from the individual to the institutional perspective.

Figure 2. *Practical implications*



From the PIs' perspective, a lack in the training that the PIs received has been detected, so when they have to face the role of PI, they need to learn on the fly (Cunningham et al., 2015). Hence, the scale can help them to self-evaluate their competences, so that they can direct their efforts toward improving the weak aspects of their HC (Mathieu et al., 2014). In doing this through, for example, appropriate training actions, their efficiency and effectiveness will be directly affected and, as a result, their performance will be enhanced (Ebrahimi and Azmi, 2015). As a PI, this self-assessment may improve one's leadership competences.

From an organizational perspective, which is considered the department where the PI is working in, the measurement scale can be used as a suitable instrument to assess the most appropriate applicants for the role of PI in the research teams and select the most suitable academic profile (Hollenbeck et al., 2004). At a micro level this can be helpful in the selection process, so this can be useful to improve the level of the research project/team (Mathieu et al., 2014), because securing public funding is a success, being the PI key in this process (Cunningham et al., 2014). Since PIs are considered scientists with "entrepreneurial spirit to understand the market and its actors" (Menter, 2016, p.

200), they are presumed to have not only research performances, but also academic entrepreneurship results (Cunningham et al., 2017). So additionally, the scale can be used as a valid instrument to complement any others criteria established by the organization, to for example not only define the career plans of PIs but also the public promotion policy or to identified those academic entrepreneurs. Moreover, it can also be used to identify talent, and therefore undertake any steps to attract and retain it.

Since the institutional perspective -universities, research centers and funding agencies where the PI is working in- can be an additional criterion for awarding competitive project applications, besides selection guidance policies, the proposed scale can therefore be an essential source of information for institutions involved in this process. All these micro level implications of our study provide a valuable contribution to public policy. It will minimize the margin of error, if any, in the selection of the person who is to perform the role of PI, and those avoid the consequent economic repercussions connected to selecting the wrong person, and improve research results. Allowing the integration process of PIs in multiple work environments to be better, as well as their interaction with other helix actors (Cunningham et al., 2018). All these institutions need to support PIs more at the micro level, and providing them a more specific training of their HC factors can be a further step. In addition, the research productivity is based on the relationship between the PIs and the Technology Transfer Offices (TTO), in which the PIs have a key role (Cunningham et al., 2015), and in the value creation dynamics at the micro level in the quadruple helix, understanding the PI's HC factors can enhance the research of PIs struggling to cope with the role as per the literature (Cunningham et al., 2018). Hence applying the proposed measurement scale can be crucial in the assessment process.

The proposed HC's PI measurement scale reduce the gap between theory and practice. Measuring HC's PI can be valuable when identifying a range of different PI roles according to the combinations of the research field and the academic context. It can be used to determine those contingent characteristics of the PI’s HC which explain the RT’s performance in such combination of research field and academic context. Moreover, the following is a compilation of the possible future approaches which can be supported on this scale and even improve it. Future avenues of research should focus on the different roles that PIs can play, and assess their HC. It would also be interesting to conduct a longitudinal study of PIs or to focus on specific case studies in order to have a wider variety of information on these crucial actors in the publicly funded research. In the knowledge and technology transfer process at the individual level would be interesting to apply this measurement scale in selecting the PIs, whose relations with the TTO professionals enhance the results (Cunningham & O’Reilly, 2018). From PIs’ perspective, it would also be interesting to use the measurement scale proposed as another criterion in their institution selection process, for the purpose of selecting those universities, research centers or funding bodies in which their HC factors can be improved. Studying gender is an interesting option to deepen further our knowledge of the PI, so investigating the PI’s HC and gender that affect research productivity might be an interesting future avenue research. Moreover, a cross-country study, which will comprise a wider and larger sample, would improve the understanding of this PI role. Relying on this measurement scale and/or including other measures, a deeper study of leadership of the PIs and its different styles is required, for instance, more empirical researches.

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CHAPTER TWO

Proposal for a Typology of Research Team's Principal Investigators Based on their Human Capital: An Exploratory Analysis

Abstract

Nowadays R&D has become a challenging activity which often needs to be developed in larger and larger teams that are diverse and multidisciplinary. This highlights the key role of leadership, usually played by a researcher who performs as Principal Investigator. The role of the principal investigator is crucial in this context, highlighting the need to understand better. Based on existing literature on scientists in the principal investigator role, this paper aims to identify whether there exists a range of principal investigator profiles based on their different human capital factors. A cluster analysis was developed using a database comprised of 224 research teams, from a wide range of scientific fields. Three different principal investigator profiles were recognised: a) Conservative principal investigators; b) Balanced High-HC principal investigators; and c) Management-focused principal investigators. Both theoretical and practical considerations are discussed.

1. Introduction

Research outcomes are expected to be one of the main drivers in the development of an economy, as well as to bring about knowledge creation and additional benefits to the society (Klofsten et al., 2019; Guerrero & Urbano, 2012). Accordingly, research activities are widely supported financially, capturing a good portion of the efforts from institutions and organisations (European Commission, 2018; Kenney & Patton, 2018; Wu et al., 2015). Even though research has traditionally been carried out by solo authors, increasingly complex research processes require researchers to add efforts working in research teams (RT). These RTs are comprised of scientists from a wide range of research areas, universities or even countries (Bozeman et al., 2013; Paulsen et al., 2009). The diversity within an RT enhances knowledge creation (Martín-Alcázar et al., 2012), although it is also one of the reasons that make the R&D environment so distinctive and demanding (Paulsen et al., 2009).

Currently, the composition of RTs is increasingly larger and more multidisciplinary, which poses a challenge regarding their management and direction (Cummings & Kiesler, 2005). Therefore, the leaders in this context need to meet different requirements compared to those working in other areas (Keller, 2017). In this sense, the person leading and managing the research process is crucial, being a task mainly performed by scientists in the principal investigator (PI) role (Cunningham et al., 2016a; Menter, 2016). Several studies have highlighted the essential role played by RT's PIs in the university-industry relationships as well as in the development of the universities' Third Mission (Casati & Genet, 2014; Mangematin et al., 2014; Kidwell, 2013).

Even though there is a growing number of authors studying academic PIs in the R&D context (Kastrin et al., 2018; O'Kane et al., 2017), there is yet no analysis based on the PI's human capital (HC) (Käpylä et al., 2010). HC comprises all the knowledge, abilities and skills of the individual (Becker, 1964), and since the beginning of the knowledge-based economy, it has been considered key for organisations to reach a sustained competitive advantage (Ployhart, 2015; Youndt et al., 2004). The literature calls for a deeper understanding of the PI role, studying their HC as a way to better understand their behaviour as RT leaders (Cunningham & O'Reilly, 2018; Boehm & Hogan, 2014). Deepening into the study of PIs is, therefore, essential not only for improving RTs' management and leadership, but also for designing public research programmes (Cunningham et al., 2018). Based on the above, the purpose of this paper is to identify whether there exist different PI's HC factors that comprise their profiles, which may facilitate their profiles' classification and comparison. Furthermore, it could provide valuable insights into the selection of those PIs most suitable for the position, depending on the relevant circumstances in each case.

The remainder of this paper is structured as follows. The following section reviews the role of the PI and contains an approach to the HC theoretical background. Subsequently, the sample and the methodology utilised are described. The next section presents and discusses the analysis of the results. Finally, conclusions, limitations and a research agenda are drawn.

2. Theoretical Background

2.1. Principal Investigators

Since the R&D environment is so challenging and unique, the appearance of the PI is increasingly noticeable (Guerrero & Urbano, 2012). In fact, PIs are widely acknowledged as a key player in this context, as it is recognised in the Triple Helix model (O'Kane, 2018; Menter, 2016). Cunningham et al. (2016b) asserted that PI is a commonly used term in the academic literature as well as in the publicly funded institutions. Del Giudice et al. (2017) stated that the PI is responsible for the design and implementation of the RT research programme. In this study, we assume the concept of PI as:

> A heart of value creation through development of knowledge that can be appropriated and utilized by other triple helix actors. This PI driven value creation can result in a number of scientific, economic and societal impacts and gains that contribute to a joint production motivation of the triple helix (Cunningham et al., 2016a, p. 780).

At present, academia has turned in a highly competitive environment due to both the pressures on scholars to obtain results and the increasing specialisation of academic research (Degn et al., 2018; Leahey, 2016). As a result, academic researchers are driven to collaborate more and more with each other to survive in this highly competitive environment and overcome the publish-or-perish mandate (Kastrin et al., 2018). In this sense, the PI role is crucial to lead and manage this collaboration between researchers in order to achieve a common objective (O'Kane et al., 2017). Not only is the PI role crucial for the R&D context, but it is also an essential step in the academic career progression of a scientist (Cunningham et al., 2019). For that reason, becoming an RT PI brings prestige for a scientist among other scientists (Cunningham et al., 2014). It also provides them with the benefit of being able to plan their research agenda, and their scientific productivity is bound to grow (Feeney & Welch, 2014).

Whereas some authors highlighted obtaining funds for RT research activities as the most relevant responsibility of PIs (O'Kane et al., 2017), others asserted that the PIs also manage the available resources, enable everyone to accomplish their aims, brake boundaries and span them (Cunningham et al., 2016a; Mangematin et al., 2014). Moreover, PIs also have to accomplish some academic responsibilities, such as supervising, mentoring and teaching (Boehm & Hogan, 2014). In every single scientific field there is a consensus on how important the PI is, not only in the RT internal dynamics, but also in enhancing knowledge and technology transfer beyond RTs (Lin et al., 2016; O'Kane et al., 2015; Carmeli et al., 2011). PIs constitute an important key actor in making university-industry engagement more viable (O'Kane, 2018; Cunningham et al., 2016b; Menter, 2016). Indeed, PIs are better positioned to act as an effective link to overcome any potential barrier between industry and academia than anyone else (Del Giudice et al., 2017).

Nonetheless, this role is not without its complexities, so the PI needs to be more than just a good researcher. For instance, the requirements that PIs have to face are specific and challenging (Casati & Genet, 2014; Kidwell, 2013). Actually, PIs must make decisions, based on their own competences and the RT available resources (Kidwell, 2014). For this reason and also because there is still a lack of knowledge in a microlevel, particularly in determining factors or characteristics that could establish a suitable profile of PIs (Cunningham & O'Reilly, 2018; Menter, 2016; Casati & Genet, 2014), identifying PI's HC would be helpful to define possible PIs profiles based on their HC.

2.2. Principal Investigators and Human Capital

To be a PI requires having a specific HC to manage an RT successfully in order to ensure the continuous improvement of research outcomes. That is, to have a specific kind of HC (Cunningham et al., 2018), which is deemed essential to improve research outcomes (Bozeman et al., 2001). HC will be defined here according to the differentiation of the SKA dimensions –Skills, Knowledge and Abilities (Ployhart, 2015). Considering how particular the R&D context is, PIs usually require a range of skills, knowledge and abilities quite different to that of other managerial positions (Keller, 2017).

Abilities address those distinctive features of scientists relevant to their specific field of study (Lindberg & Rantatalo, 2015). Among the *hard-academic skills,* which any researcher should have, are those of being rigorous in the research process, being able to present and publish the findings of their research, and being able to propose hypotheses (McNie et al., 2016). Additionally, fostering collaboration within the RT, as well as analysing the findings resulting from the study, are other essential abilities that any scientist should have (Bozeman et al., 2013; Marie, 2008).

Knowledge is defined as the training completed by the researchers. Taking into account the wide variety of existing research fields, this training may vary considerably throughout the predoctoral and postdoctoral periods, depending on each particular case (Bozeman et al., 2001). Ployhart & Moliterno (2011) defined it as the "understanding of principles, facts and processes" (p. 134). Moreover, researchers' past experiences are also considered a form of knowledge for scientists (Hitt el al., 2001). As stated in the literature, potential future publications might depend both on the academic knowledge of the scientists and on the influence that the postdoctoral training has been able to exert (Su, 2014; Lovitts, 2005). In this sense, all the knowledge acquired throughout the scientist's education and training will be to their benefit and will be reflected in their scientific outcomes (Jacob & Lefgren, 2011). In fact, both an in-depth study of the topic which is being explored and developed, and the knowledge of the methodological aspects contribute to this purpose (Bazeley, 2010). The differentiation between know-how –i.e. research methods and technical aspects– and the know-that –i.e. theoretical training in a particular scientific field– will be used in this research to define the knowledge dimension of the HC (Bozeman et al., 2001).

Skills are those qualities which contribute towards achieving better results in research (McNie et al., 2016). For instance, in the public-funded research, skills such as time management and time allocation have a significant impact on the results of the study (Cunningham et al., 2016b). Researchers' creativity provides flexibility and adaptability to any variation in the initial research planning, which can also impact on the results of the study (Bazeley, 2010; Marie, 2008). Developing appropriate protocols to support the study, publishing studies in high-impact journals, communicating effectively, leading and managing are some of the key skills required by individual scientists doing research (McNie et al., 2016).

PIs are researchers, although they are not regular researchers (Mangematin et al., 2014). They have to manage the available resources of their RTs and lead them to accomplish their objectives (Kidwell, 2014). Every PI has distinctive knowledge, abilities and skills that make them behave differently when making decisions, and thus they influence the outcome of the RT (O'Kane et al., 2015). When carrying out their responsibilities, PIs must have certain abilities and skills beyond technical expertise or knowledge (Carl, 2020; Cunningham et al., 2018; O'Reilly & Cunningham, 2017). Therefore, PI's HC influences the outcome of the RTs. Accordingly, it would be valuable to analyse PIs HC to pinpoint different patterns based on several combinations of these distinctive knowledge, abilities and skills.

3. Methodology

3.1. Data Collection and Sample

An empirical work was undertaken in order to identify features that shape the PI's HC, which could be fundamental in the achievement of macro-, meso- and micro-level objectives in the R&D context (Cunningham et al., 2018; Käpylä et al., 2010). Due to the absence of empirical studies on academic HC, a two-phase research approach was developed. First, an exploratory research based on an expert panel was developed to identify and design the survey. Then, an exploratory research approach was applied. In doing that, an inductive methodology was carried out through a cluster analysis developed on a sample comprised of PIs.

In the first stage, based on the Delphi technique, a panel of experts was created to formulate the survey. This technique relies on the anonymous exchange of experts' opinions among themselves, with the ultimate goal of reaching a common consensus (Hsu & Sandford, 2007; Landeta, 2006). Two conditions were met by the experts who composed the panel: 1) to belong to different research fields to ensure no biases, and 2) to be an RT PI who had achieved competitive public funding (Okoli & Pawlowski, 2004). The panel was comprised of 62 experts who, following the expert discussion process by the Delphi method, identified 22 HC items after three rounds. Then, a draft questionnaire was distributed among the experts to get feedback. Each item included in the draft questionnaire was coded with a five-point Likert scale (1 = total disagreement, 5 = total agreement), adding a space where the experts could include any kind of suggestions for improving each of the items. Once all the pre-test surveys were received, the final questionnaire was developed.

The survey was emailed to PIs of RTs at Spanish public universities, with experience in developing research projects with national or international competitive public funding in any scientific field. This research was performed in RTs from a wide range of scientific fields in Spanish public universities –Engineering and Architecture, Social and Legal Sciences, Health Sciences, Arts and Humanities, and Sciences. RT's PIs were contacted by email, although to maximise the number of questionnaires received, the head of the PI's department and the university vice-rector for research and transfer affairs also received an email explaining our research objectives and calling for some help prompting their RT's PIs to collaborate. Our final sample was comprised of 224 PIs of RTs (Table 1). After examining the descriptive statistics and the characteristics of the sample, we can conclude that the sample is representative of the population, because there was no serious non-response bias problem ($\chi^2_{\text{scientific fields}}$=0.270, sig.=5.173; χ^2_{age}=0.946, sig.=23.509; $\chi^2_{\text{seniority in the university career}}$=0.112, sig.=5.991).

Table 1. *Descriptive Statistics of the Sample*

Variable	Descriptive statistics	Percentage
Gender	PIs Female	33%
	PIs Male	67%
Research areas	Engineering and Architecture	26.8%
	Social and Legal Sciences	21%
	Health Sciences	12.1%
	Arts and Humanities	11.6%
	Science	28.6%

Prior to initiating the assessment of the cluster analysis results, the connection between different variables in the sample was examined to amplify our knowledge of the sample (Table 2). Thus, the connections between gender and scientific fields, with performance at both PI and team level were analysed. In this study, the h-index (Hirsch, 2005) was utilised to measure performance at both individual and team level. The h-index is a measure combining the number of citations and the number of publications, concentrated in a single indicator (Hirsch, 2005). The h-index can be measured not only at an individual but at a team level too, and both figures are already available in SciVal

(Colledge & Verlinde, 2014). Significant differences were found at both levels of productivity: PI and team level. There is a discrepancy between the gender of the PI and their individual h-index which, on average, is higher for male PIs. There are also clear differences based on the scientific field at both levels of the h-index. Thereby, there are scientific fields where productivity is much higher in some areas. Actually, Science, Health Sciences, and Engineering and Architecture are the areas where the h-index mean is vastly greater, at both PI and team level. By including these measurements into our analysis, we would broaden our vision of the context and the evaluation of the resultant profiles could be more complete.

Table 2. *ANOVA research productivity of PIs and RTs, gender and scientific field*

ANOVA (h-index of PIs – Gender)				
Gender	N	Mean (Standard Deviation)	F	Sig.
Female	69	14.37 (12.67)	5.031	<0.05
Male	145	18.54 (12.72)		
ANOVA (h-index of PIs– Scientific field)				
Scientific field	N	Mean (Standard Deviation)	F	Sig.
Arts and Humanities	23	3.30 (4.89)	31.038	<0.001
Science	63	26.39 (13.68)		
Social and Legal Science	43	8.83 (7.62)		
Health Science	26	20.46 (8.84)		
Engineering and Architecture	59	17.45 (9.69)		
ANOVA (h-index of the RT – Scientific field)				
Scientific field	N	Mean (Standard Deviation)	F	Sig.
Arts and Humanities	26	5.73 (5.98)	58.705	<0.001
Science	62	50.93 (19.49)		
Social and Legal Science	47	18.21 (11.31)		
Health Science	27	39.51 (10.85)		
Engineering and Architecture	60	39.05 (16.25)		

Considering the high number of HC items of the PI to be assessed –22 items– and also in order to make the cluster analysis more feasible, a preliminary dimension reduction was undertaken (Hair et al., 2010). An exploratory factor analysis was conducted, obtaining five factors (Table 3). In this process, non-significant items were excluded (*I consider myself an observer, I can autonomously develop research, I know* *how to conduct research (thesis, research projects, etc.), I consider myself an altruistic person,* and *I am able to identify research topics in my research context*). Findings revealed and confirmed the SKA model's approach based on the Kaiser–Meyer–Olkin (KMO) index value, which was 0.86. Therefore, the resultant five HC factors are applicable to the variables studied (Ployhart, 2015). The eigenvalues of the five factors are higher than one, so they fulfil the latent root criterion. Moreover, these factors constitute 67.359% of the total variance and are consistent with the requirements stipulated in the literature (Hair et al., 2010). Cronbach's alpha value was 0.864, which is considered high and means that the scale is reliable (George & Mallery, 2003). The resulting factorial model fits correctly to explain the data, since Bartlett's test of sphericity is significant ($p<0.001$).

Table 3. *Exploratory factor analysis*

	Factor				
Items	**1**	**2**	**3**	**4**	**5**
HC1: I have the theoretical training necessary to research in my scientific field	0.813				
HC2: I have the necessary training in research methodologies and techniques	0.773				
HC4: I have the required capacity to obtain and manage the information necessary for the research	0.770				
HC3: I know the most relevant publications in my scientific field	0.649				
HC11: I have the ability to interact fluently with other researchers		0.837			
HC10: I can expound and communicate my research results		0.782			
HC12: I am able to adapt to changes within my research context		0.627			
HC7: I can relate the observed facts to the results obtained and draw conclusions		0.581			
HC5: I master the language usually used in journals/books and in scientific meetings in my academic field		0.527			
HC22: I consider myself a disciplined person			0.861		
HC15: I consider myself an organized person			0.827		
HC19: I consider myself a persevering person			0.677		
HC18: I consider myself a creative person				0.812	
HC21: I consider myself a person with initiative				0.784	
HC17: I consider myself a person motivated by research				0.553	
HC13: I consider myself a self-critical person					0.805
HC14: I consider myself a person with the ability to accept criticism from others					0.635
Eigenvalues	5.961	1.927	1.361	1.200	1.003
Variance explained by each factor	35.064	11.334	8.003	7.058	5.900
Cronbach's alpha	0.827	0.776	0.787	0.711	0.567
Kaiser–Meyer–Olkin: 0.860					
Bartlett test of sphericity: Chi-square: 1512.4957					
Degrees of freedom: 136					
Signification level: <0.001					

The first factor (F1) is composed of four items related to the basic knowledge to develop research activities, thus it was labelled as "*scientific educational training*". The second factor (F2), composed of five items comprising the necessary abilities to carry out an academic research, was labelled "*investigation abilities*". The third factor (F3) was labelled "*self-mastery skills*" because it is composed of three items, which referred to self-management and self-control. The fourth factor (F4) is composed of three items, which correspond to skills associated with more flexible responses to changes, such as being creative and having initiative and motivation. Accordingly, it was labelled "*openness-to-change skills*". The fifth factor (F5) is composed of two items related to being critical and being able to accept criticism from others. For that reason, it was labelled "*self-analytical skills*" (Table 4).

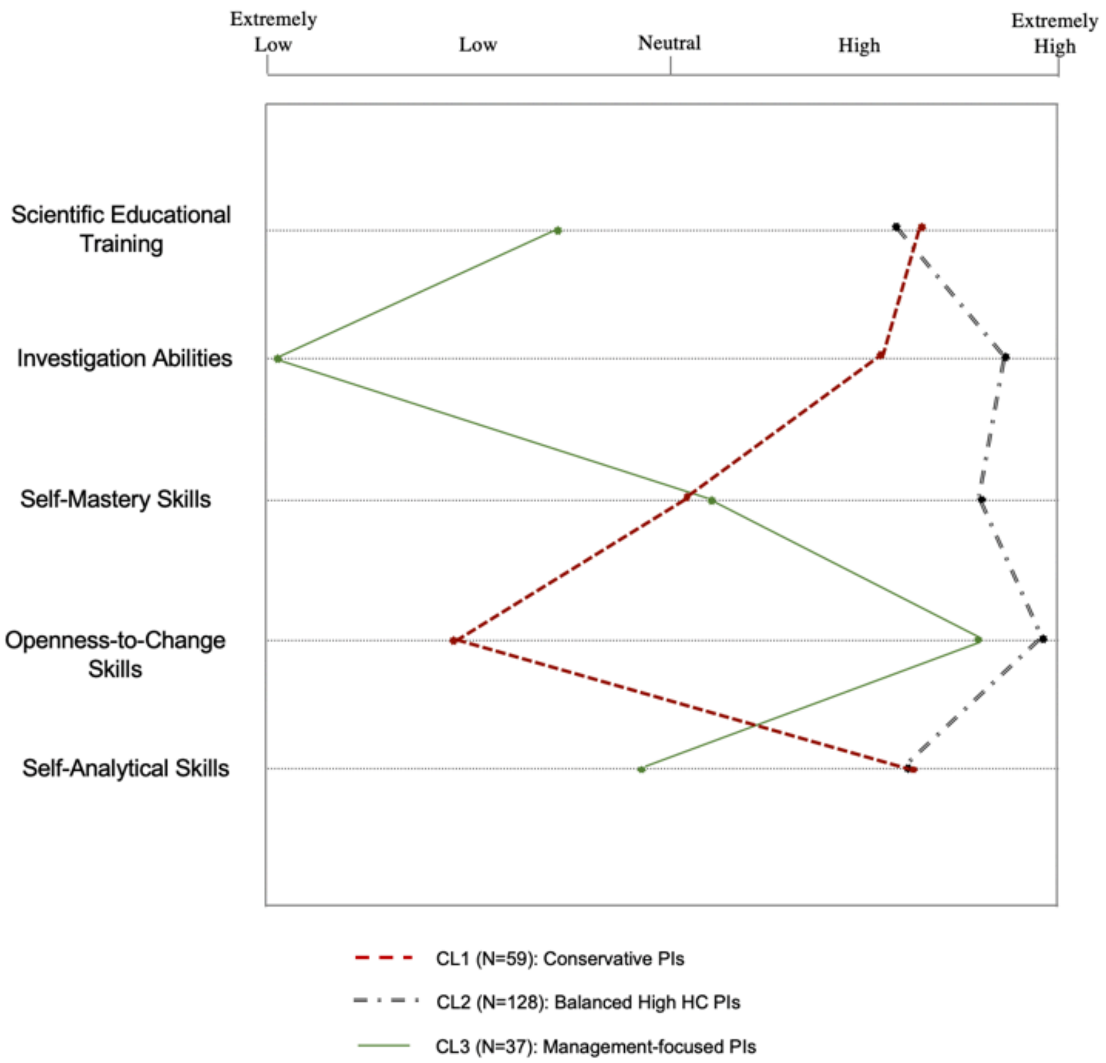
Table 4. *HC factors of the PIs*

FACTORS	ITEMS
F1. Scientific Educational Training	I have the theoretical training necessary to research in my scientific field (HC1)
	I have the necessary training in research methodologies and techniques (HC2)
	I have the required capacity to obtain and manage the information necessary for the research (HC4)
	I know the most relevant publications in my scientific field (HC3)
F2. Investigation Abilities	I have the ability to interact fluently with other researchers (HC11)
	I can expose and communicate my research results (HC10)
	I am able to adapt to changes in my research results (HC12)
	I can relate the observed facts to the results obtained and draw conclusions (HC7)
	I master the language usually used in journals/books and in scientific meetings in my academic field (HC5)
F3. Self-Mastery Skills	I consider myself a disciplined person (HC22)
	I consider myself an organized person (HC15)
	I consider myself a persevering person (HC19)
F4. Openness-to-change Skills	I consider myself a creative person (HC18)
	I consider myself a person with initiative (HC21)
	I consider myself a person motivated by research (HC17)
F5. Self-Analytical Skills	I consider myself a self-critical person (HC13)
	I consider myself a person with the ability to accept criticism from others (HC14)

3.2. Cluster Analysis

Based on the five HC factors identified in the previous section, our study then carried out a cluster analysis of the data in order to determine whether or not distinct PI profiles emerged, with the aim of stablishing a typology of PIs which could help to better understand their characteristics, in the light of empirical evidence. In order to make this typology useful and actionable, the different PI profiles identified had to be as internally homogeneous yet externally different from each other as possible; while also being conceptually interpretable (Schmitt et al., 2007). For this purpose, before carrying out the hierarchical cluster analysis, it was necessary to establish the number of profiles according to the sample (Ketchen & Shook, 1996). After the implementation of the dendrogram and the assessment of its results, it was concluded that the optimal number of clusters was three (Ketchen & Shook, 1996). Then, after verifying that all five factors of the HC of PIs were considered significant according to ANOVA tests, a K-means cluster analysis was conducted. From the K-means cluster analysis, three different PI profiles were identified with 59 cases (CL1), 128 cases (CL2) and 37 cases (CL3) respectively (Figure 1).

Figure 1. *PIs Profiles of the RT and Cluster analysis*



FACTORS	ANOVA	
	F	Sig
Scientific Educational Training	15.930	<0.001
Investigation Abilities	89.749	<0.001
Self-Mastery Skills	17.820	<0.001
Openness-to-Change Skills	104.101	<0.001
Self-Analytical Skills	8.047	<0.001

To amplify our knowledge of these profiles, the connections between clusters and h-index at both PI and team level were also analysed. There were variations between clusters at both levels of the h-index (see Table 5). All the information that has emerged from the data obtained by applying the ANOVA test to the variables may be highly valuable in explaining the different PI profiles.

Table 5. *ANOVA h-index of PIs and clusters and h-index of the RT and clusters*

ANOVA h-index of PIs and clusters						
Cluster	N	Mean (Standard Deviation)	Min	Max	F	Sig.
CL1	58	18.86 (14.19)	0	74	3.376	<0.05
CL2	122	17.82 (12.81)	0	69		
CL3	34	12.11 (8.86)	0	29		
Total	214	17.20 (12.82)				
ANOVA h-index of the RT and clusters						
Cluster	N	Mean (Standard Deviation)	Min	Max	F	Sig.
CL1	58	41.13 (21.73)	3	112	7.190	<0.001
CL2	127	33.67 (21.41)	1	112		
CL3	37	24.59 (16.89)	2	73		
Total	222	34.11 (21.40)				

4. Results and Discussion

The results of the empirical analysis provided three different clusters, which led to the identification of three distinct PI profiles that were named Conservative PIs, Balanced High-HC PIs and Management-focused PIs respectively. The composition of each profile in terms of gender and scientific fields is shown in Table 6.

Table 6. *Gender and Scientific Field Distribution*

	Conservative PIs (CL1)	**Balanced High-HC PIs (CL2)**	**Management-Focused PIs (CL3)**	**Full Sample**
Gender				
Male	76.3%	61.7%	73%	67%
Female	23.7%	38.3%	27%	33%
Scientific Field				
Arts and Humanities	6.8%	13.3%	13.5%	11.6%
Sciences	35.6%	31.2%	8.1%	28.6%
Social and Legal Sciences	16.9%	20.3%	29.7%	21%
Health Sciences	13.5%	9.4%	18.9%	12.1%
Engineering and Architecture	27.1%	25.8%	29.7%	26.8%

The first profile is comprised of 59 scientists in the PI role, mainly belonging to Science (35.6%) or Engineering and Architecture (27.1%) scientific fields, and displays the lowest representation of women (only 23.7%). This profile has been labelled as

Conservative PIs (CL1 – red line in Figure 1) because they consider that they have the lowest openness-to-change skills of the three clusters. They do not consider themselves very creative or as having too much initiative. This profile is comprised of all those PIs who consider that they have the highest scientific educational training –theoretical and methodological knowledge. They regard themselves as highly trained to carry out research in their own scientific field, having the necessary methodological knowledge to undertake it. These PIs also rated themselves as having the highest self-analytical skills and, as a consequence, they present a high capacity for criticism, not only from themselves but also from others. They consider themselves to be highly skilled in investigation abilities, although they did not display the highest scores. Nonetheless, among these abilities, they believe themselves skilled enough to be able to interact easily with other researchers. Finally, they rated themselves with the lowest self-mastery skills. These preliminary results could suggest that they might not be considered disciplined scientists and they could show a lack of organisation in their research. However, this PI profile has the highest h-index mean, at both individual and RT level (Table 5).

Balanced High-HC PIs (CL2 – blue line in Figure 1) is the most abundant profile, because it is comprised of 128 scientists in the PI role. As in the former cluster, most of them belong to Science (31.3%) or Engineering and Architecture (25.8%) scientific fields. Almost 40% of them are women, making this profile the group with the highest representation of female scientists in the PI role. This profile is comprised of all of those PIs who consider that they have high values in all of the different HC factors. In this sense, this profile shows the highest scores in three of the five HC factors: openness-to-change skills, investigation abilities and self-mastery skills. These preliminary scores might suggest that they believe that they are creative, they are able to network with other researchers, besides being motivated for research. These openness-to-change skills might enable them to be flexible with the changes that come up in their scientific fields, in order to adapt their research agenda (O'Kane et al., 2015). It is noteworthy that this is the only group of PIs who highly rated themselves in self-mastery skills, since they positively believe that they are accurate and disciplined. Moreover, not only do they regard themselves as having the necessary scientific educational training –both theoretical and methodological knowledge– to carry out an investigation in their area of expertise, but also as able to obtain and manage the information required for this purpose. Strikingly, even though this cluster has shown the highest scores in several HC factors –self-mastery skills, investigation abilities and openness-to-change skills– it has not been enough for them to obtain the highest h-index mean results, either on a personal or on a team level (Table 5).

The Management-focused PIs profile (CL3 – green line in Figure 1) is the smallest cluster, which is comprised of 37 scientists in the PI role, of whom 27% are women. Within this cluster, even though the Engineering and Architecture scientific field is well represented (29.7%), more than 40% of the PIs belong to the two least productive scientific fields –Arts and Humanities and Social and Legal Sciences–, which may be connected to the fact that this profile shows the lowest h-index values at both individual and team level. Apart from that, they also showed the lowest score in three of the five HC factors –scientific educational training, investigation abilities and self-analytical skills–, suggesting that they might lack essential skills required to produce high-impact research outcomes. This deficit contrasts with a rather high value in openness-to-change skills and a moderate value in self-mastery skills, which implies that, even though they do not consider themselves as particularly well trained in theoretical and methodological grounds, they do regard themselves as highly creative and motivated, as well as reasonably disciplined and organised. This combination of characteristics might indicate that the PIs who comprise this profile are not mainly focused on research and that they might devote most of their time to managerial and administrative tasks, prioritising certain aspects of the PI role –such as the allocation of time and resources– over the rest, and that is why they were labelled Management-Focused PIs.

All the profiles are predominantly composed of PIs –over 70% of them– who have a long experience, although in the case of the Balanced High-HC PIs profile the proportion almost reaches 80%.

5. Conclusions, Limitations and Future Research

It is becoming increasingly common for RTs to have a multidisciplinary composition (Tyran & Gibson, 2008; Cummings & Kiesler, 2005). So much so, that this is often an explicit requirement in order to obtain public funding (O'Kane et al., 2017). However, the management of this knowledge-intensive multidisciplinarity is challenging (Harney et al., 2014). This diversity within RTs demands that whoever is to direct and manage them should have a wide range of competences –Knowledge, Skills and Abilities– that define their HC (O'Kane et al., 2020; Cunningham et al., 2018). Naturally, each PI will have a particular mix of competences in their HC, with varying degrees of proficiency in each aspect, that account for differences in behaviour. When these differences have to do with the way they make decisions, this could influence the final outcomes of their RTs and, by extension, their performance (Cunningham et al., 2017; Ebrahimi & Azmi, 2015). Therefore, the aim of this paper is to determine whether different PI profiles can be identified based on their HC, whose behaviour in managing RTs differs from that of others. Furthermore, discerning the HC factors that comprise each profile might not only provide valuable insights that may facilitate the classification and comparison of PIs, but also have managerial implications.

From our study, three different PI profiles were revealed from the cluster analysis: Conservative PIs, Balanced High-HC PIs and Management-focused PIs. Among these three profiles, two of them –Balanced High-HC PIs and Management-focused PIs– are in sharp contrast with each other. While the former consistently shows high or extremely high values in all five HC factors, the latter shows low or extremely low values in most of them. The third profile –Conservative PIs– could be considered somewhat in between the other two, showing a combination of rather high values in certain HC factors together with low or moderate values in the remaining ones.

In terms of performance, our analysis also revealed significant differences in h-index values among the three profiles, at both individual and team level (Table 5). Individually speaking, Conservative PIs achieve the best results, followed closely by Balanced High-HC PIs, while Management-Focused PIs obtain considerably lower values. As a matter of fact, the maximum h-index of a PI in the Management-Focused cluster –29– is less than half the maximum h-index of the other two clusters –74 for Conservative PIs and 69 for Balanced High-HC PIs. At an RT level, the magnitude of these differences is exacerbated, but the relative performance of each cluster overall remains the same: Conservative PIs stand out as the most successful profile, Balanced High-HC PI's have a close to average performance and Management-Focused PIs show again remarkably lower results.

The fact that Management-focused PIs presented the poorest outcomes at both individual and team level may be due to a few reasons. On the one hand, as mentioned above, it might be related to the representation of certain scientific fields in this cluster. The presence of PIs belonging to the fields of Social and Legal Sciences, as well as Arts and Humanities, is the highest of all the profiles. As is known, these two scientific fields generally tend to show lower values of h-index than other research areas, for instance, due to the preference of publishing books with the results of their research rather than papers, among other factors (Hirsch & Buela-Casal, 2014). On the other hand, the fact that they showed the lowest scores in scientific educational training, investigation abilities and self-mastery skills cannot be overlooked. This lack could seriously hinder their ability to produce high-quality results or even to identify which hot topics in their scientific fields need to be explored. Therefore, in their case, they should surround themselves with well-trained scientists in their RTs to compensate for these weaknesses if they are to succeed with the increasing level of competition to publish in the context of

R&D (Kastrin et al., 2018). In their favour, they are conscious of their weaknesses, as is proven by their own self-assessment. For that reason, they can approach different strategies to enhance them, such as training (Alexandrov & Bourne, 2013; Kidwell, 2013).

At the opposite end of the spectrum, Conservative PIs not only have the highest personal h-index mean, but they are also capable of leading their RTs to achieve the highest h-index mean. These results suggest that those PIs in this cluster might be able to enhance the performance of their RT, as well as their own. As was the case with Management-Focused PIs, a number of factors might contribute to these results. For instance, it should be taken into account that this is the profile where the presence of IPs belonging to Sciences is the highest, and this scientific field is also the one which obtained the highest h-index values at both individual and team level (Table 2). Even though there might be differences among certain disciplines within this field, in general, Science researches obtain much higher values of h-index than those in Social and Legal sciences or Arts and Humanities (Hirsch & Buela-Casal, 2014), whose representation in this cluster is the lowest of all. Additionally, this profile displays high scores in both theoretical and methodological knowledge, which could also account for the good results of their teams. Being technically well prepared is a required quality of an effective leader and it ensures that they are both trusted and respected (Paulsen et al., 2009; Sapienza, 2005). On the same note, their capacity both to accept criticism and to interact easily with other researchers are key skills for diminishing conflict and motivating RT members (Croucher et al., 2020; Sapienza, 2005).

One last finding in terms of performance is that, surprisingly, the Balanced High-HC PIs profile –which consistently has high or extremely high scores in all five HC factors, and the highest ones in three of them– was not the profile that displayed the highest level of h-index mean at either PI or team level. Instead, it is the Conservative PIs profile which achieved the best results, while Balanced High-HC PIs remain in second place. The contrast between these two profiles is sharpest in their scores of openness-to-change skills –the highest ones in Balanced High-HC PIs and the lowest ones in Conservative PIs–, which might suggest that a factor explaining their performance could be based on differences in the way each profile interprets all the information from the ongoing research and in their understanding of the R&D context (Jarratt & Stiles, 2010). Additionally, the fact that both profiles score rather high in scientific educational training seems to agree with other studies that based their PI selection only on the technical expert role (Huang & Lin, 2006; Clarke, 2002). However, our findings contrast sharply with the “more is better” assumption, which expects that researchers with higher HC will obtain higher outcomes (Ployhart et al., 2014).

These differences in performance among clusters do not seem to be affected by seniority in the university career. In our study, this factor was measured from the year of the first publication in order to ascertain whether it could have an influence on the h-index results (Smith et al., 2018; Carter et al., 2017). Nevertheless, seniority in the university career has a surprisingly similar mean in the three clusters (4.55 for CL1, 4.67 for CL2 and 4.56 for CL3), and the median and mode values for each of them coincide (5).

Regarding gender, our results show significant differences in performance between male and female PIs (Table 2). On average, male PIs have a 23% higher h-index mean than female PIs, which is consistent with other studies (Carter et al., 2017). However, it is noteworthy that the presence of women in the different scientific fields and clusters is markedly uneven. On the one hand, women are grossly overrepresented in the Arts and Humanities scientific field (50%), which is the least prolific one. On the other hand, their presence in the Balanced High-HC PIs cluster is also substantially higher than among Conservative PIs or Management-focused PIs (38.2%, 23.7% and 27%, respectively) but that does not seem to affect the overall performance of this cluster, which is only slightly lower than that of Conservative PIs. All in all, this emphasises the suggestion that there are scientific fields that are predominantly male-dominated, which should be taken into account together with the fact that, even though there has been an increase of female representation in higher education (Mayer & Rathmann, 2018), their presence in senior structural positions in the university, such as PI, is blurred (Cunningham et al., 2020; West et al., 2013).

Based on these conclusions, our study provides managerial and research implications on a range of key considerations that should be addressed. Our results will be helpful for both universities and research centres to identify those PIs which best adapt to them, to their research approach or to their policies on the future lines of research that they will undertake. Even though the literature has not explicitly examined the process through which PIs learn to carry out their functions, it is suggested that they learn by doing (O'Kane et al., 2017; Cunningham et al., 2016a). In this sense, it will also be beneficial for any training proposals offered to scientists in the PI role in order to be better prepared for the challenges they address, opening the way for them to become more tailor-made proposals rather than generalist suggestions, since it has been demonstrated throughout this analysis that PIs are not homogeneous based on their HC. Moreover, it will facilitate the self-assessment of PIs, thus enabling them to identify those HC factors on which they can further improve, according to the objective to be achieved. Therefore, it could be considered critical to establish development policies and training practices to improve the PI's HC factors in which they are lacking (Youndt & Snell, 2004). However, the aim should not be to have very high levels in each of the HC's factors, but to enhance those that are considered essential (Pierce & Aguinis, 2013). Indeed, PIs could take advantage of the multidisciplinarity of the RTs that they lead by using the HC that other researchers in their teams can provide in order to complement their own and thus they could focus only on the areas that would benefit the most to the whole RT (Hollenbeck et al., 2004; Mathieu et al., 2014).

Our study is not without its limitations, which are detailed as follows and should be taken into consideration when drawing conclusions. There is a limitation in relation to self-reporting bias, since all respondent data was collected individually and PIs were self-assessed. In future studies, including at least one survey of the supervisors of the RT PIs should be considered, to avoid the only data available being the responses of PIs themselves. As an additional limitation, the contextual characteristics of the Spanish public research system constrain the possibility of generalising the results to other countries and other nationalities. Thus for future studies, exploring this analysis in other countries or other cultures is suggested. Another limitation is related to the measure of the performance of PIs and RTs, since there are certain concerns about the use of the h-index to compare several researchers and different scientific fields. For this reason, it is proposed that other measures be considered in future investigations, or that the h-index be complemented (Hirsch, 2010). Since the PI does not need to have certain SKA to perform their functions leading the RT, it is a breakthrough in the understanding of the PI role. This opens up an interesting future line of research.

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CHAPTER THREE

A Gender Study of Principal Investigator Lead Public R&D Centres and Funding

Cunningham, J. A., Escribá-Esteve, A., Foncubierta-Rodríguez, M. J., Martín-Alcázar, F. & Perea-Vicente, J. L. (2020). A Gender Study of Principal Investigator lead Public R&D Centres and Funding. *Economics of Innovation and New Technology*. https://doi.org/10.1080/10438599.2020.1843990

Abstract

To survive and grow public Research and Development (R&D) centres need to raise competitive funds (Santamaría et al., 2010; Muñoz, 2007; Bazeley, 1998; Lee & Om, 1996). The factors that can influence the capacity of national R&D teams within R&D centres to apply for and obtain competitive funding does not seem to have been studied in depth. The purpose of study is to firstly, to examine whether a consistent set of priorities defined by R&D centre lead principal investigators (PI) secures more competitive funding. Secondly, to examine whether the PI gender moderates the effect of the PI's priorities on the amount of competitive public funds that the R&D team of the PI obtains. Our study focuses on R&D activities carried out in Spanish public centres in the areas of Health and Biomedicine. Our results found that there were no gender differences in relation to the acquisition of competitive funding which is contrary to findings of other studies (Lerchenmueller & Sorenson, 2018; Mayer & Rathmann, 2018).

1. Introduction

Increasingly, public institutions strive to increase productivity of research funds, fostering research strategies, improving innovation and promoting policies to increase the effectiveness in securing funding (Kaló et al., 2019; Nielsen, 2016). From a policy perspective it is essential to ensure that the available funding is appropriately distributed, bearing in mind the needs of society and, the research areas that need to be developed further in order to improve people's quality of life (Gómez-García et al., 2014). For national governments public R&D can realize several benefits such as increasing technological and scientific capacity, further wealth creation through patents, spin off firms and ensuring societal outcomes (Leyden & Link, 2016). For public institutions and R&D centres such funding is essential to build sustainable research relationships with stakeholders, to strengthen their existing research capacity as well as developing new scientific knowledge, deepening existing research areas or opening up new research avenues (Cunningham et al., 2014). For scientists in the principal investigator (PI) role, securing public funding is essential and critical to furthering their research programmes and sustaining the research teams that depend on them (Cunningham et al., 2018). As a consequence, to obtain public funding for research has become a highly competitive market (Fang & Casadevall, 2015; Grimpe, 2012).

Nevertheless, public funds scarcity intensifies the competition between R&D centres and the PIs that lead them. Only those highly competitive projects that can meet and realize several spheres of impact –scientific, economic, societal, technological– secures the necessary funds. This means decreasing the number of projects financed under public R&D programmes (Kaló et al., 2019; Muñoz, 2007). For this reason, the ability to attract funds on a competitive basis is a key factor for the survival of the research programmes (Wadman, 2009) initiated by PIs within R&D centres. This natural selection of R&D projects ensures the most efficient distribution of the R&D public funds. Actually, competitive public funding processes frequently establish some minimum requirements such as on composition and size of the R&D team (Cummings & Kiesler, 2005), because funding usually addresses groups rather than individual researchers (Beaudry & Allaoui, 2012). It is the scientist in the PI role that leads the response these public funding calls with research programme grant applications and in doing so mobilizes industry and academic partners (Cunningham, 2019). The existing literature has highlighted the importance of public funding programmes for research, even though relatively few studies have focused on identifying those factors which contribute to its acquisition (Ebadi & Schiffauerova, 2015; Galsworthy & McKee, 2013).

The R&D team is defined as “a stable team formed by one or more scientific leaders, several researchers, young people on training internships and technical support personnel, that share technical-scientific goals, resources, infrastructure and equipment, with joint participation in research, development and innovation projects” (CICE 2006). The success of R&D teams in obtaining public competitive funding is influenced by a number of factors, whose better understanding is a key issue both for the public R&D system and R&D team's PI (Kaló et al., 2019; Ebadi & Schiffauerova, 2015). One and the other can benefit from this knowledge and can improve opportunities to secure funds. In order to continue to secure competitive funding PIs constantly strategize and are open to collaborate with a range of stakeholders to realize their scientific mission (O'Kane et al., 2015). PIs capture value from public R&D through two value capture mechanisms, boundary spanning and brokering (O'Kane et al., 2020). However, PIs experience ongoing managerial challenges in leadings public R&D programmes and they learn how to manage and lead on the job as a PI (Cunningham et al., 2014). In essence PIs are managers and need to have know-how capabilities particularly with respect to commercialization and technology transfer (Cunningham et al., 2020). Moreover, the PI role demands management capacity –which reflects "the tacit management know-how" (Zorn et al., 2019, p. 1491)– and capability –which represents the responsibility to get things done effectively and efficiently (Boardman & Ponomariov, 2014) and play a central role when developing certain types of activities in relation to competitive projects (Barreto & Patient, 2013; Barnett, 2008; Cho & Hambrick, 2006).

One of ongoing challenges scientists have in the PI role is how best to allocate their time in relation to dealing with a range of responsibilities such as research, technology transfer and commercialization (Cunningham et al., 2016). Taking attention-based view of the firm is as Ocasio (1997) states "what decision-makers do depend on what issues and answers they focus their attention on". Based on this, managers focus their attention on certain issues by observing and interpreting the stimulations present and the environmental features on which they focus and to which they respond (Ocasio, 1997). The PI role identify –science networkers, project manager, research contractor and entrepreneurs– as posited by O'Kane et al. (2020) shapes how their decisions on which R&D activities they have to spend their resources on and in doing so they define their priorities. For this reason, it is proposed that their priorities can be one of the factors affecting the efficacy of R&D teams achieving public competitive funds.

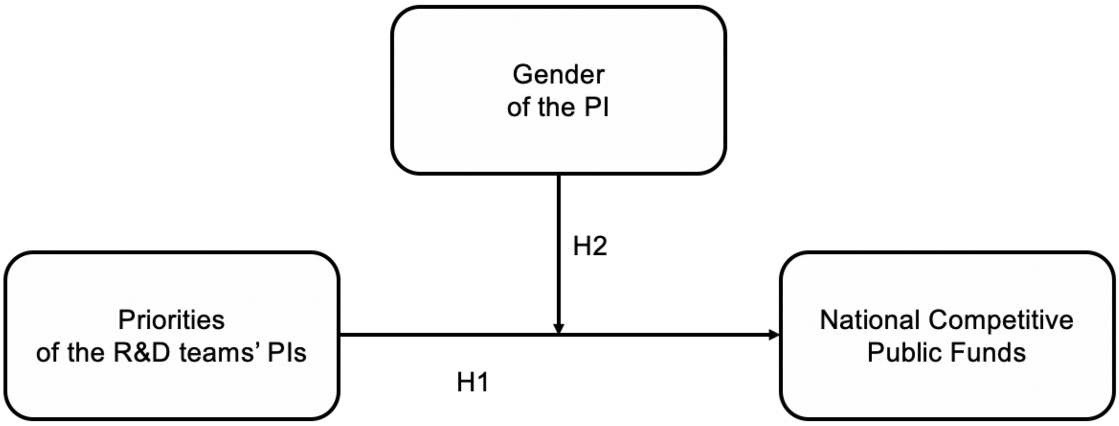
Notwithstanding the increase in the number of women in science, gender differences still persists in relation to gender balance and research productivity (Mayer & Rathmann, 2018; Beaudry & Larivière, 2016; West et al., 2013). Some studies have found some differences in obtaining public funds when R&D teams' PIs are women (Burns et al., 2019; Hechtman et al., 2018). For example, Burns in a large-scale Canadian study the reviewed 55,700 grants involving 4,087 researcher found women 31.1% of grant applications, experienced lower grant success rates and had lower personnel award success. Burns et al. (2019) conclude:

> Gender disparity existed overall in grant and personnel award success rates especially for grants directed to selected research communities. Funding agencies should monitor gender differences in grant success rates by content and explore possible explanations for gender disparity when identified.

Similarly, Hechtman et al. (2018) found that women accounted for 31% of grantees of the National Institutes of Health in the US and that they had similar funding longevity compared to men. So not only are we studying the relationship between the priorities that the PIs establish in their R&D teams and the competitive public funds that they obtain, but also the gender effect in this relationship. This also responds to the call to improve gender equality in research fields (Burns et al., 2019; Mayer & Rathmann, 2018).

In this study, we have addressed the aforementioned gap in the research by proposing a model (Figure 1) which analyse the effects that the priorities established by PI has on the success in obtaining competitive public funds, considering the moderation role of gender. We organize the paper as follow. After this introduction, our literature considerations focus on priorities in the R&D environment and gender differences in submitting and acquiring R&D competitive public funding. Then we develop an exploratory K-means cluster analysis to identify PI profiles in the sample and we also conducted a multiple regression analysis. Then the results are presented. After presenting the conclusion and discussion is developed, some limitations are presented along with further research avenues.

Figure 1. *Model proposed*



2. Background Literature and Research Hypothesis

2.1. Priorities in the R&D Environment

There is a growing pressure on R&D centres to maintain and grow their research activities, income and human capital. However, they face a constant lack of financial funds and intense competition in obtaining funds has increased (Kaló et al., 2019; Nielsen, 2016; Clausen et al., 2012). The capacity and the ability to attract funds to finance their research projects has been highlighted as essential for them to ensure the viability of R&D centres and to foster their future sustainability (Cunningham et al., 2014; Wadman, 2009). Obtaining competitive public funds not only rewards the hard work of the research that has been carried out, but also provides the resources needed to continue with present and future lines of research (Larivière et al., 2011). The ability to obtain these funds is related to the number of projects submitted, which in turn will have a positive impact on the final amount of funding they will be able to receive (Burns et al., 2019). Furthermore, as more projects are submitted, more expertise is accumulated in the submission process that can benefit future project submissions. In this sense, those who incorporate past reviewers' recommendations in their next project submissions can enhance their proposal writing skills for funding programmes thereby, they can increase their probabilities of obtaining funds (Ebadi & Schiffauerova, 2015).

To attain this level of competitiveness required by funders the priorities of R&D centres need to be clearly established, the objectives to be achieved need to be clearly defined (Ocasio, 1997). The unique and particular nature of the research environment makes it even more important to have clear objectives and priorities for the R&D teams in order to achieve the desired objectives and maintaining the viability of the R&D centre and associated scientific and support personnel (Zhu & Chen, 2016; Stock et al., 2014). Furthermore, it influences research development favorably (Shepherd et al., 2017). Taking the attention-based premise (Ocasio, 1997), R&D team's PI will establish the set of priorities depending on the competitive funding environment. In this sense, these priorities are designed to enhance the probability of obtaining competitive funding that meets the funders expectations and that are aligned to the current and or future industry and market needs. The creation of priorities can depend on such issues as defining the scale and scope of disciplinary focus, the fields of use for the knowledge created along with the industrial sector setting and end customer application. Such clear priorities can then enable the R&D team to scope out and respond in a focused manner to public competitive funding calls. Moreover, having a consistent set of priorities provides clarity of purpose and focus for the R&D team and certainty overtime. It also not alone the PI but also the R&D team to adapt a proactive strategic posture rather than a reactive one that can lead to poorer outcomes (O'Kane et al., 2015). Priorities also make it easier for R&D centre researchers and PIs and key stakeholders to be clear about the strategic direction and scope of R&D activities. As long as the PI clearly identifies the priorities of the R&D team in order to achieve the established objectives, it contributes to the process obtaining funding in such a competitive environment as the research environment has become (O'Kane et al., 2015; Cunningham et al., 2014; Bazzoli et al., 2000). By doing this, PIs establish R&D teams' priorities over a specified period of time as part of a proactive strategy that is designed to support the probability of obtaining funding. The PI determines those activities that will be undertaken earlier than others, establishing an order, and sending a clear message about the activities on which efforts and resources should be focused (Lin et al., 2005).

There are a sparse number of studies that have focused on the factors that determine which teams obtain funding with respect to others (Ebadi & Schiffauerova, 2015). Although none have focused on studying the influence that an internally consistent set of priorities defined by PI has over the funding of R&D team projects. So, knowing the priority of the PI will be crucial to a better understanding how R&D teams obtain competitive public funds and what make them different from the others. For that reason, the following hypothesis is proposed:

Hypothesis 1 (H1): *A more consistent set of priorities defined by PIs, more funds are obtained by competitive public funds.*

2.2. Gender Differences in Submitting and Acquiring R&D Competitive Public Funding

Notwithstanding the appearance of similarity in the possibilities for men and women, throughout the literature there is a significant evidence of the difference between them still persists (Burns et al., 2019; Lynn et al., 2019). Even though women representativeness has increased in recent years in science, there are evidences that still deep gender differences remain in a number of spheres as scientific production, career progression, commercialization, number of submission applications and acquiring competitive public funds, or successfully maintaining their line of research (Lerchenmueller & Sorenson, 2018; Mayer & Rathmann, 2018; Rose & Dawson, 2006; Bordon et al., 2003). All these drawbacks, seriously inhibit the progression of women into more senior positions (Abramo et al., 2015).

From the existing literature, it has been demonstrated that for a female scientist is tougher to get to a leader position, so they have to break through a lot of barriers (Howe-Walsh & Turnball, 2016; Fox, 2005). Fox (1991) asserted that formal network –institutional support– or/and informal network –interaction with colleagues inside and outside their organisation– affect their likelihood of receiving information about funding processes. Even though, recently it has been suggested that gender inequality has been decreasing (Ceci & Williams, 2011), differences still persist if we compare scholarly authorships (West et al., 2013). In some research areas it is even harder, such as science, technology and engineering (West et al., 2013). In some cases, it has been identified boys club in these disciplines (Barnard et al., 2010). Thus, gendered cultural within academia go against women progression in particular within science, technology and engineering seniority positions, for instance, the predominance of men among recruiters, selectors and promoters (Howe-Walsh & Turnbull, 2016). This reinforces the notion that there is a need for role models in which women can be identified (Ecklund et al., 2012; Stout et al., 2011).

Previous studies have highlighted lower presence of women in peer-review journals which inhibits them from making the requisite advancement in their scientific career to achieve the necessary prestige (Mayer & Rathmann, 2018; West et al., 2013). Moreover, becoming a project PI and managing R&D teams is seen as a prestigious scholarship standing indicator and a milestone achievement in a professional career (Cunningham et al., 2014). There are more male PIs than female PIs, in some cases this difference reaches 20% (Lerchenmueller & Sorenson, 2018; Bornmann et al., 2007).

There are academic career differences in accessing and developing their academic careers (Leahey et al., 2008; Ding et al., 2006; Probert, 2005). Moreover, Cunningham et al. (2017, p. 239) found that gender differences among PIs “with respect to commercial experiences, sources of funding, numbers of projects and career planning” and male PI had secured more international funding than women PIs. Previous studies have also found the level of specialization, the research collaborations and the limitations associated with the pivotal role of women in the family unit as causes of gender difference in scientific productivity and academic career progression (Abramo et al., 2013; Leahey, 2006; Fox, 2005). Witteman et al. (2019) suggested three main ideas to explain the reasons why women are poorly evaluated than men when they submit for competitive public funds: reviewers' subjective evaluations, the unfairly evaluations favouring male PIs and less compellingly applications.

Despite these gender differences and inhibitors found in previous studies, the success rate of women and men acquiring funds is similar, although men submitted much more applications than women (van den Besselaar & Sandström, 2017). Nevertheless, there are no studies that have investigated the moderating effect of gender on the impact of the R&D teams’ PI priorities in obtaining competitive public funding. Being able to obtain competitive public funds is one of the requirements academic career progression (West et al., 2013). Therefore, women who want to develop a career and aspire to be promoted to senior positions must demonstrate their ability doing it (Howe-Walsh & Turnbull, 2016). Even though, in literature there is a majority of researchers who posit that there are disadvantages for women (Witteman et al., 2019; Head et al., 2013), some other researchers state that women in PI roles achieve similar results. In this case, the difference is in number of competitive public funding submissions (van den Besselaar & Sandström, 2017; Ceci et al., 2014; Sotudeh & Khoshian, 2014). In this study, we address Burns' call (2019) to find an explanation for the gender gap in the acquisition of competitive public funds, examining the moderating effect of gender on the relationship between the R&D team's PI priorities and the funds obtained. So, we propose the following hypothesis:

> ***Hypothesis 2 (H2):*** *The PI gender moderates the effect of the PI's priorities on the amount of competitive public funds that the R&D team of the PI obtains.*

3. Methodology

3.1. Background, Data and Sample

The study was conducted in R&D teams of Spanish R&D public centres which research is focused in the areas of Biomedicine and Health. In the Spanish context, during the process of submitting funding applications R&D teams can rely on Research Management Office. Actually, one of the most common functions of Research Management Offices is to support R&D teams in the process of searching for funding sources. Furthermore, they offer advice on the verification of funding applications. In addition, not only do they provide support in the process of submitting applications to the relevant funding agencies, but also in the reception and acceptance processes. Therefore, even though they review the formal aspects of the submitting applications, they do not review the quality of the proposal (Spanish Universities Rectors Conference, 2017). Furthermore, in Spain the directors of the research centres, where the R&D teams are, do not review the quality of the proposal either. One reason for this is because in many cases they are not experts in all fields, and another is that in many cases they are designated by political rather than scientific criteria. Nevertheless, there are many authors that disagree with the benefits proclaimed by Research Management Offices, and define them in some cases as hampers in these processes, in which they should be facilitators (Belitski et al., 2019; Grimaldi et al., 2011; Siegel et al., 2007).

Several secondary sources of information were considered to identify the population. Our study was limited to those R&D teams who had applied for competitive funding projects from national or international programmes from 2011 to 2016. In this period of time, there were not any kind of dedicated equality support for female scientists in the PI role, in the Spanish context –national or regional level– (European Regional Development Fund, 2017). The resulted list of R&D public centres was consulted to a panel of experts from the ISCIII European Office and the European Office of the Spanish Ministry of Economy, Industry and Competitiveness through the Secretary of State for Research, Development and Innovation (SGCTI) to evaluate its suitability and relevance. They agree with the final list, and they also recommended to include some other important R&D centres and associated PIs to the population list. Therefore, the population is comprised of 68 Spanish R&D public centres. We sent e-mails to the whole population. In fact, emails were sent to every single director of the 68 R&D public centres. In the email we explained in detail the procedure we planned for collecting the data and requested her/him to inform each of the R&D teams' PIs that existed in her/his centre that we would be contacting them. Finally, we received answered questionnaires from a total of 47 R&D public centres (69,11%). In these R&D public centres are 128 R&D team's PIs. We received valid answered questionnaire from a total of 97 R&D team's PIs (75,78%), where 23,71% are women. Therefore, the final sample is comprised of 97 R&D team's PIs which research is focused in Biomedicine and Health areas.

Previous to sending the questionnaire, a pre-test analysis was developed. A draft questionnaire was sent to a group of experts in the fields of Biomedicine and Health and Management Research. This allowed us to review some typo and rewrite some information on the presentation of the questionnaire. Then the questionnaire was sent to the target population through the SocialSci platform to be answered directly through its online platform. A total of 128 answered questionnaires of the R&D teams' PIs were received. The questionnaire included some demographic questions both of PI such as gender, experience (years in PI position) and of the R&D team like size. Experience of the PI, which was measured by the number of years in an R&D team's PI position; and the size of the R&D team, which was measured by the number of members who comprise the R&D team, were utilized as control variables. Also, a 17-items scale of five-point likert scale by Clausen et al. (2012) was included asking in order to identified R&D team's PI priorities (Table 1). The dependent variable in this study is national competitive public fund which is measured by the amount of public competitive funds that the R&D teams of the PIs obtained from national calls.

Table 1. *Priorities of the R&D teams' PIs*

To get higher long-term financing associated to projects.
To get more basal funds not coming from national or international projects
To increase the number of international scientific publications
To attract good researchers
To improve the international collaborations
To develop a better scientific program
To get more support from the CEO and TMT
To improve the scientific leadership of the R&D area
To achieve better support from the policy makers institutions
To improve the researchers' employment opportunities
To increase collaborations with industry
To develop education & training programmes
To get practical and applicable results from the developed research projects
To get more support from other R&D areas
To improve the research culture of the area and the centre
To increase the support from other local or regional R&D areas
To face communication or collaboration internal problems

Note: Clausen et al. (2012)

3.2. Method 1: Cluster Analysis

For our analysis, a K-means cluster analysis was developed to identify the different PI profiles. Previously a hierarchical cluster analysis was carried (Ketchen & Shook, 1996) to determine the number of profiles depending on the sample. Based on the resulting dendrogram two profiles were the most accurate number of profiles for this sample. After developing a K-means cluster analysis, two different profiles of PIs were identified with 41 and 56 cases each that were based on the priorities that the PIs chose. ANOVA indicated that all items were significant for clustering except one "to get higher long-term financing associated to projects' (Table 2).

Table 2. *Cluster analysis*

GROUPING VARIABLES	ANOVA	
	F	Sig.
To get higher long-term financing associated to projects	3,901	0,051
To increase the number of international scientific publications	14,018	0,000
To attract good researchers	21,134	0,000
To improve the international collaborations	11,612	0,001
To get more basal funds not coming from national or international projects	44,49	0,000
To develop a better scientific programme	53,411	0,000
To get more support from the CEO and TMT	29,392	0,000
To improve the scientific leadership of the R&D area	23,307	0,000
To achieve better support from the policy makers institutions	27,742	0,000
To improve the researcher's employment opportunities	22,838	0,000
To increase collaborations with industry	24,625	0,000
To develop education & training programmes	36,252	0,000
To get practical and applicable results from the developed research projects	52,159	0,000
To get more support from other R&D areas	44,649	0,000
To improve the research culture of the area and the centre	40,287	0,000
To increase the support from other local or regional R&D areas	49,629	0,000
To face communication or collaboration internal problems	26,529	0,000

3.3. Method 2: Multiple Regression Analysis

A new variable was defined to capture belonging of respondents to a profile 1 – *Supporting and Empowering R&D Team Focused PIs*– or 2 –*Prioritized R&D Team*

Focused PIs–, which we termed based on our analysis. Multiple regression analysis was utilized to check the hypotheses. Three models were estimated. Model 1 only contain the effect of the control variables (experience of the PI and size of the team) on the national competitive public funds acquired. In the Model 2 and Model 3 the two hypotheses were tested. In Table 3 are represented the descriptive statistics –minimum and maximum values, means and standard deviations– and the correlation matrix of variables of the proposed model. Multiple regression analysis runs fine when independent variables have weak correlations, as is the case in this study, where the variance inflation factor of all independent variables are close to 1. Therefore, it does not exist a problem of multicollinearity (Stock & Watson, 2015; Greene, 2000). Having applied the Welch and Brown-Forsythe test, it is confirmed that there is a relationship between all the variables in the model, even though the standard errors are robust for heteroscedasticity (Vallejo & Ato, 2012).

Table 3. *Descriptive statistics and correlation matrix*

Variable	Min	Max	Mean	SD	1	2	3	4	5
National Competitive Public Funds	0	4	2,180	1,211	1				
Experience of the PI	1	3	1,990	0,777	0,028	1			
Size of the Team	0,69	5,71	2,689	1,269	0,644**	0,163	1		
Profiles	1	2	1,58	0,497	0,284*	-0,205	0,074	1	
Gender of the PI	0	1	0,75	0,434	-0,08	-0,034	0,12	0,015	1

Note: ** Correlation is significant at the 0.01 level; * Correlation is significant at the 0.05 level

4. Analysis

Supporting and Empowering R&D Team Focused PIs is comprised of 41 R&D team's PIs. Just 7 out of 41 are women, thus 17% of this profile are female PIs. They are those PIs that have ranked each of the priorities with the lowest average scores of the sample. This group represents a profile of PIs who are aware of supporting and empowering the R&D team, but it is not such a priority. They demonstrate a moderated intensity in priorities towards achieving competitive public funds. For them attracting good researchers and retaining them by improving employment opportunities are the two most valued priorities, but not as high as in prioritized R&D team focused PI profile. As in prioritized R&D team focused PI profile, the group ranked 6 priorities the same, although in a different order and with a difference of one point between the averages of the scores (Table 4). Therefore, we have considered that the PIs comprising this group are aware that they should support and enhance the R&D team, but not what they focus on most.

Prioritized R&D Team Focused PIs profile is comprised of 56 R&D team's PIs. About 17 out of 56 are women, thus 30% of this profile are female PIs, almost the double than profile 1. PIs within this group present a profile that demonstrates an intense focus in supporting and empowering the R&D team. They are those PIs that have valued each of the priorities with the highest average scores of the sample. These PIs demonstrate a higher intensity in priorities towards achieving competitive public funds. In this case, the set priorities with the highest average score are also those oriented to strengthening the resources of the R&D team, but with a higher average of the scores. For instance, the two most valued priorities are focused on supporting and fostering the R&D team's human resources. The first of them refers to attracting good researchers and the other to retaining them, both of which are basic principles in HR policies (Nyberg et al., 2018).

Table 4. *Cluster Supporting and Empowering R&D Team Focused PIs and Prioritized R&D Team Focused PIs*

GROUPING VARIABLES	**Supporting and Empowering R&D Team Focused PIs (Mean)**	**Prioritized R&D Team Focused PIs (Mean)**
To get higher long-term financing associated to projects	4,71	4,89
To increase the number of international scientific publications	3,66	4,37
To attract good researchers	3,63	4,59
To improve the international collaborations	4,1	4,7
To get more basal funds not coming from national or international projects	3,56	4,62
To develop a better scientific programme	3,37	4,61
To get more support from the CEO and TMT	2,73	3,95
To improve the scientific leadership of the R&D area	3,05	4,09
To achieve better support from the policy makers institutions	3	4,11
To improve the researcher’s employment opportunities	3,95	4,71
To increase collaborations with industry	3,24	4,18
To develop education & training programmes	2,56	3,73
To get practical and applicable results from the developed research projects	3,41	4,61
To get more support from other R&D areas	2,71	3,95
To improve the research culture of the area and the centre	2,63	3,84
To increase the support from other local or regional R&D areas	2,51	3,84
To face communication or collaboration internal problems	2,17	3,38

From the following six most valued priorities, five are variables that are highly valued in the assessment processes to achieve competitive public funding. These are scientific production variables such as, number of publications and applicability of research project results. Moreover, improving international collaborations and collaborations with industry are key to obtain public competitive funds (Ebadi & Schiffauerova, 2015; Beaudry & Allaoui, 2012). In addition, another variable is to develop a better scientific programme, which indirectly has a positive effect on the quality and consistence of the submissions.

As Table 5 depict H1 is supported, but it is not the same with H2. Contrary to expected H2, the PI gender does not moderate the effect of the PI’s priorities on the amount of competitive public funds that the R&D team of the PI obtains. The estimation of the third model was not significant. This result is contrary to the extended idea that there is a gender difference in acquiring competitive public funds (Lynn et al., 2019; Mayer & Rathmann, 2018).

Table 5. *Results of multiple regression analysis*

Variables	Model 1		Model 2		Model 3	
Constant		(0,37)		(0,543)		(0,536)
Experience of the PI (control variable)	-0,079	(0,158)	-0,028	(0,156)	-0,048	(0,155)
Size of the Team (control variable)	0,657***	(0,091)	0,631***	(0,088)	0,651***	(0,088)
Profiles			0,232*	(0,23)	0,313*	(0,256)
Profiles x Gender of the PI					-0,175	(0,158)
R^2	0,421		0,472		0,494	
Durbin-Watson					2,203	
Overall F	24,342***		19,645***		15,872***	

Note: *p<.05; **p<.01; ***p<.001

5. Discussion

In the career of PIs acquiring competitive public funding has become an essential feature (Kaló et al., 2019; Larivière et al., 2011). Because obtaining funding is crucial in the promotion process to higher career positions of the scientists in the PI role. Previous empirical studies found gender differences persists in acquiring competitive public funds (Lerchenmueller & Sorenson, 2018; Mayer & Rathmann, 2018), hence our study was to analyse gender differences in the process of obtaining funds. Therefore, it is important to understand the factors that influence on the amount of funds that PIs of the R&D teams acquire, as well as knowing the moderating effect of gender on this relationship (Ebadi & Schiffauerova, 2015).

There are few studies in the literature so far which have focused on the factors that can demonstrate the acquisition of competitive public funds (Kaló et al., 2019; Ebadi

& Schiffauerova, 2015; Galsworthy & McKee, 2013). This study proposes a new factor that explains it based on the attention-based theory (Li et al., 2010). From an exploratory cluster analysis, two different profiles of R&D teams' PIs establishing priorities of their teams were defined. This identification of the different profiles of the PIs contributes to clarify the influence that priority setting has on the amount of competitive public funding, which is crucial in the career progress of the PIs and on the survival of the R&D team (West et al., 2013; Wadman, 2009).

We approached this theme by studying the relationship between the priorities of R&D teams' PIs and the amount of competitive public funding obtained by those PIs, in a sample of R&D teams in the fields of Biomedicine and Health Sciences from Spanish R&D public centres. Results have revealed that those R&D teams' PIs who, through the establishment of their priorities, have an intense focus on supporting and empowering the R&D team will obtain a greater amount of national competitive public funds. However, as the priorities of the R&D teams' PIs become less focused on supporting and empowering the R&D team, the number of national competitive public funds will decrease. Therefore, the H1 is supported (Table 5). From the cluster analysis we can conclude that the profile in which there is the highest female representation –actually the prioritized R&D team focused PI profile it is almost double that of supporting and empowering R&D team focused PI, 30% versus 17% respectively– is the one where exists an intensity of priorities more ambitious and determinate to improve R&D teams' opportunities of achieving more competitive public funds. Therefore, prioritized R&D team focused PI profile is more successful obtaining funding in national calls.

Moreover, it is interesting to reflect on the difference between the experience average of the profiles and its average of the sample. In prioritized R&D team focused PI profile the average number of years in the same position is lower than the sample average. Surprisingly, something that may seem negative at first and according to Ebadi & Schiffauerova (2015), in this case we observe that it is not. This may be the result of a new vision of how an R&D team should be managed, renewed strength or the enthusiasm for reaching a needed objective in their career progress (Robson et al., 2012). This is the opposite for *Supporting and Empowering R&D Team Focused PIs* where the average experience is higher than the sample average. It might be because this profile is mainly comprised of PIs who have already reached the desired career level and they are in their later stages of their careers, so their ambitions have been already fulfilled (Robson et al., 2012). Therefore, their efforts in the acquiring competitive public funds are decreasing and focusing on other types of priorities. The variable measuring the size of the R&D teams is significant and positively related to competitive public funds acquire. This result can be explained by the fact that with more people on the team, there is a higher probability of submissions for national public competitive funds, and their subsequent obtainment (Burns et al., 2019).

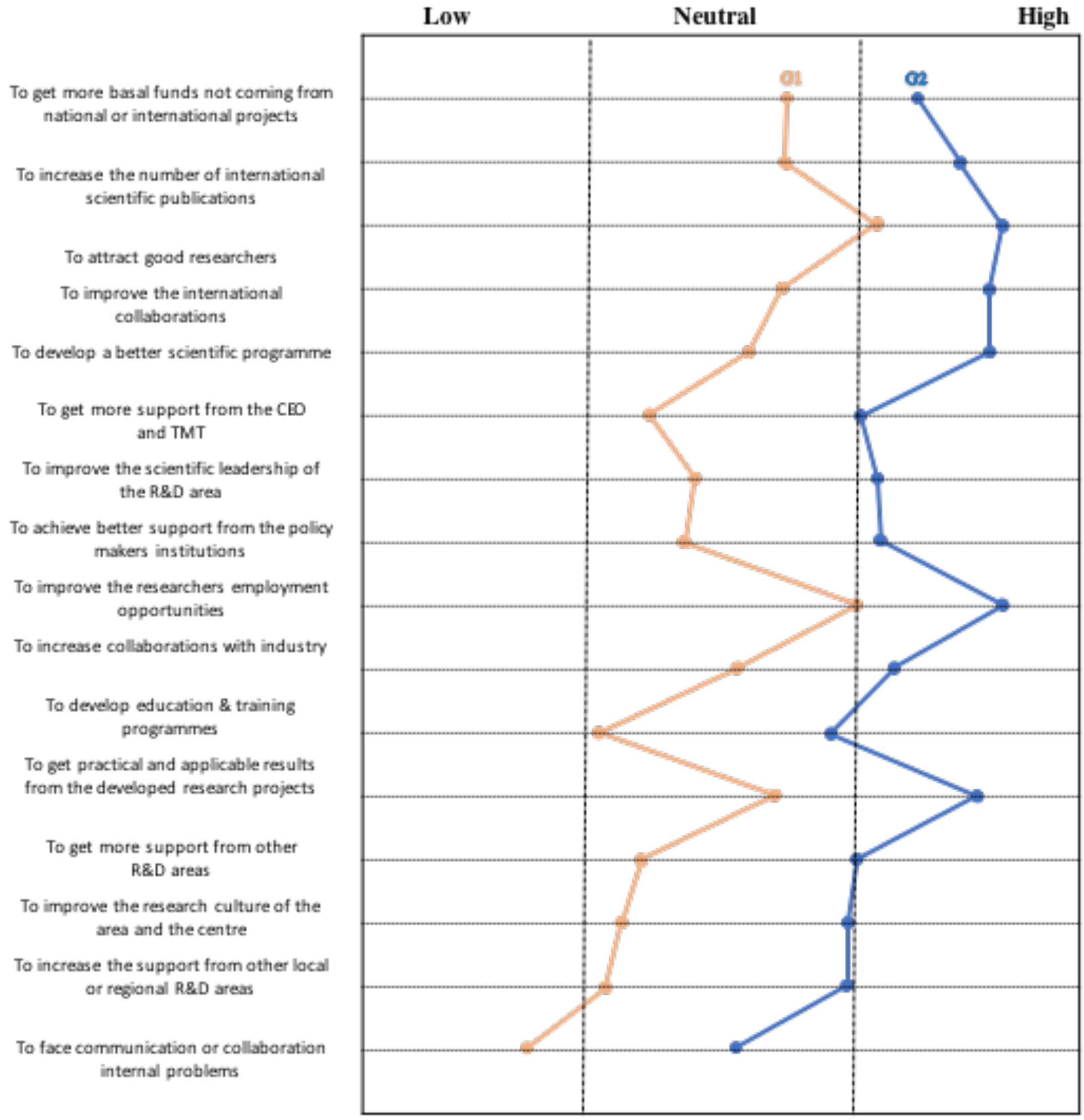
Even though, the representation of women in higher education in the last few years has increased (Mayer & Rathmann, 2018) and the number of female and male scientists are almost similar (Spanish Universities Rectors Conference, 2017). In our sample female PIs are underrepresented in comparison to male colleagues so, there is a structural underrepresentation of female PIs. This is not uncommon and similar to what Cunningham et al. (2020) of their large-scale study of PIs that successfully secured EC structural funding. Unfortunately, this ratio is more common than it should be (Lerchenmueller & Sorenson, 2018; Howe-Walsh & Turnbull, 2016).

Nevertheless, the study does not demonstrate the moderate effect of gender differences in the relationship of the model proposed (Figure 1), in our sample, most female PIs are committed to establish an intense focus of priorities oriented towards improving the R&D team to enhance their chances of obtaining more competitive public funds. That profile is more efficient than the first one. These results lead us to assume that although H2 has not been supported, it is necessary for a further understanding of gender differences.

6. Conclusions and Implications

Based on the results we can conclude that the priorities established by PI's in their R&D teams have a positive influence on the acquisition of competitive public funding and that the PI profile that is most efficient in achieving these objectives –prioritized R&D team focused PI profile– is where there is a greater female presence (Figure 2). Furthermore, we can also conclude that gender does not have a moderating effect on the relationship priorities of the R&D teams' PIs and the amount of public competitive funds that the R&D teams of the PIs obtained from national calls. Even though there is not a gender moderating effect in the relationship between PI's priorities and the amount of competitive public funds that the R&D team of the PI obtains, one may conclude that although in absolute numbers men are able to submit more applications for national public funding, women obtain the same success percentage when submitting in relative terms. Thus, when they reach the position of PI of an R&D team they are as successful as men can be. One might even say that they are more efficient, because although they present fewer applications and accumulate less experience in these processes, they are still able to achieve the same success rate (van den Besselaar & Sandström, 2017).

Figure 2. *R&D team's PIs profiles*



Note: Supporting and Empowering R&D Team Focused PIs (G1). Prioritized R&D Team Focused PIs (G2).

Therefore, it might not be so much a question of the quality of the application submitted, but a question of the capacity to lead teams able to submit a higher number of proposals and about the knowledge of these competitive public funding applications, and the composition of their network and relevant sources of information (Woehler et al., 2020; Lutter, 2015; Whittington & Smith-Doerr, 2005). This might be explained on the basis that the quality of the projects submitted may not differ in terms of gender, but there are still some obstacles in the race to reach PI positions for women (Belitski et al., 2019;

Grimaldi et al., 2011). In this sense, women are at a disadvantage compared to men, which slows them down and often even prevents them from reaching for higher career positions, such as PI roles (Lutter, 2015). Moreover, since many decision panels and managerial levels have a higher percentage of men than women, it does not benefit their progression in the academic career (Howe-Walsh & Turnbull, 2016; Lutter, 2015). Nevertheless, it remains interesting that there is an underrepresentation of females in PI roles, while the percentages of men and women among researchers are much more balanced, especially in certain knowledge areas such as health research.

Our research is not without limitations given the narrow scope of this study. One of the limitations is related to the self-reporting bias with both of the variables involved in the proposed model: priorities of the R&D teams' PIs and the amount of public competitive funds that the R&D teams of the PIs obtained from national calls. However, in all cases we asked, in a complementary survey to the Research Management Office representatives, about the number of total projects submitted and achieved by each research center, and the data is consistent with the numbers and percentages of success reported by the PIs. In any case, future studies might ask to the co-PIs or the director of the R&D department to assess the former variable and might ask for corroboration of the latter variable, such as a confirmation of the amount of public competitive funds that the R&D teams of the PIs obtained from national calls. Another limitation is related to the size of the studied population. Even though the Spanish R&D public centres of the fields of Biomedicine and Health Sciences were chosen because research in this area is frequently considered to demonstrate how knowledge is produced and often leads to important results in research policy, the population is not as large as would be desirable. An additional limitation is the contextual and constraints characteristics of the Spanish public research system. Defining our dependent variable as the amount of public competitive funds that the R&D teams of the PIs obtained from national calls is another limitation, because we are limiting the effect of the priorities of the R&D teams' PIs to that specific competitive public funding. However, all public research centers in Spain pay a lot of attention to the national research program, and all of them apply regularly to these funding calls, and consequently we think that this measure may be a good indicator of the proactivity and efficiency of research teams in terms of getting funds for research.

Since the difference between the two profiles was the intensity in which PIs determined each of the different priorities, it offers the possibility of broaden the investigation of the factors that influence the acquisition of competitive public funds from a gender perspective. Therefore, a possible future research can be based on the self-determination theory, since the contextual characteristics and individual differences of each of the PIs from a gender perspective and their motivations can be factors that influence to increase the competitive public funding obtained (Harris, 2019; Dewett, 2007). Future research should be focused on widening the range of financing instruments as well as including international competitive public funding calls. It could be interesting to study the influence on the acquisition of competitive public funds of the relational capital of the PIs within their R&D team members, with R&D team's members of other areas and also with the research management office's members and manager who manage their funds submission. Does gender influence matter? Studying the direct effect of gender of the R&D team's PI on the amount of public competitive funds that the R&D teams obtained is an interesting future research line (Stock & Watson, 2015).

Another limitation might be that gender may include internal elements that may overlap the actual effect. It would have to be considered whether or not, on a contingent basis, there is gender discrimination, and therefore whether or not the same results are obtained. In our research we have not asked for contingent circumstances of the PI –for example, cultural circumstances, family circumstances, surrounding circumstances–, in order to compare whether these issues explain the differences in funding results instead of the gender itself. However, differences in the roles assumed by men and women in all occidental societies are still different and these aspects have been frequently documented as factors that hinder the possibilities for women to develop a more successful professional career in comparison with men (Ely et al., 2014). Hence, a future line of research could be to undertake a more in-depth study on the contextual differences between genders, which would capture that information and allow for a broader analysis.

Finally, our study raises an important issue for policy makers in relation to the under-representation of women PIs being in a position to compete for and ultimately secure public funding for large-scale research programmes. New support and funding instruments, different career and funding evaluation criteria and other appropriate equality and diversity measures need to be considered by policy makers in the design of public research programmes. Our study clearly demonstrates that there is not a moderating effect of gender in the relationship between priorities of the R&D teams' PIs and the amount of public competitive funds that the R&D teams of the PIs obtained from national calls and since women PIs are in position to acquire public competitive funding they can be as successful as male PIs, which is contrary to what Lerchenmueller & Sorenson (2018), and Mayer & Rathmann (2018) found in their studies. However, the ongoing challenges is a systemic one that requires proactive measures and policies to deal effectively with women under representation and to ensure as Link (2017, p. 2) succinctly notes so to: “ensure opportunities for underrepresented minorities and women in the entrepreneurial ecosystem”.

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CHAPTER FOUR

Conflict and Performance in Research Teams: How Principal Investigator Can Influence this Relationship

Abstract

The lack of consensus about overcoming the negative impact of conflict on team performance within research teams has become a challenge. Based on the complex context of knowledge-intensive teams, this study examines the effect that a transformational leadership style of the Principal Investigator has on the relationship between team conflict and team performance. We propose an inverted U-shaped relationship between research team conflict and research team performance, and examine the impact that the Principal Investigators' transformational leadership has on this curvilinear relationship. Using survey data from 205 research teams, our results confirm both hypotheses. Actually, those PIs who apply the transformational leadership style will extend the positive conflict area, so, they will be able to manage a higher level of conflict in the research team. Our findings contribute to enhancing the understanding of the impact of conflict and the principal investigator's transformational leadership style on team performance. Both theoretical and practical considerations are discussed.

1. Introduction

Research is a pillar of society and organisations which supports part of their success and future projection (Wu et al., 2015). Nowadays, research is mostly performed by research teams (RTs) (Jeong & Choi, 2015; Bozeman et al., 2013) that are becoming increasingly multidisciplinary in order to address the complexity of the problems they face (Martín-Alcázar et al., 2012a), which demand a close collaboration between team members. The rationale behind this fact is that the combined efforts of the members of an RT are likely to enhance both individual and team performance (Kyvik & Reymert, 2017). This assumption is so widespread nowadays that both a certain size and a multidisciplinary composition of an RT have become key requirements for successfully applying for public research funding, either from national or international calls. However, as the literature highlights, this way of conducting research is not exempt from difficulties and may represent a double-edged sword (Ayoko & Callan, 2010; Tyran & Gibson, 2008).

A multidisciplinary composition in an RT involves working not only with a variety of scientific backgrounds but also with a myriad other differences in skills and personality traits that translate into a highly diversified human capital (Martín-Alcázar et al., 2012b; Liu et al., 2011). Although the diversity of human capital of an RT could be considered a positive disruptive condition for improving team performance (Lenka & Gupta, 2019; Williams & O´Really, 1998), several authors have pointed out that such teams are susceptible to developing team conflicts, which negatively influence team performance (Zhao et al., 2019; Huang, 2012; Ayoko & Callan, 2010). Although this can be true for any group of people working together, in the case of a knowledge-intensive context, with highly-specialised profiles, the difficulty of managing such teams can be greater and the stakes attached to their performance can be higher (Stock et al., 2014).

Notwithstanding the lack of consensus on the effects of diversity in an RT, the truth is that overcoming the negative impact that conflict has on the performance of RTs has become a challenge that calls for further research (Flores et al., 2018; de Wit et al., 2012). Effective conflict management can have a significant impact on team performance (Zhao et al., 2019; Solansky et al., 2014), and the role of the leadership style of the Principal Investigator (PI) may be crucial. Maltarich et al. (2018) suggest that team conflict has a negative impact on team performance when the management approach of such conflict is competitive rather than cooperative. Promoting the creation of a cooperative context that encourages and endorses dissent within the RT could therefore be a challenge for PIs (Tjosvold, 1991). In this sense, it has been found that applying Transformational Leadership (TFL) enhances team coordination, which, in turn, promotes a more cooperative approach to managing conflict, resulting in a positive impact on team performance (Zhang et al., 2011). Nonetheless, the TFL style might represent a double-edged sword in team conflict resolution because, by encouraging collaboration and cooperation among RT members, the likelihood of conflicts arising between them is also increased (Kotlyar & Karakowsky, 2006). Therefore, great caution is necessary when assessing the role that a PI plays, as their leadership of the RT may ignite higher probabilities of future conflicts. Despite this fact, few studies have focused on the impact that PIs have on the relationship between team conflict and team performance (de Wit et al., 2012).

Accordingly, our study aims to answer to two calls in the literature (Cunningham et al., 2018; de Wit et al., 2012). Firstly, it is to examine the relationship between RT conflict and RT performance in the academic context (Degn et al., 2018). Since conflict is unavoidable whenever working in teams, it is important not only to ascertain whether conflict within RTs has an impact on their outcomes, but also to obtain a more detailed understanding of the underlying factors involved in this relationship in order to manage this common occurrence in the most effective way possible (Puck & Pregernig, 2014). For that reason, secondly, the influence of the PI's TFL in the relationship between RT conflict and RT performance will be analysed. Thus, when conflictive situations arise, PIs may know how to influence them so that there could be the least possible detrimental impact, or even an advantageous one to both the RT and its results.

In doing this, this paper is organised as follows. After this introduction, there is a deeper review of the literature on RT conflict, PIs in the R&D context and TFL. Then, the methodology whereby the study was undertaken is explained. Subsequently, we present our results. Discussion, conclusions, limitations and future research avenues are presented in the last section of the paper.

2. Theoretical Background and Hypotheses Development

2.1. RT Conflict and RT Performance

Even though there is an emerging literature on the effects of RT conflict on RT performance (Degn et al., 2018; Puck & Pregernig, 2014; De Witt et al., 2012), there are still some questions that remain unresolved or that have received opposing answers (Zhao et al., 2019). Conflict has mainly been defined as any actual or perceived discrepancy among the team members of a team (DeChurch et al., 2013; De Dreu & Weingart, 2003). In knowledge-intensive organisations, RTs are crucial to achieve a sustained competitive advantage and constant innovations (Zhou et al., 2018; Grant, 1996). RTs are comprised of a diverse set of highly trained researchers who undertake many complex challenges; networking within and outside RTs encourages a more suitable performance of the RT (Nieto-Guerrero et al., 2019; Chung & Jackson, 2013). This diversity reflects the differences between RT members, which may have a reasonably positive impact on team performance, but which can also lead to negative consequences, such as a higher probability of team conflict or even no significant effects on team performance (Puck & Pregernig, 2014). The working dynamics within an RT of this dimension and complexity must be supported, to ensure that each RT member is able to start developing learning mechanisms to improve and take advantage of the valuable knowledge and resources that the other members can contribute, in order to go a step further towards achieving the RT's objectives (Kearney & Gebert, 2009). Therefore, even though an RT is created to capitalise on the heterogeneity of human capital provided by its members, this diversity can also trigger an array of internal conflicts (DeChurch et al., 2013).

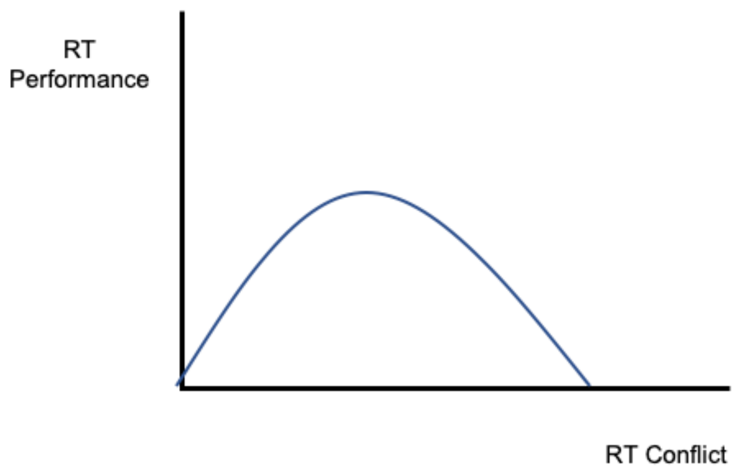
In their daily routine, RT members are in regular contact and usually have discussions on the issues they are involved in, providing reasons that support their individual approaches (O'Neill & McLarnon, 2018). This situation might enhance team conflict within RTs (Mitchell et al., 2011). In the R&D context, the environment is so complex –due to the heterogeneous background and experience of the RT members– that a clash of various approaches to solving problems and achieving objectives is possible (Zhou et al., 2016). In this case, good conflict management is key to success, because intra-team conflict could be detrimental to the team outcomes if not effectively managed (Ayoko & Callan, 2010).

Even though in the literature it is accepted that conflicts within RTs influence team outcomes, there is no consensus on the nature of that influence, which could be positive, negative or even non-significant (Maltarich et al., 2018; Puck & Pregernig, 2014; de Wit et al., 2012). In addition, whenever there is conflict in the RT, this can cause unity or division to occur, and the latter could result in the immediate breakdown of balance within the RT (Suifan et al., 2020). Two different general strategies can be developed by the leader to manage conflict (Yin et al., 2020; Tjosvold, 2006). First, a competitive approach to conflict resolution will result in increased friction and disagreement between team members, which will make communication between them more difficult, with the inevitable negative effect on the achievement of goals. Conversely, a cooperative conflict resolution strategy has a positive impact on the sense of belonging to the team, encouraging team members to participate and strive towards reaching their goals (Tjosvold et al., 2006). Furthermore, excessive emphasis on harmony within the team often pushes team members to take an evasive approach to potential sources of conflict. This alternative has a surprisingly negative impact in the medium/long term, as it has been shown that not discussing the issues that have given rise to the conflict triggers negative feelings that will ultimately be sources of future conflict (Huang, 2010).

There are a few studies in the literature demonstrating that the impact of dissenting thinking in an RT can be significant for the ignition of creativity. Thus, challenging group thinking in any situation and initiating a discussion to solve the problem have a positive impact on the final outcome, although they can also increase conflict (De Dreu & West, 2001; Van Dyne & Saaverda, 1996). Furthermore, some studies asserted that conflict related to the task at hand can be positive for team performance (Humphrey et al., 2017; de Wit et al., 2012). On the contrary, the majority of the studies emphasised the negative impact of conflict on team performance (Suifan et al., 2020; Zhou et al., 2016). These inconsistent results may indicate that the relationship between RT conflict and RT performance is non-linear. Drawing on what has been previously considered, it is expected that conflict will be beneficial for RT performance, although only to a certain point. Beyond that specific point, RT conflict will start to become detrimental for RT performance. Nevertheless, as far as we are concerned, no study has yet focused on that and/or empirically considered the non-linear relationship between RT conflict and RT performance in the R&D context. In this sense, and based on the "too-much-of-a-good-thing" effect (Pierce & Aguinis, 2013, p. 313) and on the studies that suggested a curvilinear relationship between conflict and performance in groups and organisations (Kreitner & Kinicki, 1997; Jehn, 1995), a non-linear relationship between RT conflict and RT performance model is proposed (Figure 1). Therefore, the proposed hypothesis is as follows:

> ***Hypothesis 1 (H1):*** There is a positive relationship between the level of conflict within an RT and its performance, which becomes negative after reaching a certain inflection point.

Figure 1. *The relationship between RT conflict and RT performance*



2.2. PI and Leadership Style

The PI's leadership experience in large teams enhances the RT outcomes (Stankiewicz, 1979). Consequently, the larger the team becomes, the more crucial the role of the PI will be (Murayama et al., 2015). In this sense, searching for the optimal leadership style to achieve the desirable team outcomes has been a recurring theme among researchers (Kammerhoff et al., 2019; Zhao et al., 2019). As Lazear & Rosen (1981) stated, since those who constitute the top management of the team are more qualified to manage situations occurring within the team, such as conflicts, PIs can therefore have positive effects on RT performance (Zhao et al., 2019). Team members' interactions within the RT developing the research process can result in an internal conflict that needs to be managed by PIs. The manner in which PIs manage conflicts that arise within the RT could be key, and it is conditioned by their leadership style (Deutsch, 2006).

Due to the heterogeneous composition of the RT's human capital, TFL is a suitable leadership style to enhance team performance (Kammerhoff et al., 2019, Peltokorpi & Hasu, 2015). As Maltarich et al. (2018) asserted, implementing leadership styles which foster cooperative team behaviours towards team conflicts has a positive impact on team performance. Thus, the PI's TFL approach to conflict makes a twofold contribution to achieving team performance: enhancing cooperative attitudes and reducing the negative effects of competitive work patterns, which have an indirect positive impact on team performance through team coordination (Zhang et al., 2011). Dionne et al. (2004) also suggested a positive relationship between TFL and team conflict management skills which would enhance team performance. The literature developed in the area of RT highlights TFL as the leadership style with the most significant impact on team performance. Actually, TFL has been considered a leadership style which manages team conflict well (Kammerhoff et al., 2019; Bai et al., 2016; Gelfand et al., 2012). Even though TFL is one of the most studied leadership styles, there is yet no unanimous understanding of its specific influence on team conflict (Zhao et al., 2019). While the literature highlights the benefits that TFL provides in the successful management of RT conflicts (Maltarich et al., 2018; Zhang et al., 2011), at the same time, it has also been pointed out that TFL could spark unwanted friction (Kotlyar & Karakowsky, 2006).

TFL is applied by those PIs who seek to encourage their supporters to go beyond their limits, not only to reach their own goals, but also to further the achievement of the team’s objectives (Bass, 1985). Ayoko & Chua (2014) asserted that the negative effect of team conflict can be reduced if every RT member trusts the others’ competence to fulfil their responsibilities, something to which the PI’s TFL may contribute significantly. The reason is that when PIs apply a TFL style in managing and leading the RT, they enhance trust among RT members. Through TFL behaviours, such as assisting and helping RT members to achieve their aims or inspiring them to collaborate in achieving the RT’s outcomes, PIs are able to foster RT members’ trust in them (Zhu & Akhtar, 2014).

In contrast, some authors have questioned the benefits of TFL. For instance, TFL is considered a double-edged sword in team conflict resolution because, by promoting cooperation and collaboration among team members, it indirectly increases the RT's propensity for conflict. This is because those PIs who implement TFL will manage to generate productive conflict but, at the same time, this could also promote a disproportionate high level of dysfunctional conflict (Kotlyar & Karakowsky, 2006). Moreover, those PIs who have developed a self-enhancement of their TFL behaviours will undermine their relationship with the rest of the RT members and therefore would enhance team conflict (van der Kam et al., 2014). Regarding the way in which PIs implement their TFL, Cai et al. (2017) asserted that although those PIs who carry out individual-focused TFL behaviours will enhance RT conflict, those PIs who perform group-focused TFL behaviours will diminish team conflict.

Based on the benefits of the TFL on RT performance and RT conflict, we proposed that the effect of the PI's TFL leadership style could extend the area in which conflict has positive effects on team performance, i.e. it moves the inflection point to the right and upwards (Figure 2). This raises the amount of conflict with positive effects that the group can handle compared to when the PI does not have this type of leadership. Therefore, the proposed hypothesis is as follows:

> ***Hypothesis 2 (H2):*** The TFL style of RT PIs will positively impact in the relationship between RT conflict and RT performance, increasing the positive conflict area by moving the inflection point to the right and upwards.

3. Method

3.1. Procedure and Sample

Nowadays, pressures on academics to obtain results and an increasing specialisation of academic research have turned academia into a competitive environment, driving researchers to collaborate more and more with each other (Degn et al., 2018; Leahey, 2016). PIs are key in handling the internal dynamics of the RT (Lin et al., 2016), a highly complex task due to the difficulty of managing and leading a team of highly specialised scientists (Stock et al., 2014). In the context of public universities, it becomes even more complicated since the RT PI has to approach the objectives by counting on those researchers who are available to comprise their RT, being unable to hire or fire anyone (McDonough & Barczak, 1992).

Data used for the empirical study was collected from RT members and PIs from a wide range of fields in Spanish public universities. The unit of analysis in this study is the RT, composed of diversely qualified researchers who, led by the PI, collaborate towards achieving defined objectives through sharing their knowledge and experience (Hautala & Jauhiainen, 2014; Jiménez-Sáez et al., 2011). In order to obtain the maximum number of surveys answered, we contacted the Vice-Rectorates for Research of all the Spanish public universities, explaining to them the nature of our research project and asking for their collaboration in disseminating the questionnaires in their universities. As a result, we received a total of 1,290 valid responses. Responses were considered valid if the questionnaire allowed us to identify the research team to which the respondent belonged. Then, to identify RTs in our study, we removed those RTs not fulfilling either of two criteria: (i) to have a minimum of three questionnaires, and (ii) to represent at least 50% of the RT members (Chen et al., 2019; Cai et al., 2017). Thus, we finally ended up with 205 RTs.

3.2. Measures

Team conflict. Inspired by Jehn’s conflict scale (Jehn, 1995) eight items were designed adapted to the academic RTs specificities. This change was considered to be necessary because the original scale was designed to understand the effects of conflict in work groups operating within a business organisation, which is slightly different to an academic RT. Since RT members may have diverse opinions about the level of conflict in the team, in this study they were asked about their perceptions of conflict within the RT (Lu et al., 2011). As an example, these are some of the items used and adapted for our specific research context: “*in the RT, there was a high level of conflict due to the personality and/or emotions of RT members*”, and “*in the RT, there was a high level of tension in the relationships among RT members*”. A five-point Likert scale was used, ranging from 1 (absolutely not) to 5 (yes, always). The confirmatory factor analysis proved one factor, Cronbach’s alpha for this scale was 0.932, and the Keiser-Meyer-Olkin index was 0.922.

TFL of PIs. Items oriented to measure the PI leadership style were answered only by RT members. To measure the PI’s TFL style, we adapted the Bass & Avolio (2000) leadership style scale to focus only on this. A sample item of TFL style is: “*throughout* *the development of the research project, the PI created a working environment that encouraged responsible behaviour by all members of the RT*". A five-point Likert scale was used, ranging from 1 (absolutely not) to 5 (yes, always). The confirmatory factor analysis proved one factor, Cronbach's alpha for this scale was 0.758 and the Keiser-Meyer-Olkin index was 0.693.

Team performance. A wide range of metrics are provided in the literature to measure the scientific outcomes of the researchers. We based our study on the h-index as a measure of the RT performance (Hirsch, 2005). Even though it is an individual measure of a researcher's scientific production, our study is based on the RT h-index. The source used to obtain all the RTs' h-index was the data available in SciVal. This is an Elsevier proposal through which information from more than 9,000 research institutes is provided. Several tools are available to facilitate the research process and benchmarking across diverse research organisations (Colledge & Verlinde, 2014).

Control variable. The mean age of RT members was introduced in the model to reduce the potential bias. Older members of RTs are likely to have more relevant expertise related to the issues examined in this study. Therefore, this control variable was considered in our model (Maltarich et al., 2018; Cai et al., 2017).

In order to verify the proposed model and before testing our hypotheses, a confirmatory factor analysis was undertaken. This was carried out using AMOS 23 to validate the construct of the variables considered in this study. Since our variables are measured at the team level, and the proposed hypotheses are also at the team level, the process to validate the construct variables was undertaken at the team level. Based on the results of the confirmatory factor analysis (χ^2=149.8, df=53, p<.001; comparative fit index (CFI) =0.94; standardised root mean square residual (SRMR) =0.051), the structural model fits the data well (Cha et al., 2015; Hu & Bentler, 1999). Therefore, the unidimensionality of the model is proved.

3.3. Data Aggregation

As team conflict and the PI's TFL were measured at an individual level, a data aggregation was needed to compile the answers at a team level. Needless to say, this aggregation process must be done relying on theoretical and empirical basements (Bliese, 2000). For team conflict, since team members interact while they are collaborating with each other during the research process, it is presumed that they share conflict perceptions among themselves (Zhang et al., 2011). Concerning the PI's TFL, however, it has been discussed whether team members' perception of it is homogeneous or not (Yammarino & Dansereau, 2008), since it relies on the PI's consistency in their interactions with the team members (Zhang et al., 2011). As Ayoko & Callan (2010) stated, team conflict is considered to be team-level assumptions. The empirical justification is based on the intra-class correlation coefficients: the ICC1 which represents the explained variance and the ICC2 which is used to define the reliability of teams (Bliese, 2000). In our study, ICC1 and ICC2 of team conflict were 0.62 and 0.99 respectively, and ICC1 and ICC2 of the PI's TFL were 0.57 and 0.99 respectively. Therefore, the pre-established conditions to proceed with the aggregation of data from an individual to a group level were fulfilled (Bliese, 2000).

4. Results

Descriptive statistics of the variables and correlations are shown in Table 1. The hypotheses were tested using hierarchical regression in SPSS Statistics, version 26. The mean age of RT members, as a control variable, was introduced in the first step. Two hierarchical regression analyses were carried out to confirm the proposed hypotheses. One was carried out to study H1 (Table 2). Hierarchical regression analysis was developed in three models, considering RT performance as the dependent variable. Model 2 considered only the effect of the RT conflict, and Model 3 the RT conflict as the quadratic term (H1). The coefficient for the RT conflict was significant (β= 0.215, $p<0.01$, Model 3) as well as its quadratic term (β= -0.270, p<0.001, Model 3). The former presented a positive impact of RT conflict on RT performance, and the latter presented a negative impact of RT conflict on RT performance. Thus, as expected, there is a curvilinear relationship, specifically an inverted U-shaped relationship, between RT conflict on RT performance. Results show that H1 was supported (Table 2).

Table 1. *Descriptive statistics of the variables*

Variable	M	SD	1	2	3	4
Mean Age of RT Members	27.99	6.39	1			
RT Conflict	0	1	-0.042	1		
TFL of PIs	0	1	0.055	-0.464**	1	
RT Performance	27.41	20.06	-0.061	0.156*	0.076	1

Note. N=205. *p< 0.05, **p< 0.01

Table 2. *Results of the hierarchical regression*

Variable	Model 1	Model 2	Model 3
Step 1: Control variable			
Mean Age of RT Members	-0.061 (0.220)	-0.054 (0.218)	-0.032 (0.211)
Step 2: Independent variable			
RT Conflict		0.154* (1.394)	0.215** (1.383)
Step 3: Quadratic term main effect			
RT Conflict squared			-0.270*** (1.025)
Overall F	0.747	2.836	7.120***
R^2	0.004	0.027	0.096
Durbin-Watson			1.775

Note. N=205. *p<0.05, **p<0.01, ***p<0.001.

In order to facilitate the interpretation of the data, we use a centralisation strategy. This centralisation strategy is commonly used to test the effect of TFL on the relationship between RT conflict and RT performance (H2) (Li, 2018). Considering the sample size, the best option to apply the tests of contrasts was to consider three categories for RT conflict (high, moderate and low) and two categories for TFL (Freeman, 1987; Peduzzi et al., 1996). Regarding RT conflict, values that are greater than the sum of the mean plus the standard deviation will be considered in the high-level range. On the contrary, values that are lower than the result of subtracting the standard deviation from the mean will be considered a low level of RT conflict. The values in between those two limits will be considered as moderate. In the case of TFL, values above the mean will be considered as a high level of TFL, while values below the mean will be considered as a low level.

The interaction variable was then calculated. The ANOVA test indicates that there is an association at an error level of 0.1%, which means that the null hypothesis is rejected –all interaction variable categories do not have similar means with respect to RT performance. Therefore, an analysis was carried out to identify those categories which have statistically significant means at an error of less than 5%. Due to the presence of homoscedasticity –confirmed by the Levene test– the Bonferroni test was undertaken. Those scenarios whose means diverge are represented in Table 3. This shows where the associations between the level of RT conflict and the application or non-application of TFL by the PI have an impact on the RT performance. The association low-level RT conflict with high-level TFL is taken as reference.

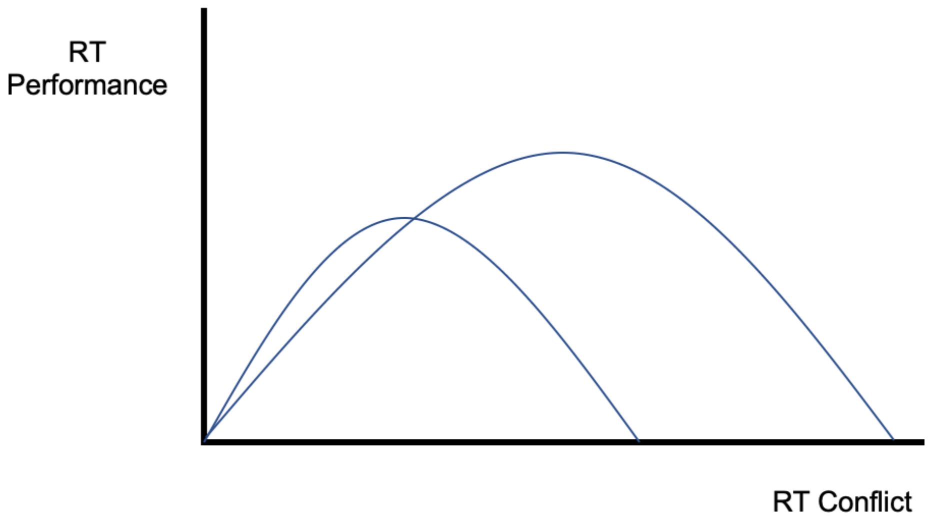
Table 3. *Bonferroni test results*

Associations (RT conflict – TFL)	**Means Difference**	**Standard Deviation**	**Sig.**
Low-level RT conflict – High-level TFL	Reference association		
Moderated-level RT conflict – Low-level TFL	-15.1005*	5.0229	0.045
Moderated-level RT conflict – High-level TFL	-16.3352*	4.9408	0.017
High-level RT conflict – High-level TFL	-20.9607*	6.4993	0.022

Note. *p<0.05, **p<0.01, ***p<0.001.

These results confirmed H2, so when the PI applies a TFL leadership style within the RT, the inflection point of the curvilinear relationship between RT conflict and RT performance will be moved to the right and upwards, making the positive conflict area bigger (Figure 2).

Figure 2. *The impact of the TFL style of PIs of RTs in the relationship between RT conflict and RT performance*



5. Discussion, Conclusions and Limitations

Our study aims to deepen the understanding of the impact that RT conflict has on the performance of all the members as a team. The objective is not to avoid conflict –since this might result in team ineffectiveness– but to understand RT conflict and its effect on RT performance (Puck & Pregernig, 2014). As previously stated, conflicts are inevitable in teamwork, so they can arise in any form and at any time (Jehn, 1995). There are several indications that show that conflicts are the cause of social instability within an RT and that they prevent the progress and fulfilment of the milestones they pursue as an RT (Rousseau et al., 2006). In the literature, although there is evidence of a broad consensus about the harmful effects of conflict within teams on team performance (Costa et al., 2015; Shaw et al., 2011), there are also some references and studies claiming that conflict can push researchers out of their comfort zone, encouraging them to improve themselves and to continue upgrading their knowledge and skills (Humphrey et al., 2017; De Wit et al., 2012). In this regard, Van Dyne & Saaverda (1996) and Pelled et al. (1999) highlighted that if there are disagreements in the RT on some working issue, those researchers involved in it would have to study and learn more about the arguments of the other side, in order to be victorious in the discussion, so that their proposal or way of doing things prevails over the alternatives. Taking both the negative and the positive effects into account, it could be expected that the relationship between RT conflict and RT performance is in fact curvilinear, as our results have shown, in the form of an inverted U-shape.

Furthermore, by analysing the impact of the PI's TFL on team conflict, we provide an in-depth understanding of PIs (Cunningham et al., 2018). We hypothesised that the PI's TFL would have a significant impact on the relationship between RT conflict and RT performance, making the positive conflict area bigger. We came to this conclusion because the transformational leader enhances team cooperation and team interaction, which benefits the management of the RT conflict (Gelfand et al., 2012; Zhang et al., 2011).

In conclusion, the main findings of our study could be summarised in three different points. First, this study provides theoretical evidence for an inverted U-shaped relationship between team conflict and team performance, which has been later confirmed empirically. In doing so, we have answered the call to better understand the relationship between team conflict and team performance in the specific academic context (Degn et al., 2018). Our results reveal that the effects of team conflict on team performance are more complicated than a simple linear relationship (Suifan et al., 2020), as had sometimes been assumed. On the contrary, the impact of conflict on performance turns from positive to negative as the level of conflict increases. In our study, the data suggests that, up to a certain amount of conflict, the performance of the RTs is actually improved. This might be due to the positive impact that the task component of the conflict has on team performance (Sinha et al., 2017; de Wit et al., 2012). Task conflict "exists when there are disagreements among group members about the content of the tasks being performed, including differences in viewpoints, ideas, and opinions" (Jehn & Bendersky, 2003; p. 200), and the positive effect of this type of conflict can counterbalance and even exceed the negative effect of both relationship and process conflicts. Regarding these two last types of conflict, the former exists "when there are interpersonal incompatibilities among group members" (Jehn & Bendersky, 2003; p. 200) and the latter is "about the means to accomplish the specific tasks" (Jehn & Bendersky, 2003; p. 201). Even though the effect of relationship conflict can sometimes be diminished through effective management strategies (de Wit et al., 2012), its negative impact on team performance has been widely established (Costa et al., 2015; De Dreu & Weingart, 2003). As Suifan et al. (2020) stated, process and relationship conflicts undermine teamwork quality, interfere in intragroup communication and have a negative influence on team coordination. Hence, this may be a reason for a decline in the team's performance from the inflection point of the curve onwards.

Second, considering the positive effects of TFL, our study also explored the possibility of analysing the impact on the curvilinear relationship between RT conflict and RT performance if the PI applies the TFL leadership style. The results show that the application of TFL by the PI would have an effect on the curve so that the inflection point would be moved to the right and upwards, expanding the positive area of conflict. Thus, TFL PIs can afford a higher level of conflict in their RTs. This positive conflict area is amplified by encouraging the discussion of ideas and the exchange of points of view. However, if this level of conflict exceeds a certain point –for instance, if there is too much noise or if there are irresolvable disagreements between the RT members– it can become detrimental to RT performance. In this sense, Eisenhardt & Zbaracki (1992) suggested that the answer resides in stimulating productive conflict while reducing the emergence of dysfunctional conflict. Therefore, managers and leaders should be aware of inappropriate conflict management. Avoiding team conflicts is also counterproductive (Puck & Pregernig, 2014). Managers and leaders need to learn to deal with conflict and be able to keep the level of conflict within RTs at a point that is acceptable to their environment. In other words, the benefits of conflict should always be exploited.

Third, even though we adapted Jehn's (1995) scale, in which they differentiate three dimensions in team conflict (task, relationship and process conflicts), in our exploratory factor analysis, they came out to be just one single factor that contained all the items, being therefore validated as one unidimensional variable for team conflict in the confirmatory factor analysis. Through our proposed scale we might contribute to mitigate Nieto-Guerrero's et al. (2019) criticism and to consider the possibility that the scale proposed by Jehn (1995) might not be well suited to the academic context of RTs –where team members are highly qualified and specialized professionals (Perkmann et al., 2011; Eisenbeiß & Boerner, 2010)–, which is something that further studies should consider when measuring conflict in the academic context.

In light of the above, there are significant practical implications from our results. The main practical implication derived from our study is for RT leaders to know that being affected by a certain level of conflict within their RT could potentially result in better RT performance. However, they must also know that there is a point from which the conflict is harmful for RT performance. While the particular point of inflection is contingent on the circumstances and RT characteristics, the essential question here is to be aware that such an inflection point exists and, more importantly, to know which are the factors that affect it. In current research, it is becoming quite common for teamwork to be seen as a dynamic yet complex system (Mathieu et al., 2014), so we could expect a contingent behaviour of this relationship with several factors playing some kind of influence. Factors such as RT size, human capital mix, internal social capital, or contextual circumstances, among others, could be analysed. Additionally, our study indicates that the relationship between team conflict and team performance is neither linear nor just negative (Suifan et al., 2020). On the contrary, this relationship starts by having a positive effect, up to a certain point at which the effect becomes negative. Therefore, based on these results, we suggest that PIs could attempt to increase team performance by maintaining a level of conflict within the team close to the point of inflection. This approach could thus benefit from a situation of conflict, which is an inevitable effect of the day-to-day work of a group of researchers (Jehn, 1995).

Finally, even though our study broadens our understanding of the relationship between team conflict and team performance, there are some limitations worth mentioning. We were not able to isolate the effects of the three dimensions of conflict explained in the literature, so we were not able to compare our results with other studies in this regard (Jehn & Mannix, 2001; Jehn, 1995). For this reason, in future research, it could be advisable to use the intragroup conflict scale suggested by Nieto-Guerrero et al. (2019) in order to overcome the limitations of other measurements, granting a broader vision of the impact of team conflict on team performance. On a separate note, we only analysed TFL leadership style, but it might be equally interesting to investigate the effect of other leadership styles on the relationship between team conflict and team performance. Among them, the positive effect of shared leadership style in fostering team performance has been demonstrated (Gu et al., 2020; Bruccoleri et al., 2019), so this leadership style might be a good candidate to be studied. Another limitation of our study, as was the case in the study by Humphrey et al. (2017), is that the contextual factor undermines the possibility of transferring our results to other types of teams. The RTs under study have the particularity of being multidisciplinary teams. Therefore, the interaction of their members and the sharing of knowledge, skills and capabilities are fundamental to achieve their objectives.

The inconsistent results between different studies on the role of conflicts within teams and their achieved outcomes led us to think that they were indicative of the probable existence of some kind of variable moderating or mediating this relationship. In the literature, some studies can be found that have researched the mediating effect of certain variables, such as teamwork quality, team innovation (Suifan et al., 2019) or cooperation (Puck & Pregernig, 2014). In other papers, it was a moderating effect that was proposed, as is the case of team reflexivity (Suifan et al., 2019) or task complexity (Chen et al., 2019). Kearney & Gebert (2009) stated that TFL leaders were able to moderate the negative effect that diversity could have on information development and thus to reduce the potential for conflict within the RT. Ayoko & Konrad (2012) highlighted the moderating and even mitigating effect of TFL on the negative impact of team conflict on team performance. Therefore, as a future research avenue, it might be interesting to check whether the claims about TFL being a moderating or mediating factor that contributes to better results in the management of conflicts could be true. Should this be the case, they would be in contrast with previous findings by other authors, who proposed that only certain dimensions of TFL might be effective in alleviating the negative effect of conflict in RTs (Van Knippenberg & Sitkin, 2013; Ayoko & Konrad, 2012; Ayoko & Callan, 2010), or even that this type of leadership –in which the PI inspires and shares a vision, goal or even values– may not be so effective in a research environment, where the members of RTs are highly specialized (Zhao et al., 2019).

6. References

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CHAPTER FIVE

Conclusions

Conclusions

The social and economic contributions of R&D are essential in the development of countries, since they are the motor for their progress (Guimón et al., 2018; Wu et al., 2015; Azagra-Caro, 2007). Research can be implemented by companies, but it can also be implemented in universities and research centres. The results of the research carried out in universities, and especially in public universities, have significance in the global context (Guerrero et al., 2016). This is a result of the key role that universities play in the knowledge creation process and in the knowledge and technology transfer (Kenney & Patton, 2018; Wu et al., 2015). The university is a significant component of the Triple Helix model, together with the industry and the government, creating a network to support the improvement of the economic, social and technological progress of a country or a region (Etzkowitz & Leydesdorff, 2000). Later reformulations of this model were made in order to include other components, such as the media- and culture-based public –Quadruple Helix– (Carayannis & Campbell, 2009) or the natural-environment system –Quintuple Helix– (Carayannis et al., 2012).

The research process is more and more often conducted in teams and these are increasingly multidisciplinary (Jeong & Choi, 2015; Cummings & Kiesler, 2014; Bozeman et al., 2013). This is a double-edge sword because, even though diversity among research team (RT) members could increase the generation of innovative and creative ideas –thereby potentially improving the outcomes of the RT– this heterogeneity can also have a dark side for the welfare of the RT (Martín-Alcázar et al., 2012; Huang & Lin, 2010). Therefore, when both advantages and disadvantages can emerge in a diverse RT, what can diminish the weaknesses and enhance the strengths is an effective leadership (Ayoko & Callan, 2010). As a consequence of the complexity of the R&D context, managing researchers is not an easy campaign (Zhu & Chen, 2016; Stock et al., 2014; Sapienza, 2005).

Therefore, as the workforce is increasingly composed of multi-diverse knowledge workers, R&D contexts call for an effective leader (Elkins & Keller, 2003). Since there is little research focusing on R&D leaders in the literature (Gritzo et al., 2017; Keller, 2017), this Doctoral Thesis is intended to examine the scientists in the principal investigator (PI) role. From our literature review, it seems to be clear that PIs are an essential element in the R&D context (Zhou et al., 2018; Gumusluoglu et al., 2017). They are responsible for leading and managing RTs, whose study is still generating a lot of interest among researchers, since more and more organizations rely on RTs to achieve their objectives (Start & McCauley, 2020; Bell et al., 2018). In this Doctoral Thesis an in-depth study of the PI role has been undertaken. Several studies have been carried out where the PI plays a central role, being the epicentre of the work.

Notwithstanding the relative influence of the PI in the academic context (Cunningham et al., 2018; Menter, 2016), in obtaining public funding for research projects (Start & McCauley, 2020; Barreto & Patient, 2013), in developing the Third Mission (Mangematin et al., 2014; Kidwell, 2013), in bridging some of the helixes (Cunningham et al., 2016), there is still a need for a deeper understanding of this valuable role in R&D environments (Cunningham & O'Reilly, 2018; Boehm & Hogan, 2014). In the present research, we have tried to answer a call in the literature for a deeper understanding of different aspects of the PI role, which are specific to the research process. We considered that by answering these questions we would be able to provide new knowledge for different actors at different levels.

We therefore proposed a measurement scale, which is a reliable instrument for assessing the PI's HC. In the R&D context –which is becoming increasingly complex– it is essential to know what knowledge, skills and/or abilities will be needed by PIs depending on the challenges they will face (Bidwell & De Stefano, 2019), and for this purpose, this measurement scale can be quite valuable. In contrast to Ployhart's (2015) proposal, three factors were identified in relation to skills, and two factors in relation to abilities. This might be explained by the fact that, PIs need to be versatile based on their HC dimensions and, as in other areas of research, skills and abilities need to be studied in more depth, because they have been demonstrated to be distinctive and can be required in multiple approaches (Carl, 2020; Kotzab et al., 2018).

Even though having high levels of HC is considered to be the best option, the *more is better* statement is not always the correct answer (Civera et al., 2020; Ployhart et al., 2014), as it was demonstrated in our cluster analysis results. In the case of Balanced High-HC PIs, who showed the highest scores in almost all HC factors, this was not a sufficient condition to obtain the highest outcomes, neither on a personal nor on a team level. In contrast, Conservative PIs, who are comprised of PIs with only high scores in three of the five HC factors –scientific educational training, investigation abilities and self-analytical skills– obtained the highest outcomes, both at personal and team level. This is in line with other studies which rely on the technical expertise to make their selections (Huang & Lin, 2006). This cluster analysis was developed to complement the advantages of the measurement scale, because identifying different profiles of PIs based on their HC factors would provide valuable insights in the selection of those scientists most suitable for the PI position.

Based on the measurement scale that was developed and the three resultant profiles of the cluster analysis –Conservative PIs, Balanced High-HC PIs and Management-focused PIs–, several issues that emerged, and which led us to focus on the PI, could be answered. So that, for instance, it will be a helpful instrument for PIs themselves, or for those scientists who want to become a PI, to identify on which dimensions of the HC they should concentrate their training and education. Thus, they can avoid the unpleasant situation that comes up as a result of the lack of training detected in PIs, for which a usual solution is that they have to learn on the fly (Cunningham et al., 2015; Alexandrov & Bourne, 2013). It will also be beneficial for any training proposals offered to scientists in the PI role in order to be better prepared for the challenges they address, opening the way for them to become more tailor-made proposals rather than generalist suggestions. An obvious applicability is as a single or additional mechanism on which to base the selection of the scientist who is to become the PI. It will be helpful both for universities and research centres to identify those PIs which best adapt to them, to their research approach, or to their policies on the future lines of research they will undertake. This will be particularly helpful in determining whether the person needed is within the organisation or institution, or whether it will be preferable to recruit them from outside (DeOrtentiis et al., 2018). In summary, the measurement scale and the results of the cluster analysis are valuable keys for micro, meso and macro level in universities, research centres and funding agencies.

PIs embody a crucial role in the academic context so that, having developed a useful tool to measure their HC, we have later focused on undertaking a wider analysis in order to study the essential elements of their influence on the RT's research development. We have addressed two issues on which the literature has called for further research: their influence on management and team performance. In the first case we have analysed the influence of the PI's TFL in the relationship between RT conflict and RT performance was proposed. Because when RTs are formed by relying on the benefits of multidisciplinarity, they should not be limited to a mere collection of individual HCs, but rather, the RT should be formed with the necessary competences to achieve the objectives, being also conscious that these competences, due to experiences, might be transformed and improved (Eckardt et al., 2020). Despite the potential benefits of multidiversity, it could also be a potential source of conflict (Kotlyar & Karakowsky, 2006). Thus, we first demonstrated that the relationship between RT conflict and RT performance is curvilinear –an inverted U-shaped relationship. Then, considering that TFL is a leadership style that PIs could utilise to diminish the negative effects of team conflict among RT members (Cunningham et al., 2018), PIs may know how to influence them so that there could be the least possible detrimental impact, or even an advantageous one, to both the RT and its results. Our results confirmed this hypothesis. Therefore, PI's TFL would have an effect on the curvilinear relationship between RT conflict and RT performance, making the positive conflict area bigger due to the benefits of this leadership style on the management of the RT conflict (Gelfand et al., 2012; Zhang et al., 2011).

Furthermore, obtaining competitive public funds is crucial for RTs to have financial resources to sustain and carry out further research (Cunningham et al., 2015; Feeney & Welch, 2014; Hicks, 2012). The role of the R&D team PI is key in securing competitive public funding (Start & McCauley, 2020; Barreto & Patient, 2013). Based on the attention-view of the firm theory (Ocasio, 1997), it was proposed that, given that PIs would focus their attention on a range of activities, this would influence the process whereby they set their RT priorities. Findings supported the fact that the priorities set by the PIs in their R&D teams have a positive influence on obtaining competitive public funding. Actually, *Prioritized R&D Team Focused PIs* –those who have an intense focus on supporting and empowering the R&D team– will obtain a greater amount of national competitive public funds than the *Supporting and Empowering R&D Team Focused PIs* profile, which is comprised of PIs who are aware of supporting and empowering the R&D team, but it is not such a priority –they demonstrate a moderated intensity in priorities towards achieving competitive public funds. The *Prioritized R&D Team Focused PIs* seems to be more common profile between female PIs.

A long-standing debate has going on in the literature about the continued existence of a gender bias in competitive public funding. While several studies do not perceive such a difference and even provide some evidence to demonstrate it (Forscher et al., 2019; Boyle et al., 2015), many other studies assume that these differences have not been overcome yet, stating that female R&D team PIs obtain fewer public funds than male PIs (Bautista-Puig et al., 2019; Eloy et al., 2013). Strikingly, even though women representation has increased in recent years to an almost similar number of male scientists, there are evidences that deep gender differences still remain in senior positions (Richter et al., 2020; Mayer & Rathmann, 2018). Responding to a concern in the literature as to whether or not the gender of the PI is significant, in our dissertation, we have had the opportunity to analyse the inequality of gender among PIs in acquiring competitive public funds (Graddy-Reed et al., 2019). In fact, we have been able to study whether the PI's gender has influenced that process. In this sense, the results of analysing the moderating effect of the PI's gender were not significant. However, it is interesting to see that the profile comprising the highest percentage of women (30%) was the most successful in obtaining funding. It is also noteworthy that female PIs needed to submit fewer applications to obtain a similar success rate in securing public competitive funding, so we could say that they are more efficient than men. This is in line with the results of the cluster analysis to classify the PIs. Actually, the profile with the highest percentage of women was the Balanced High-HC PIs, which comprised PIs who considered to have higher scores on the majority of the HC factors. In this case, it also happens that women are more efficient than men, because even though they are a minority in the more productive scientific fields, the difference in the h-index mean is lower (van den Besselaar & Sandström, 2017).

We believe that some academic career constraints for female scientists could still persist (Belitski et al., 2019). In this sense, the so-called leaky pipeline could be another explanation for the female underrepresentation in senior positions, i.e., when facing the perspective of such a complicated career path, female researchers might decide to abandon their academic careers or to stay on a lower rank (Martinez et al., 2007). Therefore, more needs to be explored about this issue.

Regardless of gender, the R&D leader plays a key role in the OI strategy. The R&D leader role within an OI R&D environment literature review highlighted the real need for research to address the human side of OI and in particular, the role of OI leader. Furthermore, this literature review provides OI leaders with the requisite knowledge bases, appropriate tools, techniques, tactics and approaches that they can use in an OI leadership role which is complex given the networks and relationships that need to be managed and maintained. For educators, more knowledge of OI leaders allow them to design and provide the appropriate formal formation experiences to contribute to their OI role preparation. This requires embracing different methodological approaches and novel data collection strategies to provide the necessary robustness and rigour that forms the underpinning evidence that can adequately inform practice. For OI to flourish in practice and to be adopted more widely in requires that OI leaders to have a better understanding of their role and that they are equipped with the requisite knowledge to continually be effective concerning OI strategy development and implementation.

Limitations and Future Research Avenues

The initial approach to this Doctoral Thesis identified a wide range of issues that the literature had drawn attention for further investigations. Additionally, there are questions that have emerged after carrying out this study which must be included. Although this Doctoral Thesis is not without limitations, which influence not only the comprehensiveness but also the widespread nature of its findings. There is a clear contextual limitation because the whole study was undertaken in Spain. Only data from Spanish universities and research centres was used. Therefore, the contextual characteristics of the Spanish public research system constrain the possibility of generalising the results to other countries and other nationalities.

There is also a limitation in relation to self-reporting bias. Since in all the studies undertaken, except for the study expounded in chapter three, all the respondent data was collected individually and the PIs themselves were who self-assessed, there might be a bias problem. The use of the h-index as an outcome for both PIs and RTs needs to be considered as one of the limitations we have encountered in our Doctoral Thesis. It should be complemented by additional measures (Gaster & Gaster, 2012).

After carrying out this Doctoral Thesis, we have reached a number of conclusions, although new issues have also come up that could not be addressed in this work. A new issue that has emerged, or a future research line, could be studying the impact of another leadership style in the relationship between RT conflict and RT performance, and compare with the results of applying the TFL. Moreover, it would be interesting to analyse the direct effect that other leadership styles applied by the PI would have on RT performance. A really interesting future research line could be a longitudinal study of a PI in all the phases of a publicly funded research, from obtaining the funding to achieving the objectives once the requested funds have been obtained. Furthermore, a deeper understanding of the contextual differences between genders might be helpful to have a broader and in-depth analysis, because some of the initials proposed questions are still unanswered, such as: is the gender of the researchers decisive in the process of reaching the PI position? is it just a matter of gender or is it related to some contingent circumstances, such as family circumstances, policies on work-life balance, or surrounding circumstances?

In some cases, these future research lines emerged as an answer to the limitations of the study. For instance, regarding the contextual limitation, it would be an interesting future research line to apply our hypotheses in universities and research centers located in other countries and in different cultures (Zhou et al., 2018) to confirm and to compare results from different institutional contexts. Furthermore, related to the self-reporting bias limitation, it should be considered including at least one survey from the supervisors of the RT's PIs, to avoid that the only data available are the responses of the PIs themselves.

Moreover, regarding the OI literature, such a focus is essential to advance our understanding of OI (Pellizzoni et al., 2019). Overall our OI literature review highlighted the need for future studies to focus on the leaders who have the responsibility for OI processes, structures and strategy. There is a need to understand the leadership styles that OI leaders use when they are initiating and managing OI innovation activities. Such studies may begin by examining different types of leadership styles –transformational and transactional– (Bass ,1999; Lowe et al., 1996) on how they impact on OI. Also, an interesting strand of research to pursue is what types of leadership styles OI leaders use during firm turnarounds that build on an existing body of studies (O'Kane & Cunningham, 2012). Moreover, these studies should also focus on OI leadership diversity issues (Bogers et al., 2018). Such studies of OI leadership characteristics should pay particular attention to gender (Wikhamn & Knights, 2013), which is an under-researched theme within the OI field.

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