OPEN SEARCH STRATEGY, APPROPRIABILITY STRATEGY AND COGNITIVE PROXIMITY: EVIDENCE FROM THE UNITED KINGDOM SCIENCE AND TECHNOLOGY PARKS

EHSAN KHAVANDKAR

Doctor of Philosophy

ASTON UNIVERSITY

September, 2017

OPEN SEARCH STRATEGY, APPROPRIABILITY STRATEGY AND COGNITIVE PROXIMITY: EVIDENCE FROM THE UNITED KINGDOM SCIENCE AND TECHNOLOGY PARKS

EHSAN KHAVANDKAR

Doctor of Philosophy, 2017

Summary

Although the general picture in the open innovation literature is that open innovation practices have mainly positive consequences for the large enterprises, an emerging research strand recently has started to examine the potential consequences of inbound and outbound open innovation activities for smaller firms. Nonetheless, there is scant evidence in the literature about the extent and magnitude of the effects of open search practices on smaller firms. For smaller firms, their liability of smallness presents several challenges, such as: lack of internal resources and competences, lack of financial resources, lack of human resources and skilled workers, lack of research and development resources, as well as, limited multidisciplinary competence base, weak appropriation strategy, which all is resulting in unstructured approaches to innovation, suffering from the not invented here syndrome, and leaving them with only few technological assets to bargain with. This has led to the conclusion that smaller firms` ability to engage in open search activities is constrained.

In this thesis, several theoretical perspectives from the multiple domain literature were employed in three separate studies, and using data collected from 342 micro- to medium-sized enterprises located in science and technology parks in the United Kingdom, to explore the black box of interplay between open search strategy, appropriability strategy, intellectual capital, environmental dynamism and performance. Hence, the main objective of this thesis was to explore the potential dynamics of co-creation in ecosystem of science and technology parks, being generated by a range of co-specialisation and co-evolution opportunities among the tenant firms, and between them and other stakeholders, that are associated with the development of innovation architectures in onsite firms.

The first study, by introducing a construct of open search strategy, explored central questions related to the simultaneous connections between distinct types of open search strategies and the onsite firms` ability to exhibit superior levels of performance, and whether spatial and cognitive proximities in their network relations matter. The results suggested that onsite firms` open system performance was associated with offsite market-driven, science-driven, and technical and application-driven open search strategies. The results further revealed that onsite and offsite market-driven, science-driven, technical and application-driven driven and institutional open search strategies exerted positive influences on onsite firms` rational goal performance.

The second study was motivated by a desire to understand the roles of open search and appropriability strategies in co-evolution of dynamic capabilities – social, human and organisational capital – in onsite firms, as well as the role social capital

plays in strengthening the process of human capital and organisational capital accumulation. The study found that onsite firms` overall open search strategy positively influenced the accumulation of social, human and organisational capital. Further, it illustrated that onsite firms` appropriability strategy had a positive impact on their ability to extract positive incremental returns from social proximity. In addition, it was revealed that higher levels of social capital positively associated with higher levels of human and organisational capital. The results also indicated that there might be a mediating effect of social capital by which onsite firms could benefit from their open search and appropriability strategies, and develop and manage their human capital and organisational capital.

The goal of third study was to examine the costs and benefits of different appropriation mechanisms by investigating how perceived environmental dynamism affects the appropriation of rents from the coopetitive and cooperative market-driven open search activities. The results suggested that both formal and informal appropriation mechanisms positively influenced rational goal performance in onsite firms. In addition, both onsite and offsite market-driven strategies were found to be associated with onsite firms` strategic focus on informal and formal appropriation mechanisms, while only offsite market-driven strategy was found to be associated with the use of formal appropriation mechanisms. The study also illustrated that environmental context plays a key role in influencing whether firms` appropriability strategies leads to more inbound open innovation activities or not. The study also illustrated that the environmental context played a key role in influencing whether onsite firms` appropriability strategies lead to more open search activities or not. Furthermore, my results showed that environmental dynamism positively moderated the impact of informal appropriation mechanisms on both onsite and offsite market-driven open search strategies. In contrast, environmental dynamism negatively moderated the impact of formal appropriation mechanisms on onsite market-driven open search strategy.

Key words: Open Search Strategy, Appropriability Strategy, Cognitive Proximity, Spatial Proximity, Dynamic Capabilities, Environmental Dynamism, Co-creation, Co-evolution, Co-specialisation, SME, Micro Enterprise, Innovation Ecosystem, Science and Technology Parks, United Kingdom

“ A text is not a text unless it hides from the first comer, from the first glance, the law of its composition and the rules of its game. A text remains, moreover, forever imperceptible. Its laws and rules are not, however, harboured in the inaccessibility of a secret; it is simply that they can never be booked, in the present, into anything that could rigorously be called a perception.”

— Jacques Derrida, Dissemination

“ To my Dad ”

Acknowledgements

I would like to express my utmost gratitude to my thesis supervisors, Professor Tomasz Mickiewicz and Professor Nicholas Theodorakopoulos, for all the knowledge they have imparted to me, for sharing their intellectual rigour, and for their unwavering patience and encouragement that provided me the space to flourish my creativity through the many stages of this research, and helped make my thesis more than I hoped it would be. I was indeed fortunate to have the invaluable opportunity to work closely with them and learn from them. I am forever grateful to them.

I would also like to thank Dr. Carlo Corradini for his valuable insights and suggestions during the final phase of my study. I would like to extend a very special thank you to my internal and external examiners, Dr. Hiro Izushi and Professor Nada Korac Kakabadse, for their detailed and constructive comments, that helped me to improve my thesis.

I owe special thanks to my father, Dr. Jalil Khavandkar, whose scholarly insights enriched every chapter of my thesis. Without his guiding hand and unflagging desire to convey knowledge, this work would never have come to fruition. From “Learning Alley” to “Bromsgrove Street”, I have been continuously learning from his acute intellectuality.

I would like to take this opportunity to thank Aston Business School and the Economies, Finance and Entrepreneurship Department for the generous PhD scholarship which allowed me to immerse myself in the doctoral journey and undertake this research.

I would also like to thank Mrs. Lynne Woolley, EFE departmental co-ordinator, who was always incredibly friendly and helpful. I am very thankful to her unflagging good will and enduring friendship that made my Aston experience enjoyable and stimulating.

I also want to thank the many researchers who have provided feedback, all of which proved to be inestimable value. In particular, I thank participants at RENT XXVIII, RENT XXIX, EIICI 2014 and 2015, and Midlands colloquium 2014 and 2016 for their valuable comments.

Contents

List of Tables

List of Figures

Chapter One: Introduction

1.1. Introduction

With growing complexity of technology, shortened product life cycle and unprecedented speed of technological breakthroughs, firms have faced the emergence of a hypercompetitive marketplace which has increased pressure for the reciprocal interactions with external actors to leverage co-creation opportunities and prevent existing innovations from becoming further obsolete (West & Bogers, 2014). The idea of viewing external actors and knowledge as potential resources for innovation was foreshadowed by Barney[1] (1986), Grant[2] (1996), and Teece, Pisano & Shuen[3] (1997). Since Chesbrough's seminal book on open innovation was published in 2003, however, the dominant view in the literature on innovation models has shifted. In recent years, the idea of open innovation has been perceived as a model for innovation and technology development efforts in many companies. Open innovation in Chesbrough's sense, is a model in which firms "commercialise external (as well as internal) ideas by deploying outside (as well as in-house) pathways to the market. Specifically, companies can commercialise internal ideas through channels outside of their current businesses in order to generate value for the organisation" (Chesbrough, 2003a:36-37). Over the past 15 years, the idea of benefiting from the reciprocal innovation processes has been the centre of attention in the innovation literature.

[1] The Resource-based View (RBV) theory.
[2] The Knowledge-based View (KBV) theory.
[3] The Dynamic Capability theory.

The reciprocal interactions with cocreation partners reflects the recognition that monolithic endeavours, while uncertainty is ubiquitous, are fraught with risks. Hence, firms need to proactively explore the possibilities for the "reciprocal exchange of knowledge in cocreation and other collaborative innovation processes that take place outside the firm" (West & Bogers, 2014: 824). However, the key to moving from a closed approach to innovation to open models is knowing the specific internal needs and matching them with potentially instrumental external solutions (Katila & Ahuja, 2002). A firm`s ability to making informed decisions about the nature and influencing shapers of socio-relational context in which it would likely interact with its heterogeneous partners, explains the success or failure of the open search strategy (Dahlander, O'Mahony, & Gann, 2016). Thus, to succeed in their open search missions, firms need to enable their screening mechanisms to explore the potential sources of complementary knowledge across their organisational boundaries. Once detected, firms should possess the capacity to absorb external knowledge (Cohen & Levinthal, 1990; Zahra & George, 2002), the required ability to experiment with the newly acquired knowledge (Gavetti & Levinthal, 2000; Chang et al., 2012), and capture the rents (Mansfield, Schwartz & Wagner, 1981; Liebeskind, 1996).

The concept of open innovation was built upon the observation of practices in the large firms (West et al., 2014). Consequently, the open innovation research has traditionally focused on the large enterprises. It is evident from the literature that the ability of smaller firms, compared to their larger rivals, is considerably constrained by their liability of smallness (Freeman, Carroll & Hannan, 1983). It has been frequently mentioned that their approach to innovation is unstructured (Chesbrough & Crowther 2006) due to the lack of financial resources (Grando & Belvedere, 2006), research and development resources (Madrid-Guijarro, Garcia & Van Auken, 2009), human resources and skilled workers (Bianchi et al. 2010) and internal resources and competences (Kogut, 2000). On the other hand, suffering from the syndrome of not invented here (Chesbrough & Crowther, 2006) coupled with their excessive reliance on strategic appropriation mechanisms, rather than formal protection mechanisms (Spithoven, Vanhaverbeke & Roijakkers, 2013), leave them with only limited technological assets to attract their potential external partners (Dahlander & Gann, 2010). Thence, the theory of open innovation and its applicability in explaining the reciprocal Innovation activities of smaller firms have received relatively scant attention in the earlier validation studies.

It was only recently that some researchers started paying attention to the open search activities of small and medium sized enterprises (SMEs). These researchers have noted that their findings highlight the importance of open innovation practices for the success of knowledge and technology sourcing and acquisition efforts in SMEs (Lee et al., 2010; Parida, Westerberg & Frishammar, 2012; Spithoven, Vanhaverbeke & Roijakkers, 2013; Xia, 2013; Love & Roper, 2014; Vahter et al., 2014; Verbano, Crema & Venturini, 2015; Brunswicker & Vanhaverbeke, 2015; Xia & Roper, 2016). Micro enterprises, however, have received no attention in the literature. For many researchers, it has become something of a stylised fact that micro firms are substantially different from their larger rivals, suggesting that they are less likely to invest on their open search activities (van de Vrande et al. 2009). This has led to the conclusion that micro firms` ability to engage in open search activities is limited. Nevertheless, smaller firms in general, and micro firms in particular, are known to be highly adaptable to changing conditions and agile (Bessant, 1999), socially active in their innovation efforts (Baum, Calabrese & Silverman 2000) with high learning potential (Real, Roldán & Leal, 2014). These qualities potentially enable them to benefit from engaging in open search activities.

On the other hand, smaller firms -specifically micro firms- have been the centre of attention in the government policy frameworks, industrial and entrepreneurship plans in recent years (Brown & Mason, 2014). In many countries, the establishment of science and technology parks has been regarded as a component of the larger initiatives, fuelled by government, to encourage collaborations between firms and stimulate innovation (Díez-Vial & Montoro-Sánchez, 2016). These initiatives "guarantee geographical proximity and encourage other types of proximity that fosters cooperation between firms [the majority of which are micro and small firms] and research and technology organisations" (Vásquez-Urriago, Barge-Gil & Modrego Rico, 2016: 138). Geographical proximity is known to be the key driver of cognitive proximity between co-located firms (Boschma, 2005). The higher degree of cognitive proximity increases both social and organisational proximities between the co-located firms, thus, decreases knowledge distance (Storper, 1999; Ben Letaifa & Rabeau, 2013). These positive effects would stimulate collaborations between the co-located firms, leading to formation of an atmosphere supportive of openness.

In case of science and technology parks, the story is same. Geographic proximity of the firms located in science and technology parks potentially increases the levels of cognitive, social and organisational proximities between them. The greater level of exposure to each other's knowledge creates more opportunities for co-specialisation and exploratory learning among onsite firms (Khavandkar & Khavandkar, 2015). The atmosphere of co-specialisation and co-evolution can stimulate co-innovation and interactions between the tenant firms. Hence, it would be easier for the co-located micro and small firms in science and technology parks to screen and source complementary knowledge. It is evident from the literature that the collaborative knowledge-based activities can increase the propensity of innovation in smaller firms (Sternberg, 1999; Keeble & Wilkinson, 1999; Davenport, 2005). The ecosystem of parks would naturally help them to utilise their social potentials to fuel their innovative activities, update and complement their knowledge, and compensate for their limited in-house research and development capacity by leveraging co-creation opportunities with their onsite and offsite partners. To date, however, there is little evidence in the literature on whether spatial, cognitive, social and organisational proximities in smaller firms` open search activities matter. It seems that the observed gaps in the literature may be attributed in part to a lack of broad scale data on the open search activities of smaller firms in general, and micro enterprises in particular. This study, thus, seeks to remedy the observed empirical gaps in the literature using data on the open search activities in which micro firms are involved.

There is a general agreement in the literature that firms exposed to multiple sources of external knowledge are more likely to succeed in their open search efforts (Faems et al., 2010; Chiang & Hung, 2010; Santamaria & Surroca, 2011; Chang et al., 2012; Parida, Westerberg & Frishammar, 2012; Bascavusoglu-Moreau & Hughes, 2014; Cheng & Shiu, 2015; Martini, Neirotti & Appio, 2017; Miozzo, 2016; Hochleitner, Arbussà & Coenders, 2017). Nevertheless, there has been a long-standing debate over the effects of open search activities on the smaller firms' performance. The key question is whether open search activities would bring about higher performance levels for smaller firms, and if so, how potential short-term and long-term benefits of open search activities should be differentiated from each other, as they could imply different meanings. The answer may lay in the behavioural patterns of open search activities carried out by smaller firms (Brunswicker & Vanhaverbeke, 2015). This makes it a necessity to focus on the benefits of strategic diversification of open search activities in smaller firms. However, the literature of open innovation suffers from some important gaps. As will be seen in Chapter Two, this study aims to provide an answer to the central questions related to the simultaneous connections between different types of open search strategy and the ability of smaller firms to exhibit superior levels of performance, and whether cognitive and spatial proximities in their network relations matter. On that account, this study explores the association between various open search activities and performance in the context of science and technology parks, and whether diversity in open search activities matter.

On the other hand, recent empirical studies reveal that performance growth resulting from the exploitation of potential exploratory learning opportunities may not follow a linear pattern (Laursen & Salter, 2006; Berchicci, 2013; Greco, Grimaldi & Cricelli, 2016). This raises important questions about the role of open search activities in helping firms to capture the rents from their exploratory missions, and how short-term and long-term benefits of open search activities should be simultaneously accounted for. The literature on innovation diffusion explains that higher levels of exposure to the external knowledge, frequent contacts with external partners and systematic application of external knowledge in a firm could result in diffusion and accumulation of fine-grained knowhow (Kogut, 2000; Katila & Ahuja, 2002; Brass et al., 2004; Birkinshaw, Hamel & Mol, 2008; Faems et al., 2008; Ansari, Fiss & Zajac, 2010; Tortoriello & Krackhardt, 2010; Funk, 2014; Greco, Grimaldi & Cricelli, 2016; Monteiro, Mol & Birkinshaw, 2017). These outcomes normally show themselves in the long run. The fine-grained knowhows are meant to shape a firm`s competitive advantage in the long run, and once become institutionalised predict its ability to appropriate the rents from innovation (Chesbrough, 2003).

As the potential long-term outcomes associate with a firm`s dynamic capabilities, thus they are naturally intangible and hard to measure. The stocks of fine-grained knowhow, or intellectual capital (Harison & Koski, 2010), enhance the ability of firms to screen potential opportunities for leveraging external complementary knowledge and generating new combinations (Khavandkar, Theodorakopoulos & Khavandkar, 2016), heighten the level of their attractiveness to potential external partners; as their openness, integration and experimentation capabilities become strengthened (Chang et al., 2012). In contrast, potential short-term benefits of open search activities can be directly measured, as they can be tied to the tangible financial results. This logic may provide an explanation for why a similar level of exposure to external knowledge may yield unequal returns for different firms. Nevertheless, this is a grey area in the literature. As will be seen in Chapter Three, this study aims to empirically test such associations and suggest an explanation for the observed disparities between tangible and intangible outcomes of open search activities in smaller firms. In addition, this study addresses an important question about the relationship between openness and appropriation in smaller firms, by investigating how smaller firms` allocation of attention to the different types of appropriation mechanisms affects their open search activities, and why it is central to understanding how smaller firms capture the rents from their co-innovations.

The mechanism of open search activities naturally increases the chances of imitation and opportunism. Openness decreases knowledge distance between the partners. The higher the level of cognitive proximity in open search activities, the harder becomes the process of protecting intellectual property rights (Cassiman & Veugelers, 2002), leading to increases in unintended knowledge spillovers (Frishammar, Ericsson & Patel, 2015). This reflects the notion that engaging in open search activities could heighten the costs of risking firms` appropriation power (Chen, Chen & Vanhaverbeke, 2011; Henkel, Schöberl & Alexy, 2014). Hence, the costs associated with risking appropriability may negatively influence the firms` open search activities. This may help to identify another underlying cause of unequal returns from the open search activities in firms.

The ability of a firm to capture the rents from innovations, and protect them from potential unintended knowledge spillovers, is among the key determinants of its openness (Arora & Ceccagnoli, 2006). However, smaller firms are vulnerable to unintended knowledge spillovers, as well as, rent-seeking pressures from their external partners (Veer, Lorenz & Blind, 2016). The use of appropriation mechanisms would help them to overcome the disadvantages related to their liability of smallness (Brunswicker & Vanhaverbeke, 2015; Freel & Robson, 2016). It would also signal their possession of valuable assets (Laursen & Salter, 2014). A strong appropriability strategy would potentially reduce the chances of imitation and knowledge leakages (Pisano & Teece, 2007; Hagedoorn & Zobel, 2015), however, it can also hamper the ability of firms to collaborate with external partners (von Hippel & Von Krogh, 2006; Baldwin & von Hippel, 2011). On one hand, the use of formal appropriation mechanisms clarifies the ownership of knowledge assets and signals quality of the owner (Arundel, 2001; Laursen & Salter, 2014), on the other hand, it may presage a larger threat for collaboration, acting as an alarming sign of overemphasised exclusivity (Arora, Athreye & Huang, 2016). This paradox presents a challenge for shaping open search strategy in firms (Arrow, 1962; Laursen & Salter, 2014).

In turbulent markets, which are characterised by uncertainty and unpredictability (Duncan, 1972; Dess & Beard, 1984), firms may decide to invest more on exploratory learning missions (Daft & Weick, 1984; Dutton, Fahey & Narayanan, 1983). Environmental dynamism increases the causal ambiguity which naturally would protect knowledge from being imitated by a firm`s rivals. However, it may also make it harder for the firms to transfer and acquire knowledge (Dess & Beard, 1984; Jaworski & Kohli, 1993). Hence, if a firm decides to engage in the provision of collaborative innovation activities, it would need to adopt a strategy based on the practice of selective disclosure (Henkel, 2006; Alexy & George, 2013; Henkel, Schöberl& Alexy, 2014). This would again increase their vulnerability to the opportunistic behaviours. Notably, when partners both have a proximate position, the risks of unintended knowledge spillovers are known to be higher (Miotti & Sachwald, 2003; Chen, Chen & Vanhaverbeke, 2011). Such risks can widen the scope of the paradox of openness, and intensify lock-out effects (Schilling, 1998) for the firms located in science and technology parks. Given this, it becomes a relevant question whether the association between appropriation mechanisms and open search actives is of a uniform nature, or whether it differs across the relationships that vary in terms of spatial proximity of, and cognitive proximity between the partners. Despite the growing awareness of the potential costs and benefits of openness in the literature, empirical evidence is lacking on how location of partners affects the appropriability-openness relationship. Building upon this notion, current study explores how a firm`s appropriation strategy shapes its market-driven open search activities with potential onsite and offsite partners. As will be seen in Chapter Four, this study aims to examine the costs and benefits of different appropriation mechanisms by investigating how environmental dynamism affects the co-located firms` formal and informal appropriation choices, as well as, their open search activities, when taking into account the location of partners.

Chapter Two: Open Search Strategy, Cognitive Proximity and Performance

2.1. Introduction

The centre of focus in innovation strategy faces a shift from the closed models to the open innovation models (Monteiro, Mol & Birkinshaw, 2017). Seen as an alternative to the closed approach to innovation (Roper, Vahter & Love, 2013), the open innovation paradigm is defined as a "distributed innovation process based on purposively managed knowledge flows across organisational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organisation's business model" (Chesbrough & Bogers, 2014: 12). Since the seminal work by Chesbrough (2003), theoretical and empirical contributions have converged in the conviction that firm's openness is crucial to its innovation performance. The focus on open innovation models reflects the recognition that for firms to mitigate risks of erosion and uncertainty associated with full control of internal research and development path (Casadesus-Masanell & Almirall, 2010), they need to proactively create inclusive environments for external knowledge that make it possible to leverage potential benefits of external interactions.

An emerging research strand recently has started focusing on open innovation activities in smaller firms (Lee et al., 2010; Parida, Westerberg & Frishammar, 2012; Spithoven, Vanhaverbeke & Roijakkers, 2013; Xia, 2013; Love & Roper, 2014; Vahter et al., 2014; Verbano, Crema & Venturini, 2015; Brunswicker & Vanhaverbeke, 2015; Xia & Roper, 2016). These studies highlight the importance of open innovation for smaller firms, and how the streams of external knowledge can affect their capabilities and strategies (Colombo, Piva & Rossi-Lamastra, 2014). Nevertheless, all of these studies have analysed only a sub-set of them, neglecting micro enterprises. For many researchers, it has become something of a stylised fact that the micro firms are substantially different from their larger rivals, suggesting that they are less likely to invest in open search activities (van de Vrande et al. 2009). Hence, they have received scant attention in the open innovation literature.

The possible explanations for the observed gap in the open innovation field are rooted in recognition of the limitations, which are primarily shaped because of the theoretical and methodological biases. The concept of open innovation was built upon the observation of innovation practices in large enterprises. Hence, quite in contrast to its popular conception, the foundation of open innovation remains practical rather than theoretical/epistemic in the main. This indicates a lapse between the open innovation literature in general, and its application in micro enterprises at the theoretical level. On the other hand, the multidimensionality of open innovation concept postulates a cognitive platform which is known to be key to achieve the optimal output from innovation (Brunswicker & Vanhaverbeke, 2015). From the practical point of view, this has created a pervasive research stream aimed at building connections between the concept of open innovation and more general management and innovation theories, by studying the nature of organisations, industry effects, sector effects, absorptive capacity (Roper & Hewitt-Dundas, 2013) or appropriability strategy (Laursen & Salter, 2014; Arora et al., 2016), for which data is lacking in micro enterprises. Thus, the observed gap in the literature may also be attributed in part to lack of broad scale data on the open search activities of micro enterprises, as well as the limitations of benchmarks in open innovation research. Majority of quantitative studies have relied on secondary-data sources, which only cover the firms with more than 10 employees. In open innovation research, data are commonly -but not always- originated from the large-scale surveys, such as the Community Innovation Survey. While one of the major advantages of using secondary data is related to the breadth of data available for analysis, the choice of size is often limited by the non-availability of data. It seems that the dominant rationale for the `not all sizes fit` approach in the open innovation studies is the corollary of an empirical oversight, not a theoretical shortcoming. Hence, it is important to highlight the need for survey modules and data, which are inclusive of micro enterprises.

On the other hand, studies such as Kogut (2000), Brass et al. (2004), Birkinshaw, Hamel & Mol (2008), Faems et al. (2008), Ansari, Fiss & Zajac (2010), Tortoriello & Krackhardt (2010), and Funk (2014) have highlighted the role of network dynamics in diffusion of innovation and knowledge. Looking through the lenses of innovation diffusion theory to the varying types of relationships that coexist simultaneously within the ecosystem of science and technology parks, it could be argued that the ecosystem of parks naturally promotes a culture of openness among its tenants, and between them and other stakeholder, in which the tenant firms – the majority of which are micro and small firms- are exposed to a wide range of potential co-specialisation and exploratory learning opportunities (Khavandkar & Khavandkar, 2015). The high level of exposure to the external knowledge, which is coupled with the geographic proximity of potential partners, increases the levels of cognitive, social and organisational proximities between the tenant firms (Boschma, 2005; Ben Letaifa & Rabeau, 2013). These effects can potentially stimulate the open search activities and interactions between the tenant firms. Smaller firms traditionally have been known to benefit from the collaborative knowledge-based activities (Sternberg, 1999; Keeble & Wilkinson, 1999; Davenport, 2005). As it is easier for smaller firms to screen and source complementary knowledge in science and technology parks, they are more likely to engage in exploratory learning and search activities. Considering the fact that firms exposed to multiple sources of external knowledge are more likely to succeed in their open search efforts, it is important to investigate the potential role of cognitive proximity in the context of open search strategy. Hence, the main objective of this study is to investigate how spatial and cognitive proximities influence the propensity of co-located firms in science and technology parks, to engage in open search activities. It is evident from the literature that external knowledge sourcing activities are costly processes, requiring extensive internal resource commitments (Monteiro, Mol & Birkinshaw, 2017). Hence, it is important to explore the underlying drivers of open search activities in smaller firms, specifically in micro firms, knowing that these firms are more likely to face internal difficulties in supporting their search activities.

An expanded access to multiple channels of external knowledge and ties is known to improve the innovation capacity of firms (Baum, Calabrese & Silverman, 2000), and their integration and experimentation capabilities (Chang et al., 2012). Thus, this study focuses on the benefits of strategic diversification of open search activities among co-located firms. Recent empirical studies reveal that performance growth resulting from the exploitation of potential exploratory learning opportunities may not follow a linear pattern (Laursen & Salter, 2006; Berchicci, 2013; Greco, Grimaldi & Cricelli, 2016). Moreover, there is a general agreement in the literature that the potential short-term and long-term benefits of open search activities should be differentiated from each other, as they could imply different meanings. On that account, this study explores the association between the various types of open search activities and performance in the context of science and technology parks, and whether diversity in open search activities matter. It aims to solve the long-standing problem of open innovation in small and micro firms, that is whether open search activities could bring about higher performance levels for smaller firms, and if so, how potential short-term and long-term benefits of open search activities should be simultaneously accounted for.

This study is expected to extend research on open search strategy in three key ways. First, it provides empirical evidence of the multidimensionality of open search strategy in smaller firms. Second, it answers to the central questions related to the simultaneous connections between different types of open search activities and the ability of smaller firms to exhibit superior levels of performance, and whether cognitive and spatial proximities in their network relations matter. Third, it responds to calls for empirical research on the role of network dynamics and synergies within the ecosystem of science and technology parks, which constitutes mechanisms for co-specialisation and co-evolution of onsite firms.

2.2. Theoretical Background

A firm`s open innovation strategy is based on the notion that firms can benefit from purposefully engaging in joint exploratory learning, co-specialisation and co-creation activities with potential partners (Chesbrough, 2006), "and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology" (Chesbrough, 2003b:24). `Interaction with`, and `learning from` potential external partners are two key components of the open innovation definition. Firms are not able to innovate individually in today's changing environment, thus, need to open up their boundaries to embrace external knowledge, and explore opportunities to co-innovate with their external partners (Teece, 1986). To succeed, this requires paying equal attention to `gaining variety` (Katila & Ahuja, 2002) through `searching for complementary` knowledge (Chesbrough, 2006; Dahlander & Gann 2010).

A firm`s open search activities are centred around the processes of searching and leveraging knowledge across organisational boundaries. Open search activities significantly increase the level of exposure to external knowledge (Brioschi, Brioschi & Cainelli, 2002; Nieto & Santamaría, 2007), which raises the probability of finding missing knowledge (Leiponen & Helfat, 2010). A firm`s ability to simultaneously pursue both exploration and exploitation of external knowledge through search and combination tasks (Katila & Ahuja, 2002) defines the scope of its openness (Chesbrough, 2003a; Chesbrough & Bogers, 2014). Openness represents a continuum, where "some firms actively engaged in searching for innovation beyond the internal and local sources and striving towards positive impacts of distance resource complementarity, whereas others have no aspirations to go beyond the existing organisational boundaries to sources external knowledge" (Chang et al. 2012: 444).

Firms need to systematically and purposefully screen a broad range of external sources to succeed in their open search endeavours (von Hippel, 1988; Sidhu, Volberda, & Commandeur, 2004). There is a general agreement in the literature that a systematic and purposeful search strategy would yield positive outcomes for firms (Brioschi, Brioschi & Cainelli, 2002; Katila & Ahuja, 2002; Laursen & Salter, 2006; Nieto & Santamaría, 2007; Tsai & Wang, 2009; Li & Tang, 2010; Dahlander & Gann, 2010; Leiponen & Helfat, 2010; Hwang & Lee, 2010; Chiang & Hung, 2010; Faems et al., 2010; Inauen & Schenker-Wicki, 2011; Spithoven, Vanhaverbeke & Roijakkers, 2013; Mina, Bascavusoglu-Moreau & Hughes, 2014; Roper & Hewitt-Dundas, 2015; Cheng & Shiu, 2015; Greco, Grimaldi & Cricelli, 2016; Ferreras-Méndez, Fernández-Mesa & Alegre, 2016; Caputo et al., 2016; Martini, Neirotti & Appio, 2017; Monteiro, Mol & Birkinshaw, 2017). From the practical point of view, organisational performance explains the success or failure of a firm in achieving its goals. The potential outcomes of open search activities can be attributed to two distinct dimensions of the organisational effectiveness, namely rational goal system and open system dimensions. On one hand, the open system dimension portrays system-elaborating and system-maintaining functions of the organisational effectiveness, on the other hand, the rational goal dimension represents productivity and efficiency (Quinn & Rohrbaugh, 1983). Organisational goals are heterogeneous by nature, and firms need to pay equal attention to all goals and attempt to achieve a reasonable level of them (Quinn & Rohrbaugh, 1983). On one hand, organisations engage in exploratory learning activities in order to increase their flexibility and adoptability (Pfeffer & Salancik, 1978), or, as it is better known, to enhance their open system performance. On the other hand, the rational goal dimension reflects the success of a firm in maximising outputs relative to its competitors, market and other established benchmarks. It is evident from the literature that open search activities would increase the levels of adaptability and productivity in large firms (Hernández-Espallardo, Sánchez-Pérez, & Segovia-López, 2011).

Open search activities would broaden the horizon of a firm`s understanding beyond the confines of its internal knowledge base and abilities (von Hippel, 1988; Sidhu, Volberda, & Commandeur, 2004), by enhancing its integration and experimentation capabilities (Chang et al., 2012) to encompass the external fine-grained know-how (Veer, Lorenz & Blind, 2016) and improving its innovation performance (Whitley, 2002; Chen, Chen, & Vanhaverbeke, 2011; Chen, Chen, & Vanhaverbeke, 2011). In this process, both `type of external source/linkage` and `its scope` play significant roles in predicting the success or failure of a firm`s open search efforts. Studying the nature of interactions in different contexts reveals that exploratory learning in different knowledge domains may bring about different results for firms, as characteristics vary greatly depending on the nature of source/linkage and the depth of engagement (Nieto & Santamaría, 2007). The varying characteristics of potential partners would require different norms to regulate the scope of open search activities (von Hippel 1988; Sidhu, Volberda, & Commandeur, 2004; Dahlander, O'Mahony & Gann, 2016).

Looking through the lens of the resource-based view theory, any mismatch between a firm`s internal capacity and search objectives and what is demanded externally would predict the failure of its open search activities (Chang et al., 2012). This highlights the roles of `type` and `frequency` of interactions in the various steps of the open search process (Belderbos et al., 2004). For instance, the chances of introducing new to the market innovations are known to increase when firms are engaged in frequent science-driven interactions (Chen, Chen, & Vanhaverbeke, 2011). On the other hand, incremental innovations are known to be associated with the occurrence of frequent supply chain interactions (Tödtling, Lehner & Kaufmann, 2009). Similarly, there is a general agreement in the literature that frequent interactions with customers, suppliers (Tether, 2002), and competitors (Evangelista, 2006) are associated with higher levels of cognitive performance in firms. Nevertheless, the literature of open innovation suffers from some important gaps, as there is lack of general focus on comparing distinct types of open search strategy, and exploration of which type works best, and for whom.

Firms can gain learning benefits through both interactive (Hewitt-Dundas, 2006) and non-interactive (Glückler, 2013) modes of learning. The interactive and non-interactive exploratory learning are compensation strategies used by firms to compensate for limitations in their internal resources and technological competences (Iansiti, 1997), and to diversify their knowledge and skills (Xia, 2013). Hence, the key to success in open search efforts, is to find the type of external knowledge that can complement the searching firm`s internal knowledge base (Nieto & Santamaría, 2007). This highlights the importance of absorptive capacity, as "developing and maintaining absorptive capacity is critical to a firm's long-term survival and success because absorptive capacity can reinforce, complement, or refocus the firm's knowledge base" (Lane, Koka & Pathak, 2006:833). A firm`s absorptive capacity defines its ability to acquire and assimilate external knowledge (Zahra & George, 2002). It is evident from the literature that smaller firms face more difficulties in building absorptive capacity (Roper & Hewitt-Dundas, 2013), than their larger rivals. It has led to the conclusion that there are marked differences in the type of open search activities found in smaller firms. In addition, there is very limited evidence about the impact of open search activities in smaller firms, specifically micro firms. Hence, the challenges which smaller firms face in their open search activities require a close attention, before the qualities by which openness benefits are produced can be perceived.

For smaller firms, their liability of smallness (Freeman, Carroll & Hannan, 1983) presents several challenges, such as: lack of internal resources and competences (Kogut, 2000), lack of financial resources (Grando & Belvedere, 2006), lack of human resources and skilled workers (Bianchi et al. 2010), lack of research and development resources (Madrid-Guijarro, Garcia & Van Auken, 2009), which are coupled with limited multidisciplinary competence base (Bianchi et al. 2010) and weak appropriation strategy (Spithoven, Vanhaverbeke & Roijakkers, 2013), and result in unstructured approaches to innovation (Chesbrough & Crowther 2006), and suffering from the not invented here syndrome (Chesbrough & Crowther, 2006). These leave them with limited technological assets to bargain with, and attract potential external partners (Dahlander & Gann, 2010). The `liability of smallness` has led to the conclusion that the smaller firms` ability to engage in open search activities is constrained (Hewitt- Dundas, 2006).

Nevertheless, smaller firms are known to be more flexible (Bessant, 1999), willing to take risks (Christensen, Olesen & Kjær 2005), fast learners (Real, Roldán & Leal, 2014), better decision makers (Lee et al., 2010) compared to their larger rivals. These qualities should potentially enable them to benefit from open search activities. Hence, the answer may lay in the behavioural patterns of open search activities carried out by smaller firms (Brunswicker & Vanhaverbeke, 2015). Analysing the patterns of their open search activities would be the key to understanding the nature of their openness behaviours.

Smaller firms are known to be socially active in their innovation efforts (Baum, Calabrese & Silverman 2000), that can explain the potential advantage of open search activities for smaller firms. By leveraging co-specialisation opportunities with their external partners, smaller firms can utilise their social potentials to fuel their innovative activities, find complementary knowledge and gain legitimacy (Lee et al., 2010), and compensate for their limited in-house research and development capacity (van de Vrande et al., 2009). For the firms located in science and technology parks, the ecosystem of parks provides a wide range of co-specialisation and co-evolution opportunities (Khavandkar et al., 2016). Science and technology parks are known to facilitate interactions between onsite firms, and between them and other internal and external stakeholders. In addition, spatial proximity between tenant firms can enhance cognitive, social and organisational proximities between them (Ben Letaifa & Rabeau, 2013). Hence, it is expected that the ecosystem of science and technology parks fosters exploratory learning for, and interactions between onsite firms, especially smaller firms. While research has been done on open innovation activities of SMEs (Xia & Roper, 2016; Brunswicker & Vanhaverbeke, 2015; Spithoven, Vanhaverbeke & Roijakkers, 2013; Parida, Westerberg & Frishammar, 2012), there is no evidence about how co-located firms, in particular micro firms, operationalise their open search strategies. Lack of data has been a key problem hampering research on micro enterprises.

2.3. Hypotheses

2.3.1. Market-driven open search strategy and firm performance

A firm`s market-driven open search strategy is based on the notion that firms can benefit from engaging in joint exploratory learning and co-specialisation activities with their supply chain partners and competitors (Isaksson, Simeth & Seifert, 2016). The open search activities are centred around the process of leveraging knowledge within and across supply chain boundaries, from clients, customers, suppliers, producers, services providers, and beyond those boundaries, from direct and indirect competitors (Kaufmann & Todtling, 2001; Faems, Van Looy & Debackere, 2005; Zeng Xie & Tam, 2010; Brunswicker & Vanhaverbeke, 2015). In market-based open search activities, as firms are exposed to a pool of heterogeneous knowledge, the process of exploration and experimentation is also governed by heterogeneous learning rules. Nevertheless, there is a general agreement in the literature that a firm`s partnering activities with its supply chain members, as well as its competitors, could yield a better understanding of changes in the market, and also result in higher performance, thus, higher gains (Kaufmann & Todtling, 2001; Mesquita & Lazzarini, 2008; Kaminski, de Oliveira & Lopes, 2008; Wagner, 2013). Similarly, it is evident for smaller firms that the “coordinated efforts to articulate distinct sets of interfirm resources and competencies allow them to attain collective efficiencies—that is, efficiencies that are unavailable to firms operating alone and overcome infrastructure limitations” (Mesquita & Lazzarini, 2008:360).

A firm`s customers and clients, as frequently mentioned in the literature, are among the main sources of accumulated knowledge about new demands, needs and product/service experiences (von Hippel & von Krogh 2006; Brunswicker & Vanhaverbeke, 2015). Any level of exposure to knowledge spillovers from a firm`s customers and clients, and interactions with them would heighten the rate of successful innovation (Tether, 2002; Belderbos et al. 2004; Amara & Landry, 2005; Zeng, Xie & Tam, 2010; Mention, 2011; Tomlinson & Fai, 2013), and level of adaptability to the market (Athaide & Zhang, 2011). As interaction with customers can facilitate the transfer of tacit knowledge, the role of knowledge spillovers from customers and clients in making informed decisions about the development of products and services is also highlighted by Füller & Matzler (2007). As documented by Fischer & Varga (2002), customers and clients are among the most frequently used knowledge sources. Gately & Cunningham (2014) and Dettwiler, Lindelöf & Löfsten (2006) also indicate the importance of close relationships with onsite customers and clients for the wellbeing of firms located in science and technology parks, specifically young and smaller firms.

To succeed in their open search endeavours, firms may also engage in partnering activities with suppliers. Interaction with a supplier can present itself as an additional channel for the diffusion of knowledge, whereby access to complementary resources is enhanced (Brunswicker & Vanhaverbeke, 2015; Chesbrough & Prencipe 2008) and risks associated with the development of products is shared (Clark, 1989; Kline & Rosenberg, 1986; Von Hippel, 1976;

Martín-de Castro, 2015). Prior studies show that partnering with suppliers would increase the rate of innovation (Kaufmann & Tödtling, 2001; Kaufmann & Tödtling, 2001; Tether, 2002; Wagner, 2013), and adaptability to the changing market (Chung & Kim, 2003). The impact of knowledge spillovers from suppliers increases, as the length of relationship between a firm and its supplier increases, thus, yielding better results for both parties (Whitley, 2002; Nieto & Santamaría, 2007). Smaller firms are known to benefit from interactions with suppliers far more than their larger rivals, as such relationships can compensate for the gaps in smaller firms` internal resources (Zeng, Xie & Tam, 2010; Parida, Westerberg & Frishammar, 2012; Tomlinson & Fai, 2013). It is also evident in the literature that the relationships with indirect suppliers, and other firms that operate outside the firm`s main industry are also important channels through which productivity would be enhanced (Katila, 2002). As the rate of mutual dependency and cognitive proximity between tenant firms located in science and technology parks are higher than offsite firms, lack of competition between a firm and its onsite supplier would incentivise knowledge sharing and co-creation (Benneworth & Ratinho, 2014; Khavandkar et al, 2016).

Exploration of coopetiton opportunities with competitors also would widen the pool of potentially absorbable knowledge for firms (Veugelers & Cassiman, 1999). Coopetition, once seen as a price-discriminating mechanism, refers to a paradigm that assumes "firms are able to co-opt their main rivals, defend their competitive positions and interests, and support new technological trajectories" (Ritala, 2012: 309), by cooperating with their competitors (Brandenburger & Nalebuff, 1996). Firms that intend to engage with their competitors would benefit from accessing complementary resources (Ritala & Hurmelinna-Laukkanen, 2009; Veugelers & Cassiman, 1999), sharing risks and costs associated with development of new combinations (Das & Teng, 2000), and further learning opportunities (Afuah, 2000; Kogut, 1988). Firms located in science and technology parks may obtain a higher level of benefits from knowledge inflows rooted in their cooperative activities with competitors, as both have a proximate position (Lindelöf & Löfsten, 2006). Nevertheless, risks of unintended knowledge spillovers associated with the coopetiton-based strategies are known to be high (Miotti & Sachwald, 2003; Chen, Chen & Vanhaverbeke, 2011).

On the other hand, it is evident from the literature that spatial proximity between a firm and its supply chain partners, customers, clients, as well as competitors would increase the rate of purposeful and intended knowledge spillovers between them (Jaffe, 1986; Isaksson, Simeth & Seifert, 2016). The ecosystem of science and technology parks increases the chances of exposure to knowledge spillovers from other proximate tenants, for the onsite firms (Alcácer & Chung, 2007; Khavandkar et al, 2016; Vásquez-Urriago, Barge-Gil & Modrego Rico, 2016). Geographical proximity catalyses collaborations between the onsite firms, as cognitive, social and organisational proximities between the firms with a proximate position decrease the knowledge distance between them (Boschma, 2005). On the other hand, the higher the level of cognitive proximity, the harder becomes the process of intellectual property rights protection against potential opportunistic behaviours of a firm`s partners (Ben Letaifa & Rabeau, 2013), specifically its competitors, leading to increases in unintended knowledge spillovers. Unintended knowledge spillover "refers to the loss of knowledge intended to stay within a firm's boundaries. In light of the increasingly open nature of innovation processes and supply chain management, in which active transfer of knowledge and technology may be a necessity rather than a luxury, more attention to this "dark side" of knowledge transfer is needed" (Frishammar, Ericsson & Patel, 2015:85). Hence, the mechanism of open search strategy would potentially produce various levels of outcomes, depending on the location of partners. In consideration of the foregoing, it seems reasonable to conclude that the onsite supply chain partners and competitors and their potential performance impacts must be distinguished from those located offsite, as learning potentials in open search activities are likely not to be homogeneous across offsite and onsite partners. In light of the above insights, the following hypotheses were put forward:

Hypothesis 1.1. The intensity of a firm`s offsite market-driven open search strategy will positively affect its open system performance.

Hypothesis 1.2. The intensity of a firm`s offsite market-driven open search strategy will positively affect its rational goal performance.

Hypothesis 2.1. The intensity of a firm`s onsite market-driven open search strategy will positively affect its open system performance.

Hypothesis 2.2. The intensity of a firm`s onsite market-driven open search strategy will positively affect its rational goal performance.

2.3.2. Science-driven open search strategy and firm performance

A firm`s science-driven open search strategy is based on the notion that the scientific and research-based relationships are important channels through which knowledge spillovers occur (Belderbos et al., 2004; Pekkarinen & Harmaakorpi, 2006; Villasalero, 2014). Firms can benefit from exploring potential learning opportunities with universities, public and private research centres and laboratories. Science-driven open search activities contribute to the attainment of "fundamental or applied research and scientific knowledge" (Mention, 2011: 46). Building relationships between firms and science and research-based actors is known to be a key driver of success in launching innovation (Belderbos et al., 2004; Liefner et al., 2006), specifically for smaller firms (Diez, 2000). Some of the advantages of interactions with universities and research institutions are: understanding and mitigating the risks associated with market failure (Fini et al., 2011), increasing the level of productivity (Pekkarinen & Harmaakorpi, 2006), increasing the probability of serving specialised market niches (Belderbos et al., 2004), and access to specialised knowledge (Laursen & Salter, 2004). There is also general agreement in the literature that cooperation with science and research-based actors would increase the chances of introducing new to the market innovations in firms (Kaufmann & Tödtling, 2001), and positively influence the antecedents of innovation radicalness and innovation speed in firms (Miotti & Sachwald, 2003; Fabrizio, 2009). The intensity of science-driven open search activities is also known to be positively associated with the level of research and development endeavours in firms (Laursen & Salter, 2004; Faems, Van Looy & Debackere, 2005).

As smaller firms are known to have limited in-house research and development activities (Madrid-Guijarro, Garcia & Van Auken, 2009), their limited capacity for in-house research and development may incentivise them to rely on less expensive and less risky alternatives, such as being actively engaged in collaborations with potential science and research-based partners (Dickson, Weaver & Hoy, 2006). Thus, younger and smaller firms are more prone to collaborate with universities and research institutions (Laursen & Salter, 2004). It is well documented in the literature that science-driven relationships lead to the higher levels of innovativeness (Fleming & Sorenson, 2004; Brunswicker & Vanhaverbeke, 2015), timely access to inventive trends (Fabrizio, 2009) and enhanced knowledge creation capacity in smaller firms (Bullinger, Auernhammer & Gomeringer, 2004). Among problems faced by smaller firms are lack of human resources and lack of skilled workers (van de Vrande et al., 2009). Working with universities and research institutions would compensate for their liability of smallness by providing access to a pool of skilled workers (Diez, 2000). In addition, smaller firms engaged in open search activities are exposed to risks associated with unintended knowledge spillovers, opportunistic behaviours and imitations. However, due to the strictly technical nature of knowledge involved in science-driven open search activities, “all types of partners are positively associated with imitation with the exception of universities and research institutions” (Veer, Lorenz & Blind, 2016: 1121). This may provide another explanation for why smaller firms tend to engage in more frequently in science-driven open search activities.

The ecosystem of science and technology parks is believed to facilitate knowledge spillovers form local universities to tenant firms, and provide clustering benefits for them (Siegel, Westhead & Wright, 2003), thus, benefit high-technology and knowledge-intensive firms (Soetanto & Jack, 2016). The key to achieve this goal is the accelerated rate of exchange of knowledge between tenant firms and science and research-based actors that have a proximate location in, or around the science and technology parks (Van Dierdonck, Debackere & Rappa, 1991). Prior studies show that onsite firms are more likely to benefit from cooperation with universities and research centres in close proximity, than with those which are farther away (Westhead & Storey, 1995; Diez, 2000; Löfsten & Lindelöf, 2002). Hence, the following relations were hypothesised:

Hypothesis 3.1. The intensity of a firm`s science-driven open search strategy will positively affect its open system performance.

Hypothesis 3.2. The intensity of a firm`s science-driven open search strategy will positively affect its rational goal performance.

2.3.3. Institutional open search strategy and firm performance

A firm`s institutional open search activities are based on the notion that firms can benefit from interactions with institutional actors, such as: government agencies, trade organisation, financial institutions and intermediaries, and management team in science and technology parks (Westhead, 1997; Smallbone et al., 2003; Zeng, Xie & Tam, 2010; Khavandkar et al., 2016; Escribano, Fosfuri & Tribó, 2009). In institutional open search activities, communications between a firm and its institutional partners normally occur through formal channels and help the firm to overcome its concerns about social conformity and legitimacy (Khavandkar et al., 2016).

In many countries, the national government and local authorities are responsible for devising macro-level innovation policies (Hewitt-Dundas, 2006), aimed at supporting small businesses growth and innovation ecosystems (Smallbone et al., 2003). The government agencies are also normally active in supporting research collaborations between universities andd research organisations, and firms to accelerate knowledge diffusion and transfer between them (Peres & Stumpo, 2000). Higher levels of interaction with the government agencies would help firms to gain access to a wide range of professional services, programmes, policies and information in order to make informed decisions about their next moves. In addition, firms can receive direct or indirect supports from the government, or its agencies to further their research and development activities and innovation endeavours (Matt & Wolff, 2004). It is well documented in the literature that interactions between tenant firms and government agencies would increase the rate of innovation in firms (Shin, 2001; Albahari, Catalano & Landoni, 2013; Carlos et al., 2015).

Firms also would benefit from engaging in exploratory learning activities with professional, industry and trade associations. Known as the know-how brokers and innovation intermediaries (Howells, 2006), professional, industry and trade associations can help firms to develop industry-specific abilities. Recognised as one of the key drivers behind the success of firms (Bullinger, Auernhammer & Gomeringer, 2004), interactions with the professional, industry and trade associations are positively associated with firms` increased ability to foresight and effectively predict key developments in industry-specific markets (Howells, 2006), enhanced productivity (Doloreux, 2004) and social capital (Bullinger, Auernhammer & Gomeringer, 2004). For the firms located in science and technology parks, interactions with the professional, industry and trade associations would also result in wider access to market knowledge (Albahari, Catalano & Landoni, 2013).

Having greater access to financial resources and services would help firms to advance their research and development efforts (Martin & Scott, 2000). As smaller firms are often faced with resource constraints, it is evident from the literature that they tend to utilise all possibilities to overcome their liability of smallness (Gassmann, Enkel & Chesbrough, 2010). Similarly, as smaller firms are more vulnerable to sudden changes and uncertainty in the market, interactions with the financial institutions and banks would help them to invest more on in-house research and development activities to become more flexible and responsive to their changing environments (Arthurs & Busenitz, 2006), and to succeed in pursuit of external legitimacy (Khavandkar et al., 2016). As evident from the literature (Lindelöf & Löfsten, 2001; Campanella, Rosaria Della Peruta & Del Giudice, 2014), financial institutions and banks are among important external partners for the firms located in science and technology parks.

The management team of a science and technology park has a key role in brokering the relationships between onsite firms, and between them and other stakeholders (Westhead, 1997). Firms seek to access complementary knowledge from their open search activities (Wright et al., 2008: 132), thus, the management team is responsible for the success of "management initiatives in the commercialisation process and the linking of science and technology park firms with Higher Education Institutions, other tenants on the park, as well as firms located outside the park, [the quality of managerial intermediaries] needs to be carefully monitored" (Siegel, Westhead & Wright, 2003: 181). The management team can help onsite firms to further their openness and experimentation capabilities, by facilitating their access and exposure to co-specialisation opportunities (Kahvandkar & Khavandkar, 2015). In addition, the management team can promote a culture of co-creation among onsite firms, which would increase the chances of exploratory learning and open search activities in the ecosystem of science and technology parks. There is a general agreement in the literature that a park`s management team plays a vital role in shaping the culture of learning and discovery (Westhead, 1997; Fukugawa, 2006; Westhead & Storey, 1994) and diffusion of knowledge among onsite firms (Khavandkar et al., 2016). This led to the following hypotheses:

Hypothesis 4.1. The intensity of a firm`s Institutional open search strategy will positively affect its open system performance.

Hypothesis 4.2. The intensity of a firm`s Institutional open search strategy will positively affect its rational goal performance.

2.3.4. Technical and application-driven open search strategy and firm performance

A firm`s technical and application-driven open search strategy is based on the notion that firms can also gain learning benefits in non-interactive modes. Learning and knowledge acquisition occur in both interactive and non-interactive modes (Glückler, 2013). In interactive modes, firms need to build direct and strategic relationships with their partners to accomplish learning goals. On the other hand, learning in non-interactive modes can occur through indirect modes, such as "imitation, where a firm absorbs the knowledge of other actors through observation of the actions/behaviour of the source actor; reverse engineering, where a firm derives knowledge from the final product of another firm, obtained from the market or through supply chain interaction; and the codification of knowledge, where a firm obtains knowledge through knowledge which is a public good such as news, patents and regulations etc." "Roper, Love & Bonner, 2016:12). In addition, non-interactive learning can occur through engagement with a third-party, as well as friendly imitation (Glückler, 2013). In non-interactive modes, learning occurs once a firm observes or discovers new external technical or application-oriented knowledge, understands it, localises it and finally decides to reproduce it (Malmberg & Maskell, 2002). Two key drivers of non-interactive learning are competitive push factors and social pressure elements that are stimulating the firm to imitate or acquire new knowledge in order to sustain its superiority in the market (Ansari, Fiss & Zajac, 2010). Non-interactive learning is known to reduce error for certain classes of research and development activities and increase the chances of introducing new to the market innovations (Roper, Love & Bonner, 2016).

The technical and application-driven open search activities are centred around the process of learning and leveraging knowledge across a wide range of sources, such as: conferences, meetings, fairs, exhibitions, scientific journals, trade and technical publications, trainings or external sources of professional know-how, experts, consultants or advisors (Malmberg & Maskell, 2002; Glückler, 2013; Brunswicker & Vanhaverbeke, 2015; Roper, Love & Bonner, 2016). It is well documented in the literature that frequent participation in conferences, fairs and meetings with external actors increases firms` exposure to external knowledge (Chan & Pretorius, 2007), leads to a higher level of networking capability (Hansson, Husted & Vestergaard, 2005) and innovative capacity (Díez-Vial & Fernández-Olmos, 2015), a wider access to technical knowledge (Ramirez & Li, 2009), and facilitates the process of finding new opportunities for joint research and development activities (Cassiman & Veugelers, 2002). Science and technology parks are known to increase onsite firms` access to such non-interactive learning opportunities (Van Dierdonck, Debackere & Rappa, 1991; Westhead & Storey, 1995; Löfsten & Lindelöf, 2001; Hansson, Husted & Vestergaard, 2005; Díez-Vial & Fernández-Olmos, 2015). Knowledge documented in the scientific journals, trade and technical publications enhances a firm`s ability to foresight and predict new developments in the market, anticipate competitors' moves, determine its own strengths and weaknesses, and leads to an increased level of awareness about new technologies, products and research (Villasalero, 2014; Campanella, Rosaria Della Peruta & Del Giudice, 2014; Bigliardi et al., 2006). In science and technology parks, onsite firms located normally have a wider access to such resources (Westhead & Storey, 1995). Similarly, learning through interactions with experts, consultants and advisors, as well as trainings can contribute to the development of a certain kind of strategic insights in a firm, as its exposure to the tailored-made technical knowledge increases. In addition, interactions with the experts, consultants and advisors can provide a firm with a third person perspective, transfer certain experiences and practices, and increase technical knowledge of its employees (Van Dierdonck, Debackere & Rappa, 1991; Lindelöf & Löfsten, 2002). Smaller firms are often faced with resource constraints; thus, they tend to normally invest more in learning through non-interactive modes (Brunswicker & Vanhaverbeke, 2015). The above insights supported the following hypotheses:

Hypothesis 5.1. The intensity of a firm`s technical and application-driven open search strategy will positively affect its open system performance.

Hypothesis 5.2. The intensity of a firm`s technical and application-driven open search strategy will positively affect its rational goal performance.

Fig. 2.1 illustrates all hypothesised relationships between research variables.

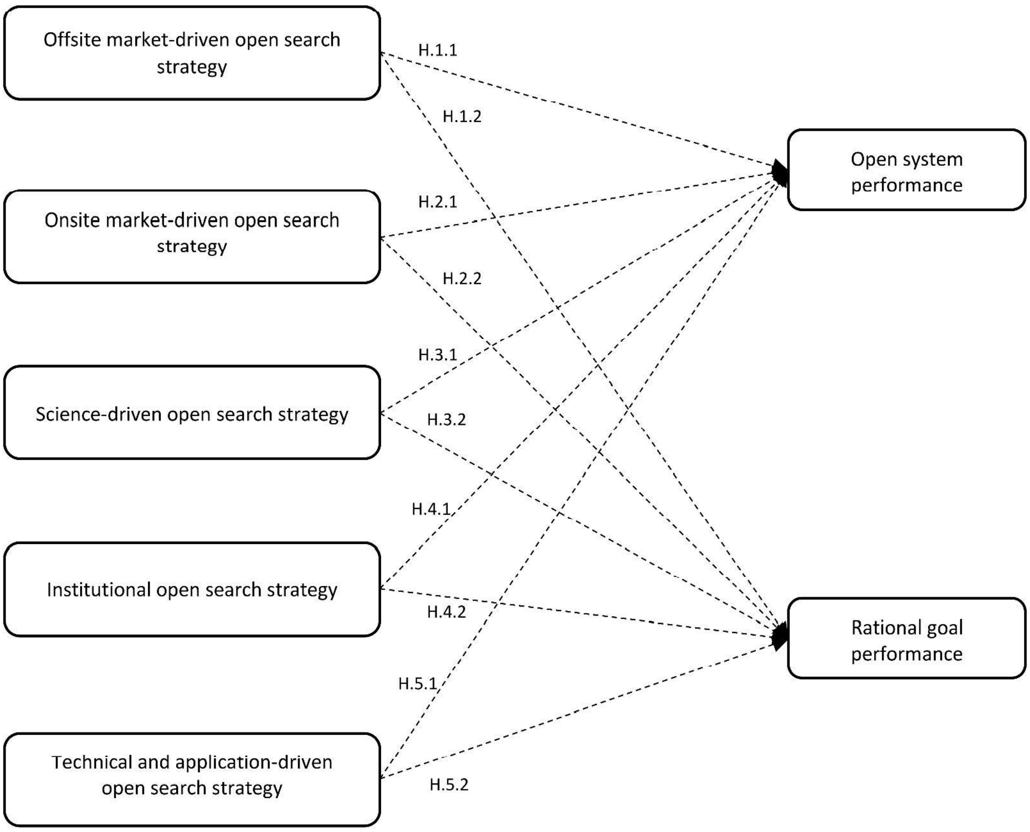


Fig. 2.1 : Research model

2.4. Methods

2.4.1. Sample and Data Collection

The dataset underlying this analysis is drawn from the Survey of Science and Technology Parks (UKSTP Survey) carried out in the United Kingdom. The UKSTP survey was launched for the first time in 2015 and aims to provide a means to measuring the levels and types of innovation activities among companies located in Science and Technology Parks in the United Kingdom. The purpose of UKSTP Survey is to collect information about business practices of onsite companies in order to generate data that will improve the empirical basis for an independent insight into a variety of policy-related issues regarding the management and economics of Innovation in science and technology parks in the United Kingdom. The UKSTP Survey samples from the population of companies located in science and technology parks in the United Kingdom. For each wave of the UKSTP Survey, a sample is drawn from the United Kingdom Science and Technology Parks Complete Database (UKSTPC[4]). The UKSTPC database is a company database listing over 6000 companies located in Science Parks, Technology Parks, Research Parks, Innovation Parks, Incubators, Innovation Centres and Accelerators around the United Kingdom. The UKSTPC database was developed between December 2014 to May 2015, as part of the UKSTP Survey project, specifically for the purpose of current study. The UKSTPC database provides a comprehensive list of firms ranging from micro to large enterprises in different science and technology parks in the United Kingdom. Each listing provides information on firm name, top management team and their contact details, location, SIC codes and employee information. Tenant firms were identified through different sources, such as: company websites, science and technology parks\` websites/directories, the United Kingdom Science Parks Association\`s publications, FAME database, Companies House website and general search engines.

All science and technology parks\` websites and each potential company\`s website which were separately and manually inspected to identify firms that could be unambiguously defined as an onsite firm. After a firm was initially identified as a candidate for inclusion, a series of further manual checks was also carried out using the FAME database and the Companies House website to draw information on industry classes, size, and location, and confirm each firm\`s profile and correct

[4] The UKSTP Survey and the UKSTPC database were both developed for the purpose of current PhD project.

errors. These adjustments helped to excluded firms with missing ownership information, those that were moved out of the science and technology parks, and those that had ceased to exist. Finally, using general search engines, LinkedIn, each company`s website and other social media sources, information on every listed firms` top management teams and their contact details were collected. The database was updated monthly through the compilation of information from archival sources and contacts made with firms` executives. Compilation of firm information from multiple sources and confirmation of the compiled details by company executives provided additional corroboration through triangulation. The UKSTPC database was specifically used for the first time in this study to collect data about innovation activities of firms located in science and technology parks in the United Kingdom.

Prior studies conclude that there are substantial differences between smaller and larger firms` innovation strategies. However, micro enterprises (with less than 10 employees) always have been excluded from the main stream of research on open innovation, since it is believed that micro enterprises generally have no or limited identifiable innovation activities (van de Vrande et al., 2009). Despite the fact that they have received scant attention in the open innovation literature, micro enterprises are strongly targeted within industrial and entrepreneurship policy frameworks, specifically in science and technology parks. According to a report published by the United Kingdom Science Park Association (UKSPA), micro enterprises and small firms with less than 15 employees accounted for 79% of all onsite businesses located in science and technology parks around the United Kingdom in 2011 (UKSPA, 2011). Science and technology parks are policy-driven initiatives that have a main common objective to promote cooperation, technology transfer and foster cooperation between tenant firms, and between them and other stakeholders (Vásquez-Urriago, Barge-Gil & Modrego Rico, 2016). Hence, in this study both service and manufacturing onsite companies with less than 250 were selected because these companies operate in a dynamic environment in science and technology parks where innovative abilities are necessary for growth and survival.

As this study was mainly interested in the effects of open search activities in small and medium sized and micro enterprises (not large companies), a relevant dataset underlying this analysis was drawn from the UKSTP2015 dataset. As stated on the survey website[5], participants from all science and technology parks

[5] www.ukstpsurvey.org

around the United Kingdom were encouraged to participate. The instructions for the survey stated that all companies which were located in science and technology parks were welcome to participate. Onsite companies with less than 250 employees were included, while individuals outside of this size range -large firms with more than 250 employees-, were not included in the final analysis. This study opted to follow the official definitions of SMEs and micro enterprises, provided by the European Commission (European Commision, 2015), OECD(OECD, 2005) and the UK's Companies Act 2006 (Legislation.gov.uk, 2006), where companies are classified into different categories according to their sizes as: micro enterprises (less than 10 employees), small enterprises (up to 50employees) and the medium-sized enterprises (from 50 to 250 employees).

Data were collected via an online survey, hosted by surveymonkey.com and mapped on the UKSTP Survey project`s official website, in two waves between 1 June to 20 October 2015. A stratified random sample of firms in 12 cluster regional areas of the United Kingdom was targeted for this study. With regards to the sample unit, since the level of analysis in this study was the organisation, the respondent to the questionnaire was a single person from each company. The survey targeted the highest-ranking official of each tenant firm, as their cognitive maps represent the essential aspects of all the members of the organisation (Lyles & Schwenk, 1992; Real, Roldán & Leal, 2014). In pursuance of maximising the data accuracy and reliability, this study followed Huber and Power's (1985) guideline on how to obtain quality data from single informants. Besides, Dillman (2000) recommendations were also considered in collecting data using online survey. To induce firms to participate, a personal and individually tailored email and an electronic leaflet (see Appendix. A) was sent to each person from the population. The electronic letter contained: a tailored message directly addressing the CEO of the company, a link to the project`s official website and a link to the online survey. The tailored electronic letter together with the electronic leaflet explained the research project, encouraged participation and guaranteed anonymity. After three follow up emails, in total, data from 384 onsite firms in 91 science and technology parks of 12 different regions of the United Kingdom were collected. The effective sample, without missing values, consisted of 342 observations. The number of responses and the response rates by region are summarised in Table 2.1.

Table 2.1: Research population, number of responses and the response rates by region

Region	*Stratum's Size (UKSTPC)*	*Stratum's Sampling size*	*First Wave*	*Second Wave*	*Total*
East Midlands	256	26	17	23	40
East of England	542	55	25	19	44
London	75	8	4	10	14
North East	51	5	9	4	13
North West	357	36	17	21	38
Northern Ireland	116	12	6	4	10
Scotland	291	29	13	26	39
South East	577	58	29	38	67
South West	162	16	19	17	36
Wales	140	14	9	5	14
West Midlands	617	62	18	27	45
Yorkshire & Humberside	248	25	12	12	24
Total	3432	346	178	206	384

Regarding the size of the firms, 65.8 percent were micro enterprises; 28.9 percent small enterprises; 5.3 percent medium size enterprises. With respect to firm sector, 84.8% represented businesses in the service sector; 22.3% were businesses in the manufacturing sector. Out of 52 manufacturing firms, based on the Eurostat classification of High-tech industry and knowledge-intensive industry (2-digit level) (Eurostat, 2014), 46.2% of firms were high-technology 32.7% medium high-technology, 9.6% of medium low-technology, 11.5% low-technology. Similarly, out of 290 service firms, 49.7% were high-tech knowledge intensive services, 12.1% knowledge intensive services (other), 27.2% knowledge intensive market services, 3.8% knowledge intensive financial services, 7.2% less knowledge Intensive services. The median age of the sample was 8.5 years, and the average number of years spent in science and technology parks was 6.13 years. Most of the sample firms were autonomous (86.3%), while the remaining ones (13.7%) were subsidiaries of other firms. In terms of market dispersion, 42.7% of the sample firm were only active in the national market, while 57.3% of them were actively engaged in selling products and services internationally. About 48.5% of the firms in the sample indicated that their firms had introduced at least one new product or service innovation into the market, and 49.4% had introduced at least one new product, process or service innovation into the business between 2012 and 2015. Table 2.2 provides an overview of the descriptive statistics.

Table 2.2: Respondent characteristics

	Number of firms	Percentage
Total number of employees		
Range		
Less than 10	225	65.8
10 to less than 50	99	28.9
50 to less than 250 250	18	5.3
Total	342	100.00
Sector Type		
Service	290	84.8
Manufacturing	52	15.2
Total	342	100.00
Aggregations of services based on NACE Rev. 2*		
Less Knowledge Intensive Services	21	7.2
Knowledge intensive services (Other)	35	12.1
Knowledge intensive services (Market Services)	79	27.2
Knowledge intensive services (Financial Services)	11	3.8
Knowledge intensive services (High Technology)	144	49.7
Other	0	0
Total	290	
Aggregations of manufacturing based on NACE Rev. 2*		
Low-Technology (Manufacturing)	6	11.5
Medium Low-Technology (Manufacturing)	5	9.6
Medium High-Technology (Manufacturing)	17	32.7
High-Technology (Manufacturing)	24	46.2
Other	0	0
Total	52	100.00
Age Level		
Entry Level (1 to 3 years)	58	17
Survival Level (4 to 5 years)	49	14.3
Post-survival Level (6 and more)	235	68.7
Total	342	100.00
Locus of control		
Autonomous Enterprise	295	86.3
Partner/Linked enterprise	47	13.7
Total	342	100.00
Market Dispersion		
National Market	146	42.7
International Market	196	57.3
Total	342	100.00
Innovativeness		
Introduced at least one product, process or service innovation into the market (between 2012 to 2015)	166	48.5
Introduced at least one product, process or service innovation into the business (between 2012 to 2015)	169	49.4

2.4.2. Variable Definition and Measurement

2.4.2.1. Independent and Dependent Variables

Open system performance: Looking through the lenses of open system models, organisations tend to engage in learning activities to manipulate their environments (Pfeffer & Salancik, 1978) and increase their flexibility and adoptability (Kumar, Stern & Achrol, 1992). The ability to adapt to the changing environment highlights the importance of a set of organisational functions which are primarily concerned with a firm`s resource acquisition activities and its external focus (Scott, 1977; Quinn & Rohrbaugh, 1983). It is evident from the literature that firms` both exploration and exploitation activities are associated with their open system performance. In this study, the scale developed by Hernández-Espallardo, Sánchez-Pérez, & Segovia-López (2011) was adopted to measure open system performance of onsite firms.

The open system performance scale consists of three items: adaptability to market changes, image of the firm and its products/services, quality of products/services. For each item, firms rated the extent to which they felt their development over the last three years relative to their main competitors had been successful, on a 7-point Likert scale (`1` = much worth or and `7` = much better). An exploratory factor analysis on the items suggested that all three items loaded on a single factor (loadings > 0.50), which accounted for 69 percent of the variance. Coefficient α for the scale was 0.77 (Table 2.3).

Table 2.3: Exploratory factor analysis: Open system performance

Items	*Loadings*
Adaptability to market changes	0.78
Image of the firm and its products/services	0.85
Quality of products/services	0.87
% of Variance	69.00
Cronbach's alpha	0.77

Rational goal performance: the rational goal dimension of organisational effectiveness represents an aspect of the organisational performance which is associated with efficiency and productivity (Quinn & Rohrbaugh, 1983). In other words, the rational goal performance reflects the degree to which a firm succeeds in achieving tangible outcomes relative to its competitors, market and other established benchmarks (Hernández-Espallardo, Sánchez-Pérez & Segovia-López, 2011). Rational goal performance of onsite firms was assessed using items adapted from Gupta & Govindarajan (1984) and Venkatraman & Ramanujam (1986).

Firms were asked to rate the degree of their firms` development over the last three years relative to their main competitors in terms of: sales growth, turnover growth, profitability and market share. The answers were measured on 7-point scales, with a rating of 1 indicating that the firm had performed much worse than its competitors, and a 7 indicating that it had performed much better than other competitors. An exploratory factor analysis was conducted on the responses to the 4 items of the rational goal performance measures which yielded a single factor solution with eigenvalue greater than one (all items were loaded highly >50, and the single factor accounted for 85.84 percent of the variance). Coefficient α for the scale was .95 (Table 2.4).

Table 2.4: Exploratory factor analysis: Rational goal performance

Items	***Loadings***
Market share	0.89
Profitability	0.91
Sales	0.95
Turnover growth	0.95
% of Variance	85.84
Cronbach's alpha	0.95

Intensity of open search strategy (scale development): The five dimensions of open search strategy (i.e. offsite market-driven, onsite-market-driven, technical and application-driven, science-driven and institutional open search strategies) were assessed with items that were initially generated deductively (Hinkin, 1998) from a review of existing literature on science and technology parks and open innovation literature and then subjected to a further set of qualitative and quantitative checks to ensure their validity and reliability (Churchill, 1979; DeVellis, 2011).

As Garriga, von Krogh & Spaeth (2013) point out, the availability of knowledge sources is a direct function of the contextual factors and environment. Hence, the ecosystem of science and technology parks environment the contextual factors of tenant firms could potentially impact their open search orientations. The limitations of commonly used data originated from the large-scale surveys such as Community Innovation Survey in measuring firms` open search strategy explain the need for a wider perception-based scale. For instance, the 4th UK Innovation Survey only included 10 possible external sources. However, the concept of open search involves a wider range of resources than those were captured by large scale surveys such as the community innovation survey. In addition, a limitation of the results obtained through non-Likert scales, as used in different waves of the community innovation survey, is that it does not allow for the analysis of the intensity and importance of open search strategy. Hence, many researchers have called for development of "fine-grained items for each of the knowledge sources" (Laursen & Salter, 2006:147).

The potential advantage of a wider perception-based scale is that it could produce results beyond the conventional approach that characterises the use of binary indicators in measuring firms` intentions towards open search. Besides, historically there was a lack of valid and reliable measures of open search strategy in science and technology parks and this led to the problem of comparability across different studies (For instance in: Felsenstein, 1994; Westhead & Storey, 1995; Siegel, Westhead & Wright, 2003; Lindelöf & Löfsten, 2004). Therefore, this study attempted to fill this gap by creating a perception-based scale for measuring intensity of firms` open search strategy of firms located in science and technology parks.

The scale development process started with a systematic review of the literature on open innovation and science and technology parks. Following the procedure outlined by Tranfield, Denyer & Smart (2003) and Thorpe & Holt (2005), first the review protocols were defined. This step included activities such as: identification of keywords, development of exclusion and inclusion criteria, specification of relevant databases and execution of search and development of primary, secondary, peripheral, conceptual and not relevant lists. Second, the relevant fields were identified and mapped. Finally, qualitative thematic analyses were carried out to identify central themes and to extract items. The process started out with a database of 198 papers for open innovation and 91 papers for science and technology park resulted from operationalisation of target domains through three clouds of key words and eleven keywords, reduced through several iterative in-depth inductive and deductive analyses. The review process covered both published peer reviewed studies in databases such as: ABI Proquest, ISI Web of Science, Science Direct, Business Source Premier, JSTOR, Wiley Online, Emerald, and working papers and conference papers stored in Social Sciences Research Network (SSRN) database. After mapping the relevant fields, a set of qualitative thematic analyses were carried out to identify key dimensions and extract items. This process yielded a total of forty-six papers that were either conceptual or contained unique measures. Overall, the results of systematic literature review revealed that conceptualisations varied in the number of dimensions, related components (sources) and measures. After comparing and matching the characteristics and components of each open search strategy dimension derived from the main definitions, and integrating or deleting the synonymous terms, five unique dimensions were identified. Five main dimensions, which explain a firm's open search strategy in science and technology parks, were found to be: offsite market-driven, onsite-market-driven, technical and application-driven, science-driven and institutional open search activities.

Following the established procedure of item generation outlined by Churchill (1979) and DeVellis (2011), a further detailed literature review was conducted by screening all forty-six papers retained from the earlier systematic review phase to identify the body of knowledge in which the measures of open search strategy dimensions was situated. Items were adopted directly from these forty-six studies, if measurement items were available for a particular dimension, or were used before to measure them in a different context or independently from each other. The rest of items were drawn from definitions or qualitative context and assigned to relevant dimensions of open search strategy. The initial pool contained thirty-five items. To ensure face validity and consistency, all items were subjected to further modifications. and remove and combine duplicates. Some of the items were deleted or combined to avoid duplicate measures. At the end of this stage, thirty-one items were retained.

In order to ensure the accuracy and comprehensiveness of items for the open search strategy dimensions, three academics and three experts who specialise in science and technology parks management were asked to judge the initial pool of thirty-one items for appropriateness. Following the procedure outlined by Netemeyer, Bearden & Sharma (2003), the judges reviewed the items and placed items into one of three categories of: items to be retained, to be deleted and to be modified. In addition, a few items which could capture the notion of open search strategy were added to the initial pool of the items. At the end of this stage, twenty-seven items kept for further analysis (6 items were deleted, 3 items were added, and 9 items were modified).

To assess the content validity of twenty-seven retained items, a new group of four academics and three professionals were invited to judge the items for representativeness. In line with Rai (2013) and following the procedure suggested by Rungtusanatham, Anderson & Dooley (1999), the judges were asked to assign each item to the most relevant dimension of open search strategy, providing them with the definition of each open search strategy dimension and a list of randomly ordered items. Next, they were requested to assess the adequacy of each measurement item in relation to its associated dimension on a 7-point Likert-type scale. The results obtained at this stage were used to assess Inter-item agreement indices and interrater reliability measure. Following the recommendations by Hardesty & Bearden (2004), twenty-six items with average pairwise agreement index values of more than 70 percent were kept for further analysis. One item failed to meet the criteria, and subsequently was discarded. For the remaining twenty-six items, the Krippendorff`s alpha (2007), or interrater reliability coefficient, was greater than the recommended threshold of 0.67. for all six judges simultaneously. Using a variant of Zaichkowsky's (1985) method, out of twenty-six items, twenty-four items had average adequacy index values of greater than 4 and standard deviation values of less than 1, while two items failed to meet the criterion for retention. The interrater reliability value for twenty-four items was α=0.82, suggesting good interrater agreement. These procedures ensured the content validity of the items.

To assess the initial item pool and the dimensionality of the scale, a total of twenty-four items retained at the end of content validity study were used to design the questionnaire. Following DeVellis's (2011) suggestion for measuring opinion, 7-point Likert scales, ranging from 1=very unimportant to 7=very important, were used to capture the extent of respondent`s agreement about the importance of each facet of open search strategy in science and technology parks. The questionnaire was presented to four CEO of tenant firms to evaluate the readability of the measure. Further face-to-face interviews were carried out to assess interpretability, and degree of understandability of items. Few items were modified to improve the general readability of the items.

The survey listed twenty-four possible external sources, and it reflected a wide range of sources and partners associated with the innovation ecosystem of science and technology parks, including: off-site clients or customers from the public sector, other off-site enterprises in other sectors, off-site competitors, off-site clients or customers from the private sector, off-site suppliers of equipment, materials, components, or software, other off-site businesses in your sector that are not direct competitors, on-site suppliers of equipment, materials, components, or software, on-site clients or customers from the private sector, on-site clients or customers from the public sector, on-site competitors, other on-site enterprises in other sectors, other on-site businesses in your sector that are not direct competitors, conferences and meetings, trainings or external sources of professional know-how, fairs and exhibitions, scientific journals and trade/technical publications, experts, consultants or advisors, commercial laboratories or R&D enterprises, public research organisations, universities and local academics, financial institutions and banks, local and national government, park management or centre management, professional and industry/trade associations.

An exploratory factor analysis with oblique rotation (promax rotation) on each type of open search strategy suggested (Table 2.7. to 2.11) that, all items were loaded highly >50, percentages of the variance explained were greater than 50%, KMO estimates were greater than 0.60 and Coefficient α was higher than 0.70 for all types of open search strategy (Hair et al., 2014). A further exploratory factor analysis (EFA) using principal factors extraction with an oblique rotation on the items suggested that, a final set of twenty-four items loaded on five factors with eigenvalues greater than one. Together, these factors accounted for 64.12 percent of the variance. Factor loadings for the twenty-four items are shown in Table 2.5.

Table 2.5: Exploratory factor analysis: Intensity of open search strategy

	(1)	(2)	(3)	(4)	(5)
Offsite Suppliers of Equipment, Materials, Components, or Software	0.75	0.32	0.31	0.28	0.21
Other Offsite Businesses in Your Sector that are not Direct Competitors	0.82	0.39	0.29	0.20	0.31
Offsite competitors	0.74	0.28	0.23	0.12	0.29
Other offsite enterprises in other sectors	0.77	0.27	0.29	0.31	0.34
Offsite Clients or Customers from the Public Sector	0.80	0.41	0.28	0.18	0.32
Offsite Clients or Customers from the Private Sector	0.70	0.21	0.25	0.16	0.19
Other Onsite Enterprises in other Sectors	0.33	0.87	0.27	0.25	0.31
Other Onsite Businesses in Your Sector that are not Direct Competitors	0.33	0.87	0.24	0.18	0.31
Onsite Competitors	0.34	0.86	0.28	0.20	0.39
Onsite Suppliers of Equipment, Materials, Components, or Software	0.36	0.81	0.33	0.33	0.31
Onsite Clients or Customers from the Private Sector	0.32	0.79	0.38	0.27	0.42
Onsite Clients or Customers from the Public Sector	0.33	0.75	0.24	0.37	0.44
Conferences and Meetings	0.29	0.24	0.84	0.29	0.28
Trainings or External Sources of Professional Know-How	0.27	0.32	0.75	0.29	0.39
Fairs and Exhibitions	0.28	0.24	0.74	0.29	0.24
Scientific Journals and Trade/Technical Publications	0.29	0.27	0.76	0.26	0.40
Experts, Consultants or Advisors	0.28	0.31	0.77	0.34	0.33
Commercial Laboratories or R&D Enterprises	0.23	0.31	0.34	0.86	0.30
Public Research Organisations	0.26	0.28	0.34	0.84	0.40
Universities or Local Academics	0.19	0.20	0.26	0.78	0.38
Financial Institutions and Banks	0.30	0.28	0.34	0.24	0.77
Local and national Government	0.26	0.26	0.32	0.37	0.78
Park Management or Centre Management	0.33	0.50	0.36	0.37	0.79
Professional and Industry/Trade Associations	0.27	0.39	0.30	0.38	0.79

In addition, the results of convergent validity tests (Table 2.6) showed that, all items were loaded highly >50 (Appendix.2: Table 2.30), all types of open search strategy had high composite reliability (CR) value >0.6 (DeVellis, 2011), and all composite validity values were greater than the values obtained for the average variance extracted (AVE) and AVE > 0.5 (Fornell & Larcker, 1981). Moreover, all values obtained for the maximum shared value (MSV) were less than the values obtained for the average variance extracted (AVE), which confirmed the discriminant validity of the scale. Confirmatory factor analysis (CFA) on the twenty-four items showed that the five-factor structure, consisting of offsite market-driven, onsite market-driven, science-driven, technical and application-driven and institutional open search strategies, exhibited excellent fit $\chi^2_{242} = 420.542, CFI = 0.952, RMSEA = 0.047, SRMR = 0.0451.$

Table 2.6: Convergent and discriminant validities

Construct	CR	AVE	MSV	(1)	(2)	(3)	(4)	(5)
(1) Institutional open search strategy	0.80	0.50	0.30	0.71				
(2) Onsite-market-driven open search strategy	0.91	0.63	0.29	0.54	0.79			
(3) Offsite market-driven open search strategy	0.86	0.50	0.22	0.46	0.47	0.71		
(4) Technical and application-driven open search strategy	0.82	0.51	0.28	0.53	0.41	0.43	0.69	
(5) Science-driven open search strategy	0.78	0.55	0.30	0.55	0.37	0.33	0.49	0.74

Intensity of offsite market-driven open search strategy: To explore the intensity of offsite market-driven open search strategy, firms were asked to indicate the level of perceived effectiveness of their reciprocal interactions with each of the six types of potential external market-based partners located outside the focal firm`s science and technology park over the last three years (2012 to 2015), on a 7-point Likert scale (where `1` denoted `very unimportant` and `7` denoted `very important). The offsite market-based partners for co-creation were: offsite suppliers of equipment, materials, components, or software etc., other offsite businesses in your sector that are not direct competitors, offsite competitors, offsite clients or customers from the public sector, other offsite enterprises in other sectors, offsite clients or customers from the private sector. A firm`s offsite market-driven open search strategy can be directed towards reciprocal knowledge exchange activities with a single offsite partner, or several of them. An exploratory factor analysis on the items suggested that all six items loaded on a single factor (eigenvalues >1), accounted for 58.37 percent of the variance. Coefficient α for the scale was 0.86 (Table 2.7).

Table 2.7: Exploratory factor analysis: Offsite market-driven open search strategy

Items	*Loadings*
Offsite Suppliers of Equipment, Materials, Components, or Software	0.75
Other Offsite Businesses in Your Sector that are not Direct Competitors	0.82
Offsite Competitors	0.73
Offsite Clients or Customers from the Public Sector	0.77
Other Offsite Enterprises in other Sectors	0.81
Offsite Clients or Customers from the Private Sector	0.69
% of Variance	58.37
Cronbach's alpha	0.86

Intensity of onsite market-driven open search strategy: To explore the intensity of onsite market-driven open search strategy, firms were asked to indicate the level of perceived effectiveness of their reciprocal interactions with each of the six types of potential external market-based partners located in a close proximity with the focal firm and on the same science and technology park, over the last three years (2012 to 2015), on a 7-point Likert scale. A '1' meant that the firm did find the given source `very unimportant` important, while a '7' meant that it was a `very important` source of market-driven knowledge for the focal firm. The listed onsite market-based partners for co-creation were: onsite clients or customers from the private sector, onsite clients or customers from the public sector, onsite suppliers of equipment, materials, components, or software, onsite competitors, other onsite businesses in the focal firm`s sector that are not direct competitors, other onsite enterprises in other sectors. An exploratory factor analysis on the items suggested that, all six items loaded (loadings >0.50) on a single factor (eigenvalues>1) that accounted for 68.61 percent of the variance. Coefficient α for the scale was 0.91 (Table 2.8).

Table 2.8: Exploratory factor analysis: Onsite market-driven open search strategy

Items	*Loadings*
Other Onsite Enterprises in other Sectors	0.86
Other Onsite Businesses in Your Sector that are not Direct Competitors	0.86
Onsite Competitors	0.87
Onsite Suppliers of Equipment, Materials, Components, or Software	0.81
Onsite Clients or Customers from the Private Sector	0.80
Onsite Clients or Customers from the Public Sector	0.77
% of Variance	68.61
Cronbach's alpha	0.91

Intensity of technical and application-driven open search strategy: To explore the intensity of technical and application-driven open search strategy, firms were asked to indicate on a seven-point Likert-type scale (1=`very unimportant` to 7=`very important`) the importance of five technical and application-based sources for their firm's innovation activities during the last three years (2012–2015). The listed technical and application-based sources were: conferences and meetings, trainings or external sources of professional know-how, fairs and exhibitions, scientific journals and trade/technical publications, experts, consultants or advisors. A firm`s technical and application-driven open search strategy can be directed towards reciprocal knowledge exchange activities with a single offsite partner, or several of these offsite market-based sources. An exploratory factor analysis on the items suggested that, all five items loaded (loadings >0.50) on one factor (eigenvalues>1) that accounted for 59.76 percent of the variance. Coefficient α for the scale was 0.83 (Table 2.9).

Table 2.9: Exploratory factor analysis: Technical and application-driven open search strategy

Items	***Loadings***
Conferences and Meetings	0.84
Trainings or External Sources of Professional Know-How	0.76
Fairs and Exhibitions	0.73
Scientific Journals and Trade/Technical Publications	0.76
Experts, Consultants or Advisors	0.77
% of Variance	59.76
Cronbach's alpha	0.83

Intensity of science-driven open search strategy: To explore the intensity of science-driven open search strategy, firms were asked to indicate the level of perceived effectiveness of their reciprocal interactions with each of the three types of potential science-based partners, including: universities and local academics, commercial laboratories or R&D enterprises and universities or local academics, over the last three years (2012 to 2015), on a 7-point Likert scale (1=`very unimportant` to 7=`very important`). A firm`s science-driven open search strategy can be directed towards reciprocal knowledge exchange activities with a single science-based partner, or several of them. An exploratory factor analysis on the items suggested that all three items loaded on a single factor (eigenvalues > 1), accounted for 69.42 percent of the variance. Coefficient α for the scale was 0.78 (Table 2.10).

Table 2.10: Exploratory factor analysis: Science-driven open search strategy

Items	*Loadings*
Commercial Laboratories or R&D Enterprises	0.86
Public Research Organisations	0.85
Universities or Local Academics	0.79
% of Variance	69.42
Cronbach's alpha	0.78

Intensity of institutional open search strategy: To explore the intensity of institutional open search strategy, firms were asked to indicate the level of perceived effectiveness of their reciprocal interactions with each of the four types of potential institutional partners, including: financial institutions and banks, local and national government, park management or centre management, professional and industry/trade associations, over the last three years (2012 to 2015), on a seven-point Likert-type scale (where `1` denoted `very unimportant` and `7` denoted `very important). A firm` institutional open search strategy can be directed towards reciprocal knowledge exchange activities with a single institutional partner, or several of them. An exploratory factor analysis on the items suggested that all four items loaded on a single factor (eigenvalues > 1), accounted for 62.37 percent of the variance. Coefficient α for the scale was 0.80 (Table 2.11).

Table 2.11: Exploratory factor analysis: Institutional open search strategy

Items	*Loadings*
Financial Institutions and Banks	0.76
Local and national Government	0.78
Park Management or Centre Management	0.82
Professional and Industry/Trade Associations	0.80
% of Variance	62.37
Cronbach's alpha	0.80

2.4.2.2. Control Variables

Previous studies of open search strategy have suggested that success in reciprocal knowledge exchange with external partners is attributable to the several contextual factors. Smaller firms face several inherited challenges which affect their abilities to engage in open search activities. The liability of smallness is believed to be the main source of the observed disparities between smaller and lager firms in terms of their open search performance. Considering the aims of this chapter and given that many studies of open innovation have mentioned the potential effects of various firm-specific variables on the firms` open search performance, two key variables of `firm size` and `years spent in park` were introduced to control for their potential effects.

Size: Prior research has shown that there are marked differences in the type and intensity of open search activities between smaller and larger firms (van de Vrande et al., 2009; Lee et al., 2010; Bianchi et al., 2010; Parida, Westerberg & Frishammar, 2012; Spithoven, Vanhaverbeke & Roijakkers, 2013; Xia, 2013; Love & Roper, 2014; Vahter et al., 2014; Brunswicker & Vanhaverbeke, 2015; Verbano, Crema & Venturini, 2015; Xia & Roper, 2016). For smaller firms, their liability of smallness presents several challenges, such as: lack of internal resources and competences, lack of financial resources, lack of human resources and skilled workers, lack of research and development resources, limited multidisciplinary competence base and weak appropriation strategy, which are said to be barriers to open search activities. On the other hand, larger firms are known to be more successful in reciprocal knowledge exchange and interactions with their external partners (Teece, 1986). This study, thus, examined the role of size, using the natural logarithm of number of employees. Out of 342 firms, 65.8 percent were micro enterprises; 28.9 percent small enterprises; 5.3 percent medium size enterprises. The average number of employees was 14.65.

Years spent in park: It is evident from the literature that geographic proximity of firms would increase cognitive proximity between them (Parra-Requena, Molina-Morales & García-Villaverde, 2010; Capaldo & Petruzzelli, 2014), and reduce knowledge distance between partner firms (Boschma, 2005). In the ecosystem of science and technology parks, three factors of close geographic proximity of co-located tenant firms, resource interdependency and complementarities progressively catalyse interactions between onsite firms, and between them and other stakeholders. Onsite firms require time to develop their knowledge acquisition capabilities, to establish their positions in, and familiarise themselves with the conditions of ecosystem and potential partners. Hence, the propensity of a firm to draw from externally available sources could be influenced by the number of years a firm spent in park as well as its age. Older firms are known to possess more refined resource that could facilitate the process of knowledge acquisition and exploitation (Sinkula, 1994; Huergo & Jaumandreu, 2004; Parida, Westerberg & Frishammar, 2012). Thus, the number of years a firm spent in a science and technology park, may potentially interfere with the relationships being studied. The variable, years spent in park, was operationalised using the natural logarithm of the total number of years each firm had spent in a science and technology park at the time of survey. The median of total number of years firms had spent in science and technology parks was 5 years.

2.4.2.3. Variables for Multi-Group Analysis

In this study, multi-group analysis was used to explore the effects of a firm`s internal capacity for research and development on the potential associations between its open search activities and performance. The objective of performing multi-group analysis was to confirm that whether the paths between two groups with `low` and `high` internal capacity for research and development were significantly different or not.

Internal capacity for research and development: The complementarity between internal knowledge based and external sources of knowledge is key to the success of reciprocal knowledge exchange activities (Lane & Lubatkin, 1998). A firm`s internal capacity for research and development is positively associated with the propensity to engage in reciprocal interactions with cocreation partners (Teirlinck & Spithoven, 2013; West & Bogers, 2014). There is a general agreement in the literature that the ability of smaller firms, compared to their larger rivals, is considerably constrained by their liability of smallness (Freeman, Carroll & Hannan, 1983). This can potentially impact their open search endeavours, as they would have less technological and knowledge assets to bargain with, and attract external partner (Dahlander & Gann, 2010). On the other hand, lack of internal capacity for in-house research and development activities (Madrid-Guijarro, Garcia & Van Auken, 2009), lack of formal R&D management structures (Teirlinck & Spithoven, 2013) and lack of human resources and skilled workers (van de Vrande et al., 2009; Sawang & Unsworth, 2011) would potentially limit their cognitive capacity to recognise, absorb and integrate external knowledge (Pavitt, 1998; Dickson, Weaver & Hoy, 2006), and may even lead to the not invented here syndrome (Chesbrough & Crowther, 2006). In general, a firm`s internal capacity for R&D is known to be the key determinant of its ability to achieve the expected benefits from external sourcing activities (Veugelers and Cassiman, 1999; Roper & Hewitt-Dundas, 2013). Nevertheless, there are differences between the requirements for various types of reciprocal knowledge exchange and joint R&D activities (Narula, 2004). As firms innovate differently, their objectives for seeking external knowledge sourcing options would also vary widely (Tether, 2005).

To explore the role of internal capacity for research and development, the importance of drawing on internal sources of specialist know-how (from the focal firm`s own business or enterprise group) over the last three years (2012 to 2015) was measured on a seven-point Likert scale (1 denoted `very unimportant` and 7 denoted `very important`). In order to observe the impact of internal capacity of research and development on the hypothesised relationships, a dummy variable was created. In practice, internal capacity for research and development of a firm was coded 0 when the respondent gave a score of 1, 2 or 3 on the scale, whereas it was coded 1 when the response was 4 to 7. Based on the obtained mean value, firms were divided into two groups: onsite firms with low internal capacity for research and development (10 percent, n = 35), and onsite firms with high internal capacity for research and development (90 percent, n = 307).

2.5. Data analysis and Results

2.5.1. Tests for Potential Biases

Non-response bias was evaluated to ensure that the sample represents the population (Armstrong & Terry, 1977). Non-response bias tests were conducted by comparing the mean figures between two groups of the early responses and the late responses on independent and dependent variables. The late responses group contained 206 questionnaires which were received during the second wave of the survey. Table 2.12 presents the results of Mann–Whitney U tests. No significant differences between the mean values obtained for the early respondents and the late respondents were detected.

Table 2.12: Non-response survey bias test: Mann–Whitney U tests

All firms (n=384)	Early respondents (n=178)		Late respondents (n=206)		Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Variable	Mean	S.D.	Mean	S.D.				
Offsite market-driven open search strategy	4.61	1.24	4.65	1.08	14261.00	24992.00	-0.05	0.96
Onsite market-driven open search strategy	3.27	1.56	3.13	1.55	13550.00	32856.00	-0.84	0.40
Technical and application-driven open search strategy	4.94	1.21	4.92	1.13	13976.50	33282.50	-0.37	0.71
Science-driven open search strategy	3.94	1.58	3.92	1.62	14243.50	33549.50	-0.07	0.94
Institutional open search strategy	3.91	1.53	3.91	1.40	14038.00	33344.00	-0.30	0.77
Open system performance	4.14	1.00	4.11	0.96	13442.00	24173.00	-0.96	0.34
Rational goal performance	4.69	1.38	4.78	1.41	13411.50	24142.50	-1.00	0.32

Data collected using surveys may also suffer from the common method variance or bias (CMB). In this study, data on the latent variables were collected through a single questionnaire, and in a self-reported form. This could potentially signal the possibility of bias caused by using a single method of data collection. In pursuance of maximising the data accuracy and reliability, this study followed the recommendations of Podsakoff et al. (2003), Huber & Power (1985) and Dillman, Smyth & Christian (2014) on how to design the questionnaire. Considerable steps were also taken before, during and after the survey to minimise any bias that CMV can introduce into the study. Firstly, both the measurement of predictor and criterion variables were psychologically separated, and the response anonymity was guaranteed. Further, to test ex post for the presence of common method bias, the Harmon's One Factor test (Podsakoff et al., 2003) and the Common Latent Factor (CLF) method (Williams & Anderson, 1994) were adopted. The results of Harmon's one-factor test are presented in Table 2.13. The results of the unrotated principal component analyses showed that no single dominant factor accounted for the majority of the co-variance across all the items (explained variance by the single factor <50%). The results indicated that common method variance was not an issue in the dataset.

Table 2.13: Common method variance or bias test: Harman's one-factor test

	Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %
1	9.84	31.75	31.75

In addition, the results of comparing standardised regression weights of the model, with and without a common latent factor, did not exceed the recommended threshold of 0.2, which was an indication of common-method variance absence. Table 2.14 presents the results of common latent factor test. The results obtained from the Herman`s one factor test and the common latent factor test implied an absence of common method bias (Malhotra, Kim & Patil, 2006).

Table 2.14: Common method variance or bias test: Common latent factor test

Variables	Standardised Regression Weights with	Standardised Regression Weights	Difference
Conferences and Meetings	0.762	0.763	0.001
Experts, Consultants or Advisors	0.708	0.712	0.004
Fairs and Exhibitions	0.654	0.658	0.004
Scientific Journals and Trade/Technical Publications	0.634	0.636	0.002
Trainings or External Sources of Professional Know-How	0.69	0.685	-0.005
Financial Institutions and Banks	0.638	0.642	0.004
Local and national Government	0.659	0.66	0.001
Park Management or Centre Management	0.81	0.795	-0.015
Professional and Industry/Trade Associations	0.711	0.715	0.004
Offsite Competitors	0.658	0.657	-0.001
Offsite Clients or Customers from the Public Sector	0.727	0.693	-0.034
Offsite Clients or Customers from the Private Sector	0.605	0.596	-0.009
Other Offsite Enterprises in other Sectors	0.781	0.792	0.011
Other Offsite Businesses in Your Sector that are not Direct Competitors	0.79	0.803	0.013
Offsite Suppliers of Equipment, Materials, Components, or Software	0.694	0.69	-0.004
Onsite Competitors	0.799	0.837	0.038
Onsite Clients or Customers from the Public Sector	0.8	0.706	-0.094
Onsite Clients or Customers from the Private Sector	0.776	0.749	-0.027
Other Onsite Businesses in Your Sector that are not Direct Competitors	0.745	0.831	0.086
Other Onsite Enterprises in other Sectors	0.763	0.842	0.079
Onsite Suppliers of Equipment, Materials, Components, or Software	0.728	0.773	0.045
Market Share	0.843	0.848	0.005
Profitability	0.867	0.871	0.004
Sales	0.938	0.943	0.005
Turnover Growth	0.937	0.944	0.007
Adaptability to Market Changes	0.628	0.63	0.002
Image of the Firm and its Products/Services	0.806	0.802	-0.004
Quality of Products/Services	0.766	0.768	0.002
Commercial Laboratories or R&D Enterprises	0.792	0.799	0.007
Public Research Organisations	0.766	0.775	0.009
Universities or Local Academics	0.632	0.641	0.009

2.5.2. Normality and Homoscedasticity

The patterns in terms of normality, homoscedasticity and multicollinearity assumptions were further tested to ensure that the model satisfies the assumptions of structural equation modelling. First, the data was tested to for normality. The Kolmogorov-Smirnov and Shapiro-Wilk (K-S) statistics (Shapiro & Wilk, 1965), presented in Table 2.15, revealed that the assumption of normality was violated.

Table 2.15: Normality test: Kolmogorov–Smirnov and Shapiro–Wilk tests

Variables	Kolmogorov-Smirnov Test			Shapiro-Wilk Test		
	Statistic	*df.*	*sig.*	*Statistic*	*df.*	*sig.*
Offsite market-driven open search strategy	0.097	342	0	0.96	342	0
Onsite market-driven open search strategy	0.132	342	0	0.94	342	0
Technical and application-driven open search strategy	0.123	342	0	0.93	342	0
Science-driven open search strategy	0.099	342	0	0.97	342	0
Institutional open search strategy	0.133	342	0	0.95	342	0
Open system performance	0.123	342	0	0.96	342	0
Rational goal performance	0.119	342	0	0.96	342	0

According to Pallant (2013), the Kolmogorov-Smirnov and Shapiro-Wilk (K-S) statistics are very sensitive to the size of sample. In addition, the larger the size of a sample is, lesser is the negative effects of non-normality (Hair et al., 2014). Moreover, Bentler & Chou (1987) point out that all data collected in the field of social sciences may potentially suffer from non-normal distributions. Hence, the significant values obtained from the K-S tests were not necessarily signs of deviation of data from normal distribution. As a further step in testing normality, data on all variables were subjected to a series of skewness and kurtosis tests (Pallant, 2013). Table 2.16 shows that all variables were within the recommended range (<±2.58) of skewness and kurtosis (Hair et al., 2014).

Table 2.16: Normality test: Skewness and Kurtosis tests

Variables	n	Mean	S.D.	Skewness		Kurtosis	
				Statistic	*S.E.*	*Statistic*	*S.E.*
Offsite market-driven open search strategy	342	4.63	1.15	-0.78	0.13	0.78	0.26
Onsite market-driven open search strategy	342	3.19	1.55	0.07	0.13	-0.98	0.26
Technical and application-driven open search strategy	342	4.93	1.16	-1.06	0.13	1.53	0.26
Science-driven open search strategy	342	3.93	1.6	-0.14	0.13	-0.74	0.26
Institutional open search strategy	342	3.91	1.46	-0.49	0.13	-0.57	0.26
Open system performance	342	4.12	0.98	-0.38	0.13	-0.43	0.26
Rational goal performance	342	4.74	1.4	-0.48	0.13	0.03	0.26

To test for the multivariate normality assumption, Mardia's coefficient was estimated. Table 2.17 complies the results obtained for multivariate normality. The Mardia's coefficient, or Multivariate kurtosis value, and the critical ratio value were 175.73 and 35.92, respectively. The critical value obtained at this stage was higher than the recommended threshold which indicated that the assumption of multivariate normality was violated (Brwon, 1982).

Table 2.17: Multivariate normality test: Mardia's test

Variables	skew	c.r.	kurtosis	c.r.
Quality of Products/Services	-0.62	-4.66	-0.46	-1.74
Image of the Firm and its Products/Services	-0.47	-3.58	-0.31	-1.15
Adaptability to Market Changes	-0.58	-4.34	0.17	0.63
Universities or Local Academics	-0.54	-4.04	-0.80	-3.03
Public Research Organisations	0.02	0.12	-1.20	-4.54
Commercial Laboratories or R&D Enterprises	-0.02	-0.13	-1.32	-5.00
Professional and Industry/Trade Associations	-0.34	-2.54	-1.15	-4.35
Park Management or Centre Management	-0.19	-1.40	-1.15	-4.33
Local and national Government	-0.59	-4.42	-0.91	-3.44
Financial Institutions and Banks	-0.10	-0.74	-1.05	-3.98
Experts, Consultants or Advisors	-1.07	-8.06	1.11	4.19
Scientific Journals and Trade/Technical Publications	-0.92	-6.92	0.09	0.34
Fairs and Exhibitions	-1.01	-7.65	0.53	2.01
Trainings or External Sources of Professional Know-How	-0.95	-7.17	0.28	1.07
Conferences and Meetings	-1.40	-10.58	1.84	6.94
Sales	-0.53	-4.02	-0.08	-0.31
Profitability	-0.38	-2.83	-0.23	-0.86
Turnover Growth	-0.46	-3.48	-0.15	-0.56
Market Share	-0.38	-2.84	-0.17	-0.63
Offsite Clients or Customers from the Private Sector	-1.05	-7.93	1.29	4.86
Other Offsite Enterprises in other Sectors	-0.66	-5.00	0.06	0.22
Offsite Clients or Customers from the Public Sector	-0.71	-5.32	-0.15	-0.55
Offsite Competitors	-0.72	-5.43	-0.09	-0.35
Other Offsite Businesses in Your Sector that are not Direct Competitors	-0.77	-5.78	0.04	0.17
Offsite Suppliers of Equipment, Materials, Components, or Software	-0.74	-5.62	-0.38	-1.42
Onsite Clients or Customers from the Public Sector	0.30	2.25	-1.17	-4.40
Onsite Clients or Customers from the Private Sector	0.00	-0.02	-1.32	-4.98
Onsite Suppliers of Equipment, Materials, Components, or Software	0.19	1.44	-1.13	-4.26
Onsite Competitors	0.46	3.49	-0.90	-3.40
Other Onsite Businesses in Your Sector that are not Direct Competitors	0.17	1.27	-1.20	-4.52
Other Onsite Enterprises in other Sectors	0.15	1.10	-1.21	-4.57
Multivariate Kurtosis Value (Mardia's coefficient)				**175.73**
Critical Ratio Value				**35.92**

The Levene`s test of homogeneity of variances was used to check for homoscedasticity. Table 2.18 shows that all obtained values were higher than the minimum significant level of 0.05 (Field, 2013). It worth noting that the results of Levene's test are also sensitive to the size of sample. In large samples, significant results may not necessary signal the presence of substantial non-normality.

Table 2.18: Homogeneity of variances test: Levene`s test

Variables	Levene Statistic	df1	df2	Sig.
Offsite market-driven open search strategy	3.31	1	340	0.07
Onsite market-driven open search strategy	0.01	1	340	0.94
Technical and application-driven open search strategy	0.03	1	340	0.86
Science-driven open search strategy	0.89	1	340	0.35
Institutional open search strategy	1.87	1	340	0.17
Open system performance	0.37	1	340	0.55
Rational goal performance	0.22	1	340	0.64

Finally, data were assessed for presence of multicollinearity. The results compiled in Table 2.19 show that all tolerance values and VIF values were respectively less than 0.20 and 5, suggesting the absence of multicollinearity.

Table 2.19: Collinearity test

	(1)		(2)		(3)		(4)		(5)	
Variables	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
(1) Offsite market-driven open search strategy	---	---	0.80	1.25	0.78	1.29	0.75	1.33	0.77	1.31
(2) Onsite market-driven open search strategy	0.75	1.34	---	---	0.71	1.41	0.71	1.42	0.76	1.32
(3) Technical and application-driven open search strategy	0.74	1.35	0.73	1.38	---	---	0.75	1.34	0.75	1.34
(4) Science-driven open search strategy	0.75	1.34	0.75	1.33	0.78	1.28	---	---	0.80	1.25
(5) Institutional open search strategy	0.65	1.54	0.69	1.45	0.67	1.50	0.69	1.46	---	---

2.5.3. Statistical Method

The partial least squares (PLS) is a powerful regression-based technique and a nonparametric approach to structural equation modelling that can handle complex predictive models, when the nature of a study necessities theory building, or has predictive applications (Chin & Newsted, 1999). In addition, the partial least squares modelling is a very useful means to model latent constructs with multiple indicators when the assumptions of normality are violated (Hair, 2017a). In this study, the partial least squares modelling was preferred over other viable options for two reasons. First, the incremental nature of current study necessitated development of new structural paths. Second, the results presented in the earlier sections of this study revealed that the assumptions of multivariate normality were violated. The multivariate normality of data is not a very strict requirement for partial least squares modelling (Chin, 1998), as it places minimal restrictions on measurement scales (Hair, 2017b). Hence, the partial least squares technique deemed to be the most suitable approach to serve the twofold purpose of the current research study. In recent years, the partial least squares technique has gained popularity among researchers in the field of business and management studies (West et al., 2016; Hung, 2017). In this study, the hypothesised relationships between independent and dependent variables were analysed through structural equations modelling, with partial least squares estimation using the SmartPLS 2.0 software (Ringle, Wende & Will, 2005).

2.5.3.1. Measurement Model

Using a two-step approach, the conceptual model presented in the earlier section of this chapter was evaluated on a hierarchal basis (Henseler & Fassott, 2010; Hair et al., 2017a; 2017b;). First, four parameters of internal consistency reliability, indicator reliability, convergent validity, and discriminating validity were examined to assess the measurement model (Hair et al., 2014; Hair et al., 2017a).

To ensure the internal consistency of measurement model, absolute correlations or standardised outer loadings are required to be greater than 0.4 (Churchill, 1979; Hair et al., 2014). The statistical results complied in Table 2.20 shows that each item`s loading on the intended dimension exceeds the standard cut-off point of .40, exhibiting satisfactory item-level internal consistency (Churchill, 1979; Chin, 1998; Hair et al., 2017a).

The construct-level reliability of measurement model was assessed using both Cronbach`s coefficient (α) (Cronbach, 1951) and composite reliability (ρ_c) measures (Fornell & Larcker, 1981). As depicted in Table 2.21, the coefficient alpha values were between 0.77 to 0.94 (>0.70), and all composite reliability values, ranging from 0.87 to 0.96, were greater than the suggested threshold of 0.7 (Nunnally & Bernstein, 1994), supporting the construct-level reliability of measurement model. To establish the convergent validity of measurement model, composite reliability values should be greater than the average variance extracted (AVE) values (Nunnally & Bernstein, 1994; Hair et al., 2014), and AVE values should be greater than 0.5 (Fornell & Larcker, 1981). Table 2.21 shows that all AVE values were higher than the recommended threshold, ranging from 0.58 to 0.86. The discriminant validity at construct-level, according to Fornell & Larcker (1981), is established when the differences between AVE values and the highest squared inter-construct correlations are positive. The statistical results compiled in Table 2.20 suggested that each construct`s square-root of AVE was greater than the inter-construct correlation values, providing evidence of discriminant validity. Item-level discriminant validity was also confirmed by examining the cross-loadings (Chin, 1998). All cross-loadings were lower than the recommended threshold of 0.4.

Table 2.20: Internal consistency tests

	Technical and application-driven open search strategy	Institutional open search strategy	Offsite market-driven open search strategy	Onsite market-driven open search strategy	Science-driven open search strategy	Rational goal performance	Open system performance
Conferences and Meetings	0.82	0.30	0.29	0.25	0.29	0.32	0.25
Trainings or External Sources of Professional Know-How	0.77	0.34	0.29	0.32	0.33	0.34	0.25
Fairs and Exhibitions	0.73	0.28	0.28	0.26	0.29	0.33	0.22
Scientific Journals and Trade/Technical Publications	0.77	0.38	0.30	0.28	0.29	0.33	0.29
Experts, Consultants or Advisors	0.76	0.38	0.28	0.32	0.31	0.32	0.26
Financial Institutions and Banks	0.34	0.77	0.29	0.30	0.28	0.34	0.19
Local and national Government	0.33	0.74	0.27	0.29	0.35	0.24	0.16
Park Management or Centre Management	0.38	0.85	0.34	0.48	0.38	0.40	0.30
Professional and Industry/Trade Associations	0.32	0.79	0.28	0.39	0.38	0.28	0.23
Offsite Competitors	0.24	0.28	0.71	0.28	0.16	0.21	0.19
Offsite Clients or Customers from the Private Sector	0.24	0.21	0.70	0.24	0.16	0.28	0.24
Offsite Clients or Customers from the Public Sector	0.30	0.33	0.78	0.29	0.27	0.32	0.25
Other Offsite Enterprises in other Sectors	0.30	0.33	0.81	0.39	0.20	0.29	0.27
Other Offsite Businesses in Your Sector that are not Direct Competitors	0.30	0.33	0.82	0.37	0.22	0.29	0.25
Offsite Suppliers of Equipment, Materials, Components, or Software	0.31	0.26	0.77	0.32	0.25	0.35	0.25
Onsite Competitors	0.29	0.41	0.34	0.85	0.22	0.29	0.22
Onsite Clients or Customers from the Private Sector	0.37	0.42	0.33	0.82	0.28	0.41	0.28
Onsite Clients or Customers from the Public Sector	0.26	0.43	0.34	0.78	0.34	0.37	0.21
Other Onsite Businesses in Your Sector that are not Direct Competitors	0.26	0.36	0.33	0.83	0.20	0.26	0.18
Other Onsite Enterprises in other Sectors	0.28	0.36	0.34	0.85	0.26	0.33	0.20
Onsite Suppliers of Equipment, Materials, Components, or Software	0.33	0.37	0.37	0.82	0.32	0.39	0.27
Commercial Laboratories or R&D Enterprises	0.34	0.34	0.23	0.32	0.88	0.33	0.33
Public Research Organisations	0.35	0.40	0.27	0.29	0.84	0.28	0.26
Universities or Local Academics	0.28	0.36	0.20	0.22	0.78	0.22	0.31
Market Share	0.38	0.34	0.35	0.33	0.29	0.89	0.45
Profitability	0.38	0.35	0.37	0.39	0.28	0.91	0.43
Sales	0.43	0.42	0.35	0.45	0.35	0.95	0.45
Turnover Growth	0.39	0.40	0.37	0.39	0.32	0.95	0.46
Image of the Firm and its Products/Services	0.28	0.26	0.31	0.30	0.31	0.45	0.86
Quality of Products/Services	0.25	0.25	0.24	0.19	0.24	0.38	0.84
Adaptability to Market Changes	0.29	0.21	0.24	0.20	0.33	0.36	0.79

Table 2.21: Descriptive statistics, simple correlations, convergent validity, construct-level reliability and discriminant validity

Variable	**Mean**	**S.D.**	**Cronbach's α**	**Composite Reliability (ρ_c)**	**Fornell-Larcker Criterion**	**AVE**	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
(1) Technical and application-driven open search strategy	4.93	1.16	0.83	0.88	0.77	0.60	---								
(2) Institutional open search strategy	3.91	1.46	0.80	0.87	0.79	0.62	0.44	---							
(3) Offsite market-driven open search strategy	4.63	1.15	0.86	0.89	0.76	0.58	0.33	0.29	---						
(4) Onsite market-driven open search strategy	3.19	1.55	0.91	0.93	0.83	0.68	0.37	0.38	0.42	---					
(5) Science-driven open search strategy	3.93	1.60	0.78	0.87	0.83	0.69	0.37	0.48	0.28	0.33	---				
(6) Open system performance	4.12	0.98	0.77	0.87	0.83	0.69	0.43	0.41	0.32	0.28	0.36	---			
(7) Rational goal performance	4.74	1.40	0.94	0.96	0.93	0.86	0.39	0.44	0.39	0.42	0.34	0.48	---		
(8) Size (ln)	1.84	1.19	---	---	---	---	0.09	0.04	0.11	-0.02	0.05	0.04	0.04	---	
(9) Year spent in park (ln)	1.53	0.78	---	---	---	---	-0.14	-0.09	-0.04	-0.14	0.06	-0.09	-0.04	0.02	---

2.5.3.2. Structural Model

In order to evaluate the structural model, a set of criteria, including: R^2 (determination coefficients; Chin, 1998; Hair et al., 2014), f^2 (effect size criterion, as an indicator of changes in determination coefficients; Hair et al., 2017a), Q^2 (cross-validated redundancy measure) and q^2 (Stone-Geisser`s criterion for predictive relevance, as an indicator of changes in cross-validated redundancy values; Geisser, 1975; Stone, 1974) were estimated. To ensure the overall robustness of structural model, the Tenenhaus et al.`s (2005) criterion of goodness-of-fit (GoF) was estimated. Finally, β (path coefficient) and t-value (significance level of the structural path coefficient) were estimated using the analytic procedures (Edwards & Lambert, 2007) and bootstrapping approach, respectively in order to test the significance of each hypothesised relationship between dependent and independent variables.

2.5.3.3. Model Fit

The cut-point values for the estimated determination coefficient (R^2) of 0.67(substantial), 0.33(moderate), and 0.19 (weak) are recommended by Chin (1998). In the base model, as depicted in Table 2.22, R^2 for rational goal performance was 0.31, and for open system performance was 0.21. On the other hand, any negative or equal to zero values of Q^2 would indicate lack of predictive relevance (Hair et al. 2017a). As shown in Table 2.22, these values were 0.28 and 0.13, respectively for rational goal performance and open system performance. Tenenhaus et al.`s (2005) criterion of goodness-of-fit can take any value between 0 and 1. Values close to 1 indicate that the model is more robust (Hair et al. 2017a). The GoF values obtained for the base model was 0.42, and for the model with control variables was 0.44.

Table 2.22: Communalities, determination coefficients, cross-validated redundancy measures and goodness-of-fit criterion

	Communality		*R^2 Value*		*Redundancy*		*Q^2 Value*	
	Model 1	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*
Technical and application-driven open search strategy	0.597	0.597	---	---	---	---	---	---
Institutional open search strategy	0.621	0.621	---	---	---	---	---	---
Offsite market-driven open search strategy	0.583	0.583	---	---	---	---	---	---
Onsite market-driven open search strategy	0.684	0.684	---	---	---	---	---	---
Science-driven open search strategy	0.694	0.694	---	---	---	---	---	---
Open system performance	0.689	0.689	0.208	0.213	0.050	0.048	0.132	0.141
Rational goal performance	0.858	0.858	0.312	0.313	0.115	0.116	0.267	0.268
Size (ln)	---	1.000	---	---	---	---	---	---
Year spent in park (ln)	---	1.000	---	---	---	---	---	---
GoF	0.419	0.443						

2.5.3.4. Test of Hypotheses

In order to estimate the standardised path coefficients and their statistical significance, a nonparametric bootstrapping analysis (with 5000 subsamples; 342 cases; individual sign change) was conducted. In addition, both explanatory and predictive power (f^2, q^2) were estimated. The explanatory power, or effect size, indicates the impact of a specific predictor construct on an endogenous construct. This study used the Cohen's (1988) effect size index to estimate the explanatory power of each predictor. The cut-point values for f^2 of 0.02 (weak), 0.15 (moderate) and 0.35 (significant) are recommended by (Hair et al., 2017a). On the other hand, the predictive relevance is an indicator of changes in cross-validated redundancy values. The cross-validated redundancy measures the "capability of the path model to predict the dependent or endogenous measuring items indirectly from the prediction of their own latent variable using the related structural relation, by cross-validation" (Tenenhaus et al., 2005: 181-182). The values of 0.02, 0.15, 0.35 are known to be respectively small, medium and strong values for q^2 (Hair et al., 2017a). The blindfolding procedure (using omission distance G =7) was utilised to estimate q^2 (Götz, Liehr-Gobbers & Krafft, 2010).

The statistical results compiled in Table 2.23 showed that Hypothesis 1.1 (β=0.16, t-value=2.78) and Hypothesis 1.2 (β=0.16, t-value=2.75) were both supported. Hypothesis 1.1 put forward the idea that the intensity of a firm`s offsite market-driven open search strategy will positively affect its open system performance. Hypothesis 1.2 predicted that the intensity of a firm`s offsite market-driven open search strategy will positively affect its rational goal performance. The explanatory and predictive power of offsite market-driven open search strategy on rational goal performance (f^2=*0.025*, q^2=*0.013*), and on open system performance (f^2=*0.026*, q^2=*0.022*) were both relatively small.

On the other hand, the intensity of onsite market-driven open search strategy was not significantly related to the open system performance (β=0.07, t-value=1.29). Both the explanatory and predictive power of onsite market-driven open search strategy were negligible (f^2=*0.005*, q^2=*0.001*). Hence, Hypothesis 2.1 was rejected. However, it was revealed that the intensity of onsite market-driven open search strategy was positively and significantly related to rational goal performance (β=0.19, t-value=3.08). Thus, Hypothesis 2.2 was supported. Nevertheless, both explanatory and predictive power values were found to be relatively small (f^2=*0.036*, q^2=*0.028*).

Hypothesis 3.1 and 3.2 were also supported. The statistical results derived from the path analyses showed that the hypothesised relationships between the intensity of science-driven open search strategy and open system performance (β=0.22, t-value=3.98) and rational goal performance (β=0.09, t-value=1.79) were both significant. Nevertheless, it exerted relatively small explanatory and predictive power on both open system performance (f^2=0.046, q^2=0.026), and rational goal performance (f^2=0.009, q^2=0.008).

Hypothesis 4.1 anticipated a direct relationship between the intensity of a firm`s Institutional open search strategy and its open system performance. However, the hypothesised relationship was not statistically significant (β=0.03, t-value=0.59), thus, rejected. The explanatory and predictive power values also revealed very small and negligible effects of the intensity of Institutional open search strategy on open system performance (f^2=0.001, q^2=0.002). In contrast, the intensity of Institutional open search strategy was positively and significantly associated with rational goal performance (β=0.13, t-value=2.26). Hence, Hypothesis 4.2 was supported. The explanatory and predictive power of the intensity of a firm`s Institutional open search strategy on its rational goal performance (f^2=0.016, q^2=0.013) were both relatively small.

Hypotheses 5.1 and 5.2 were both supported. The intensity of a firm`s technical and application-driven open search strategy was positively and significantly related to its open system performance (β=0.14, t-value=2.36) and rational goal performance (β=0.21, t-value=3.46). Nevertheless, the explanatory and predictive power of independent variable on both open system performance (f^2=0.018,

q^2=0.011) and rational goal performance (f^2=0.044, q^2=0.035) were relatively small. The structural models are presented in Fig. 2.2 and Fig. 2.3 (Appendix.2).

In addition, two control variables were deemed to have potential effects on firms` open system performance and rational goal performance. To test these assumptions, all hypotheses (direct paths) were simultaneously tested, while controlling for two variables of `firm size` and `years spent in park`. As shown in Table 2.23, however, no significant effects were found. The graphical representations of paths are presented in Fig. 2.4 and Fig. 2.5 (Appendix.2).

Table 2.23: Structural model results

Hypothesis No.	Path Direction	β		t-value		S.E.		Δ R2		Δ Q2		f2		q2		Supported/Not Supported
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	
H.1.1	Offsite market-driven -> Open system performance	0.16***	0.16***	2.78	2.792	0.06	0.059	0.020	0.020	0.012	0.013	0.025	0.025	0.013	0.015	Supported
H.1.2	Offsite market-driven -> Rational goal performance	0.16***	0.16***	2.75	2.700	0.06	0.058	0.018	0.018	0.016	0.016	0.026	0.026	0.022	0.022	Supported
H.2.1	Onsite market-driven -> Open system performance	0.07	0.06	1.29	1.055	0.06	0.062	0.004	0.003	0.001	0.002	0.005	0.004	0.001	0.002	Not Supported
H.2.2	Onsite market-driven -> Rational goal performance	0.19***	0.19***	3.08	3.059	0.06	0.063	0.025	0.025	0.021	0.021	0.036	0.036	0.028	0.029	Supported
H.3.1	Science-driven -> Open system performance	0.22***	0.23***	3.98	4.051	0.06	0.057	0.036	0.039	0.023	0.025	0.046	0.050	0.026	0.029	Supported
H.3.2	Science-driven -> Rational goal performance	0.09*	0.09*	1.79	1.672	0.05	0.053	0.007	0.006	0.006	0.005	0.009	0.008	0.008	0.007	Supported
H.4.1	Institutional -> Open system performance	0.03	0.03	0.59	0.518	0.06	0.059	0.001	0.000	0.002	0.000	0.001	0.000	0.002	0.001	Not Supported
H.4.2	Institutional -> Rational goal performance	0.13**	0.13**	2.26	2.263	0.06	0.058	0.011	0.011	0.009	0.009	0.016	0.016	0.013	0.013	Supported
H.5.1	Technical and application-driven -> Open system performance	0.14***	0.13**	2.36	2.136	0.06	0.062	0.014	0.012	0.009	0.008	0.018	0.015	0.011	0.009	Supported
H.5.2	Technical and application-driven -> Rational goal performance	0.21***	0.21***	3.46	3.525	0.06	0.060	0.030	0.031	0.026	0.026	0.044	0.045	0.035	0.036	Supported
Control	Size(Ln) -> Open system performance	---	0.00	---	0.046	---	0.056	---	0.000	---	0.000	---	0.000	---	0.000	nonsignificant
Control	Size(Ln) -> Rational goal performance	---	0.00	---	0.022	---	0.049	---	0.000	---	0.000	---	0.000	---	0.000	nonsignificant
Control	Years spent in parks(Ln) -> Open system performance	---	-0.07	---	1.048	---	0.067	---	0.005	---	0.003	---	0.006	---	0.004	nonsignificant
Control	Years spent in parks(Ln) -> Rational goal performance	---	0.03	---	0.589	---	0.046	---	0.001	---	0.002	---	0.001	---	0.002	nonsignificant

Notes: *** p<0.001, ** p<0.001, * p<0.05;

2.5.3.5. Multi-group Analysis

Multi-group analysis allows researchers to simultaneously examine the potential effects of a third variable across all hypothesised relationships, and to compare the results. In this study, the partial least squares-based multi-group analysis was adopted to investigate the impact of capacity for internal research and development on the hypothesised associations between the independent and the dependent variables. The multi-group comparison entails dividing the sample into groups according to the variable of interest. Then, the research model is estimated for each subsample separately. Finally, any statistically significant differences between the path coefficients of anticipated relationships between estimated models for each subsample would signal the departure points between two groups of observations (Qureshi & Compeau, 2009).

As discussed earlier, firms are only able to recognise, absorb and integrate external knowledge which is known to them. In other words, a degree of complementarity between external knowledge and internal knowledge base of a firm is essential for the success of its open search activities (Lane & Lubatkin, 1998). A firm`s internal capacity for research and development is known to be the key player in the success of reciprocal knowledge exchange in collaborative innovation processes (West & Bogers, 2014).

Two subsamples of firms with `low capacity for internal research and development` and firms with `high capacity for internal research and development` were used to investigate potential interplay between firms` internal capacity and their ability to gain expected benefits from various open search activities. On the questionnaire, firms were asked to evaluate the importance of their internal sources of specialist know-how for their innovation activities on a seven-point Likert scale, ranging from “very unimportant” to “very important”. A dummy variable was created by dividing the firms into two distinct groups of low internal capacity for research and development (n=35; when the respondent gave a score of 1, 2 or 3) and high internal capacity for research and development (n=307; when the respondent gave a score of 4 to 7). Two groups were confirmed to be significantly different from each other ($F=460.466$, $p<0.000$).

In order to ensure the convergent validity of measurement models (Fornell & Larcker, 1981), both AVE values and their square roots were estimated. The statistical results compiled in Table 2.24 suggested that all AVEs were greater than 0.5, and the square roots of all of them were larger than the recommended threshold value of 0.7. In addition, none of the inter-construct correlation values exceeded the individual AVE values, suggesting acceptable levels of convergent validity and discriminant validity across two groups. As shown in Table 2.25, estimated Cronbach`s coefficients (except for: science-driven open search strategy in the low internal capacity group, which was 0.63) and composite reliability values (except for: institutional open search strategy in the low internal capacity group, which was 0.75) for all constructs exceeded the recommended values of 0.7 (Cronbach, 1951) and 0.8 (Fornell & Larcker, 1981), respectively, This indicated acceptable levels of internal consistency and reliability for constructs across two groups.

Table 2.24: Descriptive statistics, simple correlations and convergent validity tests (Group differences: Internal capacity for research and development)

Low internal capacity *(n=35)* ***Constructs***	***Mean***	***S.D.***	***AVE***	***(1)***	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***	***(7)***
(1) Offsite market-driven open search strategy	4.03	1.24	0.60	0.78						
(2) Onsite market-driven open search strategy	2.28	1.30	0.67	0.50	0.82					
(3) Technical and application-driven open search strategy	3.79	1.53	0.62	0.22	0.34	0.79				
(4) Science-driven open search strategy	2.99	1.51	0.57	-0.05	0.22	0.28	0.75			
(5) Institutional open search strategy	3.04	1.43	0.53	0.34	0.59	0.31	0.17	0.72		
(6) Rational goal performance	3.65	1.45	0.90	0.37	0.47	0.21	0.27	0.38	0.95	
(7) Open system performance	5.15	0.96	0.66	0.03	0.13	0.06	0.49	0.18	0.33	0.81
High capacity *(n=307)* ***Constructs***	***Mean***	***S.D.***	***AVE***	***(1)***	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***	***(7)***
(1) Offsite market-driven open search strategy	4.70	1.12	0.57	0.76						
(2) Onsite market-driven open search strategy	3.29	1.55	0.68	0.38	0.82					
(3) Technical and application-driven open search strategy	5.03	1.09	0.56	0.36	0.34	0.75				
(4) Science-driven open search strategy	4.04	1.58	0.70	0.29	0.32	0.37	0.84			
(5) Institutional open search strategy	4.01	1.43	0.62	0.36	0.44	0.39	0.43	0.79		
(6) Rational goal performance	4.86	1.33	0.84	0.36	0.39	0.41	0.31	0.39	0.92	
(7) Open system performance	5.61	0.97	0.69	0.34	0.28	0.35	0.33	0.30	0.48	0.83

Table 2.25: Construct-level reliability, discriminant validity tests, communalities, determination coefficients, cross-validated redundancy measures and goodness-of-fit criterion (Group differences: Internal capacity for research and development)

Low internal capacity (n=35) ***Constructs***	***Composite Reliability (ρc)***	***Cronbach's α***	***Communality***	***Redundancy***	***R^2***	***Q^2***
(1) Offsite market-driven open search strategy	0.90	0.866	0.603			
(2) Onsite market-driven open search strategy	0.92	0.904	0.670			
(3) Technical and application-driven open search strategy	0.90	0.862	0.624			
(4) Science-driven open search strategy	0.80	0.638	0.569			
(5) Institutional open search strategy	0.71	0.753	0.434			
(6) Rational goal performance	0.97	0.962	0.898	-0.010	0.297	0.073
(7) Open system performance	0.86	0.762	0.664	-0.020	0.261	0.163
GoF	0.422					
High internal capacity (n=307) ***Constructs***	***Composite Reliability (ρc)***	***Cronbach's α***	***Communality***	***Redundancy***	***R^2***	***Q^2***
(1) Offsite market-driven open search strategy	0.90	0.850	0.571			
(2) Onsite market-driven open search strategy	0.93	0.904	0.675			
(3) Technical and application-driven open search strategy	0.86	0.799	0.555			
(4) Science-driven open search strategy	0.87	0.786	0.700			
(5) Institutional open search strategy	0.87	0.795	0.618			
(6) Rational goal performance	0.96	0.938	0.844	0.112	0.289	0.243
(7) Open system performance	0.87	0.774	0.688	0.063	0.215	0.139
GoF	0.409					

The determination coefficients (R^2) on both dependent variables were slightly higher for the group with low internal capacity, compared to the group with high internal capacity (rational goal performance: R^2=0.297 vs. 0.289, and open system performance: R^2=0.261 vs. 0.215), suggesting that both models had relatively moderate explanatory power (Chin, 1998). Similarly, in terms of the predictive relevance (Q^2) values, both models exerted relatively moderate predictive power on open system performance (Q^2= 0.163 vs. 0.139). However, the estimated predictive relevance value for the group with low internal capacity on rational goal performance was smaller (Q^2= 0.073) than the value estimated for the group with high capacity (Q^2= 0.243) (Stone, 1974; Geiseer, 1975). The examination of the goodness-of-fit (GoF) criterion for each group (low capacity group`s GoF=0.422 and high capacity group`s GoF=0.409) confirmed robustness of both measurement models (Table 2.25).

Table 2.26 presents the estimated path coefficients, t-values, and p-values for each equation in the hypothesised model across two groups. Overall, using pair-wise parametric t-tests, only one structural relation was found to be statistically ans significantly different across two groups. The hypothesised association between a firm`s science-driven open search strategy and its open system performance (Hypothesis 3.2) was found to be positive for both groups, however, the association was slightly, yet surprisingly, stronger for the group with low internal capacity (β=0.51, t-value=2.75), compared to the group with high internal capacity (β=0.17, t-value=2.91).

For the firms with higher levels of internal capacity for research and development, only the hypothesised association between the intensity of science-driven open search strategy and rational goal performance (Hypothesis 3.2) signalled a degree of deviation from the general pattern of relationships estimated for the total sample. However, for the firms with lower levels of internal capacity for research and development, all hypothesised associations – except for the impact of the intensity of science-driven open search strategy on open system performance (Hypothesis 3.1)- found to be non-significant.

The results obtained through the multi-group analyses confirmed the assumptions being made about the association between the internal capacity to generate knowledge and the ability to leverage external knowledge (Teirlinck & Spithoven, 2013; West & Bogers, 2014). The results also showed that the complementarity between external knowledge and internal knowledge is a necessity for the success of open search activities in firms (Lane & Lubatkin, 1998). The positive association between the intensity of science-driven open search strategy in firms with low internal capacity and their open system performance may seem surprising, at a first glance. However, science and technology parks are expected to catalyse the process of knowledge spillover form the local universities and research centres to tenant firms (Siegel, Westhead & Wright, 2003), and support interactions between them (Díez-Vial & Montoro-Sánchez, 2016). The results confirm that being located in a close proximity of universities and research centres would work in favour of tenant firms. In addition, the findings also illustrated that there are associations between firms` innovation strategy and their external search objectives (Tether, 2005). Overall, it was revealed that onsite firms would benefit more from their reciprocal knowledge exchange and co-creation activities, if they invest more in their internal research and development activities (Veugelers and Cassiman, 1999; Narula, 2004). Moreover, by simultaneously investing in internal research and development and external open search activities, they can compensate for their liability of smallness, and successfully appropriate the rents from their innovations (Brunswicker & Vanhaverbeke, 2015; Freel & Robson, 2016).

Table 2.26: Structural model results (Group differences: Internal capacity for research and development)

Hypothesis No.	Path Direction	Combined dataset (n=342)		Low internal capacity (n=35)		High internal capacity (n=307)		Test of difference		Results
		β	***t value***	***β***	***t value***	***β***	***t value***	***t value***	***p-value***	
H.1.1	Offsite market-driven -> Open system performance	0.16***	2.78	0.06	0.31	0.17	2.80***	0.56	0.58	No significant difference
H.1.2	Offsite market-driven -> Rational goal performance	0.16***	2.75	0.22	1.19	0.14	2.27***	0.41	0.68	No significant difference
H.2.1	Onsite market-driven -> Open system performance	0.07	1.29	-0.05	0.15	0.08	1.29	0.61	0.54	No significant difference
H.2.2	Onsite market-driven -> Rational goal performance	0.19***	3.08	0.25	1.15	0.17	2.62***	0.39	0.70	No significant difference
H.3.1	Science-driven -> Open system performance	0.22***	3.98	0.51	2.75***	0.17	2.91***	1.88*	0.06	Significant difference
H.3.2	Science-driven -> Rational goal performance	0.09*	1.79	0.21	1.09	0.07	1.23	0.78	0.44	No significant difference
H.4.1	Institutional -> Open system performance	0.03	0.59	0.14	0.38	0.06	1.00	0.37	0.71	No significant difference
H.4.2	Institutional -> Rational goal performance	0.13**	2.26	0.12	0.42	0.15	2.49***	0.14	0.89	No significant difference
H.5.1	Technical and application-driven -> Open system performance	0.14***	2.36	-0.12	0.46	0.18	2.75***	1.42	0.16	No significant difference
H.5.2	Technical and application-driven -> Rational goal performance	0.21***	3.46	-0.03	0.12	0.22	3.49***	1.24	0.22	No significant difference

Notes: *** p<0.001, ** p<0.001, * p<0.05;

2.6. Discussion and Conclusions

Using data collected from 342 firms located in science and technology parks in the United Kingdom, this study attempted to explore simultaneous direct effects of five distinct types of open search strategies on two main dimensions of organisational effectiveness, namely rational goal performance and open system performance. In keeping with expectations, the intensity of offsite market-driven open search strategy was significantly related to both dimensions of organisational effectiveness. Moreover, the anticipated association between the intensity of onsite market-driven open search strategy and rational goal performance was found to be statistically significant. However, the hypothesised relationship between the intensity of onsite market-driven open search strategy and open system performance was found to be statistically insignificant.

The results of these analyses revealed that the intensity of a firm`s science-driven open search strategy had significant direct effects on its open system performance and rational goal performance. Similarly, the intensity of a firm`s institutional open search strategy was found to be significantly related to its rational goal performance. In contrast, the anticipated relationship between the intensity of a firm`s institutional open search strategy and its open system performance failed to reach statistical significance. Finally, the intensity of a firm`s technical and application-driven open search strategy rational goal and open system performance. Overall, out of ten hypothesised paths between the exogenous variables and the dependent variables, this study found enough statistical evidence to prove eight anticipated associations, which were: H.1.1, H.1.2, H.2.2, H.3.1, H.3.2, H.4.2, H.5.1 and H.5.2. On the other hand, two hypothesised paths of H.2.1 and H.4.1 failed to reach statistical significance. Nevertheless, both exogenous variables exerted positive influences, yet weak, on the dependent variables.

Important motivations for this study were to integrate several theoretical perspectives regarding open search activities, reciprocal interactions with cocreation partners, and spatial, cognitive and social proximities, and to examine their possible relationships with an onsite firm`s organisational effectiveness. This study was expected to extend research on open search strategy by providing answers to the central questions related to the simultaneous connections between distinct types of open search activities and the ability of smaller firms to exhibit superior levels of performance, and whether cognitive and spatial proximities in their network relations matter. The findings of current study hold several important theoretical and practical implications.

First, although previous studies (such as: Laursen & Salter, 2006; Tether & Tajar, 2008; Grimpe & Sofka, 2009; Lee et al., 2010; Leiponen & Helfat, 2010; Garriga, von Krogh & Spaeth, 2013; Laursen & Salter, 2014; Terjesen & Patel, 2015; Ferreras-Méndez, Fernández-Mesa & Alegre, 2016; Ardito & Messeni Petruzzelli, 2017) have tended to combine all the distinct types of open search activities to create an overall measure of open search strategy, the results of this study provide empirical evidence for the theoretical contention that a firm`s open search strategy is a multidimensional phenomenon which requires to be treated as a multidimensional construct. Hence, it is necessary to distinguish different types of open search activities to more precisely examine their differing impacts on performance. This study found both significant and insignificant associations between the distinct dimensions of open search strategy and organisational effectiveness. The results suggest that a finer-grained analysis of impacts open search strategy using multidimensional construct would allow the identification of more precise associations.

Second, this study responded to calls for empirical research on the role of network dynamics and synergies within the ecosystem of science and technology parks, which constitutes mechanisms for co-specialisation and co-evolution of onsite firms. The ecosystem of science and technology parks is known to foster exploratory learning for, and interactions between onsite firms, especially smaller firms. However, there is no evidence about how co-located firms in science and technology parks, in particular smaller firms, operationalise their open search strategies. Lack of data has been always a key problem hampering research on micro enterprises. The empirical findings of this study highlighted that the adoption and utilisation of different open search activities can influence organisation effectiveness of onsite firms differently. These findings shed light on the nature of smaller firms` open search activities, and revealed interesting patterns about the dynamics of open innovation and co-evolution in knowledge ecosystems, and how spatial proximity shapes onsite firms` cognitive structure and perceptions of organisational, social and technical proximities in coopetitive and cooperative settings.

This study illustrated that the tenant firms` reciprocal interactions with offsite market-based co-creation partners improve their openness performance. This finding is consistent with previous research which has shown that frequent interactions with supply chain partners and competitors can accelerate the development of new products and services in firms and improve their adaptability to the unpredictable challenges they face (Chung & Kim, 2003). In contrast, the intensity of onsite market-driven open search activities did not show any significant effect on openness performance. Part of the reason for the apparent lack of direct association between the onsite firms` reciprocal interactions with co-located market-based partners and their open system performance may stem from the fear of unintended knowledge spillover. It is evident from the literature that the geographic proximity of tenant firms in science and technology parks would potentially enhance cognitive, social and organisational proximities between them (Boschma, 2005; Ben Letaifa & Rabeau, 2013). However, co-located firms, which are engaged in open search activities, are also exposed to greater risks of unintended knowledge spillovers, opportunistic behaviours and imitations from their partners due to the elevated levels of relational proximity.

The main driver of market adaptability is access to the relevant first-order knowledge. Both geographical and relational proximities reduce the knowledge distance between the co-located firms, which in turn would increase the chances of unfriendly imitations (Glückler, 2013) among them. It is evident from the literature that there are marked differences between the larger and smaller firms` appropriability strategies. Both larger and smaller firms use various appropriation mechanisms to limit unintended knowledge spillovers and retain the control of their key knowledge assets. The size is one of the key determinant that shapes the firms` appropriation choices (Neuhäusler, 2012). Faced with resource constraints, smaller firms usually tend to rely on informal appropriation mechanisms. Having only limited numbers of legally protected stock of knowledge (Agostini and Nosella, 2017) makes them vulnerable to knowledge leakage and actions of their partners (Hyvattinen, 2006). Labelled as the dark side of cooperation (Veer, Lorenz & Blind, 2016), the costs of risking firms` appropriation power would be higher for smaller firms which tend to engage in reciprocal activities with their co-creation partners (Leiponen & Byma, 2009; Love & Roper, 2015). Hence, the effectiveness of market-driven open search activities varies widely and appears to be influenced by their ability to appropriate the rents from their innovation (Escribano, Fosfuri & Tribó, 2009). In fact, firms may balance their open search strategies differently in absence of proper protection system. Prioritising the reciprocal interactions with offsite market-based partners over potential onsite market-based partners is a viable way to limit the chances of unintended knowledge spillovers. Earlier studies found that a majority of tenant firms in science and technology parks pursue their business interests outside the ecosystem of parks (Corsaro et al., 2012). However, two important questions of `how does a firm`s appropriability strategy influence its onsite and offsite market-driven open search activities and rational goal performance` and `what are the imacts of formal and informal appropriation mechanisms on market-driven search strategies, when taking into account the location of partners` are still unanswered. In Chapter.4, this research attempts to find an answer to these important questions.

Nevertheless, this study showed that the firms` reciprocal interactions with onsite market-based partners would bring about positive performance results, in terms of productivity and efficiency. As explained earlier, the anticipated association between the intensity of onsite market-driven open search strategy and rational goal performance was found to be statistically significant and stronger than the relationship between the offsite market-driven open search strategy and rational goal performance. This reflects the notion that the ecosystem of science and technology parks plays a significant role in providing co-creation opportunities and linking onsite firms and stakeholders with various portfolios of different assets and competencies with each other, in response to, or in anticipation of new market opportunities (Filatotchev et al., 2011; Khavandkar, 2013).

On the other hand, this study found that the intensity of a firm`s institutional open search strategy exerts no influence on its open system performance. A firm`s institutional links are naturally governed by the means of formal mechanisms, which may limit the scope of informal knowledge transfer. In practice, the nature of knowledge which is being exchanged or diffused through strictly formal channel is normally codified. The codified knowledge is easily understandable and imitable. Hence, once it moves into the public domain, every firms can obtain and apply it. Nevertheless, institutional knowledge can help firms, specifically smaller firms, to improve their productivity and efficiency in long run. The results showed that the intensity of a firm`s institutional open search strategy positively influences its rational goal performance. These findings are consistent with prior research which suggests that a firm`s institutional partners can help it to further its research and development activities and innovation endeavours (Matt & Wolff, 2004).

On the other hand, the findings of this study revealed that a firm`s open search strategy which is focused on the reciprocal knowledge exchange with science-based co-creation partners would bring about positive results, both in terms of improving its productivity and efficiency, and its image and adoptability. For smaller firms, interactions with universities and research organisations are considered as important drivers of innovativeness (Fleming & Sorenson, 2004; Brunswicker & Vanhaverbeke, 2015), which would provide them with a timely access to inventive trends (Fabrizio, 2006) and enhance their knowledge creation abilities (Bullinger, Auernhammer & Gomeringer, 2004). The results also confirmed that the ecosystem of science and technology parks plays an important role in science-driven interactions between the onsite firms and local universities and academics, that is consistent with earlier research (Vanderstraeten & Matthyssens, 2012).

This study, in line with earlier studies, (Hansson, Husted & Vestergaard, 2005; Love & Bonner, 2016), showed that the intensity of a firm`s technical and application-driven open search activities positively influence its open system and rational goal performance. Smaller firms, compared to their larger rivals, are often faced with resource constraints; thus, they tend to normally invest more on their technical and application-driven open search activities. Technical and application-driven open search activities can increase the effectiveness of organisational decision-making processes and reduce the costs associated with ` trial and error` in research and development activities. The results of this study extend prior literature on non-interactive modes of learning by demonstrating that the technical and application-based sources can help onsite firms to achieve greater degrees of efficiency and adoptability by increasing their awareness about new technologies, products and developments (Bigliardi et al., 2006; Villasalero, 2014; Campanella, Rosaria Della Peruta & Del Giudice, 2014)

Taken together, the findings of this study suggest that the reciprocal interactions with various co-creation partners are key to success of onsite firms. Regardless of their size, open search activities significantly increase the level of exposure to external knowledge, which in turn brings about positive results in terms of productivity, efficiency and flexibility for onsite firms. Smaller firms, similar to their larger rivals, can gain the optimal benefits of both exploration and exploitation through ambidexterity between search and implementation, and making full use of external resources in order to strengthen their innovativeness. This study also confirmed that smaller firms by becoming more adept at utilising effective open search strategies can compensate for limitations in their internal resources and technological competences (Iansiti, 1997), diversify their knowledge and skills (Xia, 2013), complement their internal resources, and mitigate risks and costs associated with in-house research and development activities. Nevertheless, short-term benefits of open search activities can be directly measured as they can be tied to the tangible financial results, while long-term outcomes can be less directly attributed to the open innovation activities. In the next chapter, the issue of `how potential short-term and long-term benefits of open search activities should be differentiated from each other` will be investigated.

Overall, this study suggested that onsite firms` open system performance was associated with offsite market-driven, science-driven, and technical and application-driven open search strategies. The results further revealed that onsite and offsite market-driven, science-driven, technical and application-driven driven and institutional open search strategies exerted positive influences on onsite firms` rational goal performance. The findings of this chapter indicate that the resource interdependency and complementarity between onsite firms in science and technology parks progressively catalyse reciprocal interactions between them and other stakeholders. Similarly, the factor of resource heterogeneity among onsite firms stimulates cognitive, social and organisational proximities. These proximities facilitate the interactions between onsite firms, and between them and other internal and external stakeholders.

Appendix.2

Table 2.27: Confirmatory factor analysis

Item		Construct	Factor loading
On_Oth_Sec	<---		.843
On_Oth_Biz	<---		.833
On_Comp	<---	Onsite-market-driven open search strategy	.838
On_Supp	<---		.772
On_Cus_PV	<---		.746
On_Cus_Pub	<---		.704
Off_Supp	<---		.687
Off_Oth_Biz	<---		.805
Off_Comp	<---	Offsite market-driven open search strategy	.659
Off_Cus_Pub	<---		.692
Off_OtE_Sec	<---		.792
Off_Cus_PV	<---		.593
App_Conf	<---		.770
App_Trai	<---		.688
App_Fair	<---	Technical and application-driven open search strategy	.658
App_Journ	<---		.623
App_Expert	<---		.714
Inst_Finance	<---		.639
Inst_Gov	<---	Institutional open search strategy	.665
Inst_Park	<---		.791
Inst_Trade	<---		.719
Sci_Lab	<---		.791
Sci_PubRes	<---	Science-driven open search strategy	.786
Sci_Uni	<---		.637

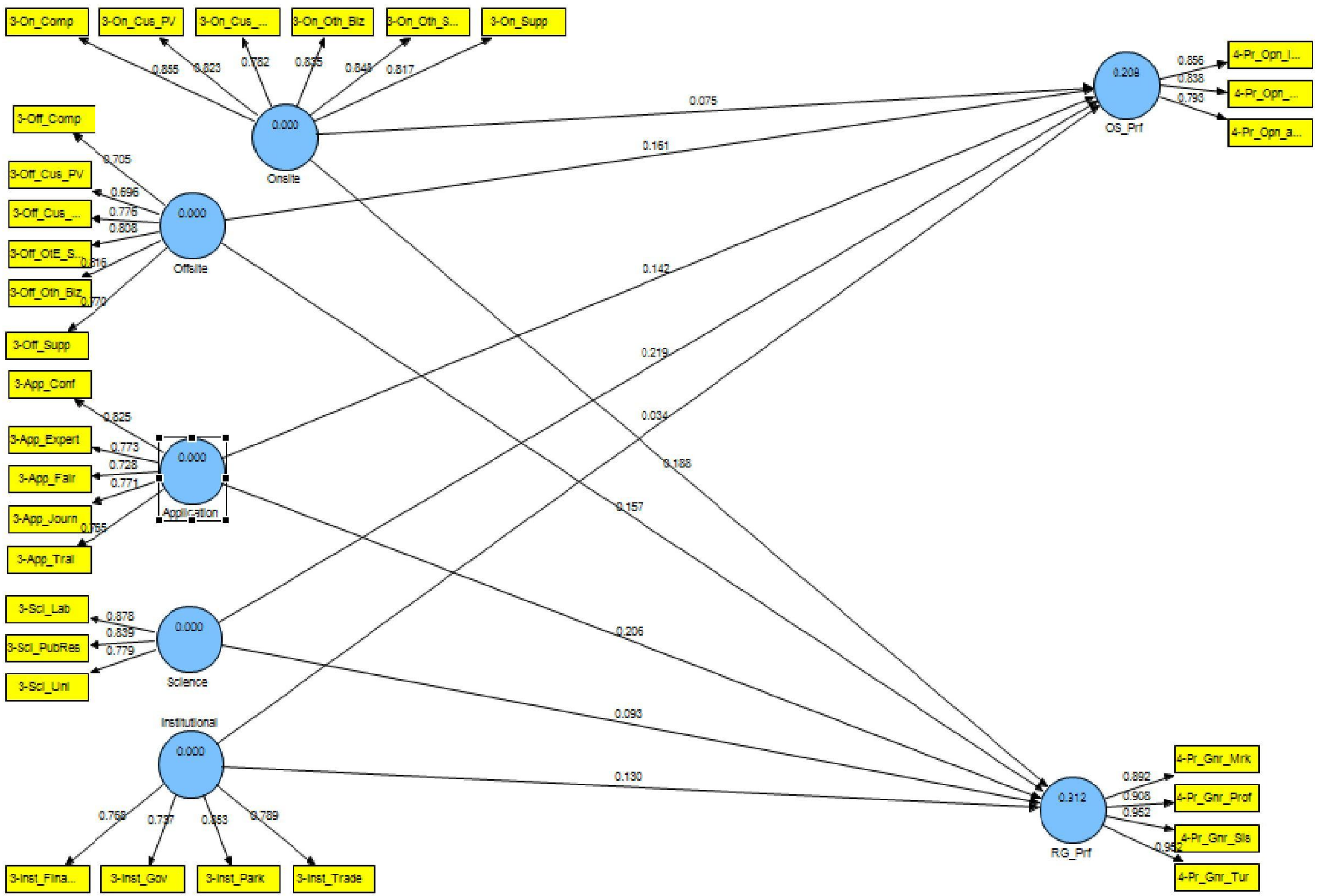


Fig. 2.2: Structural model results (path diagram)

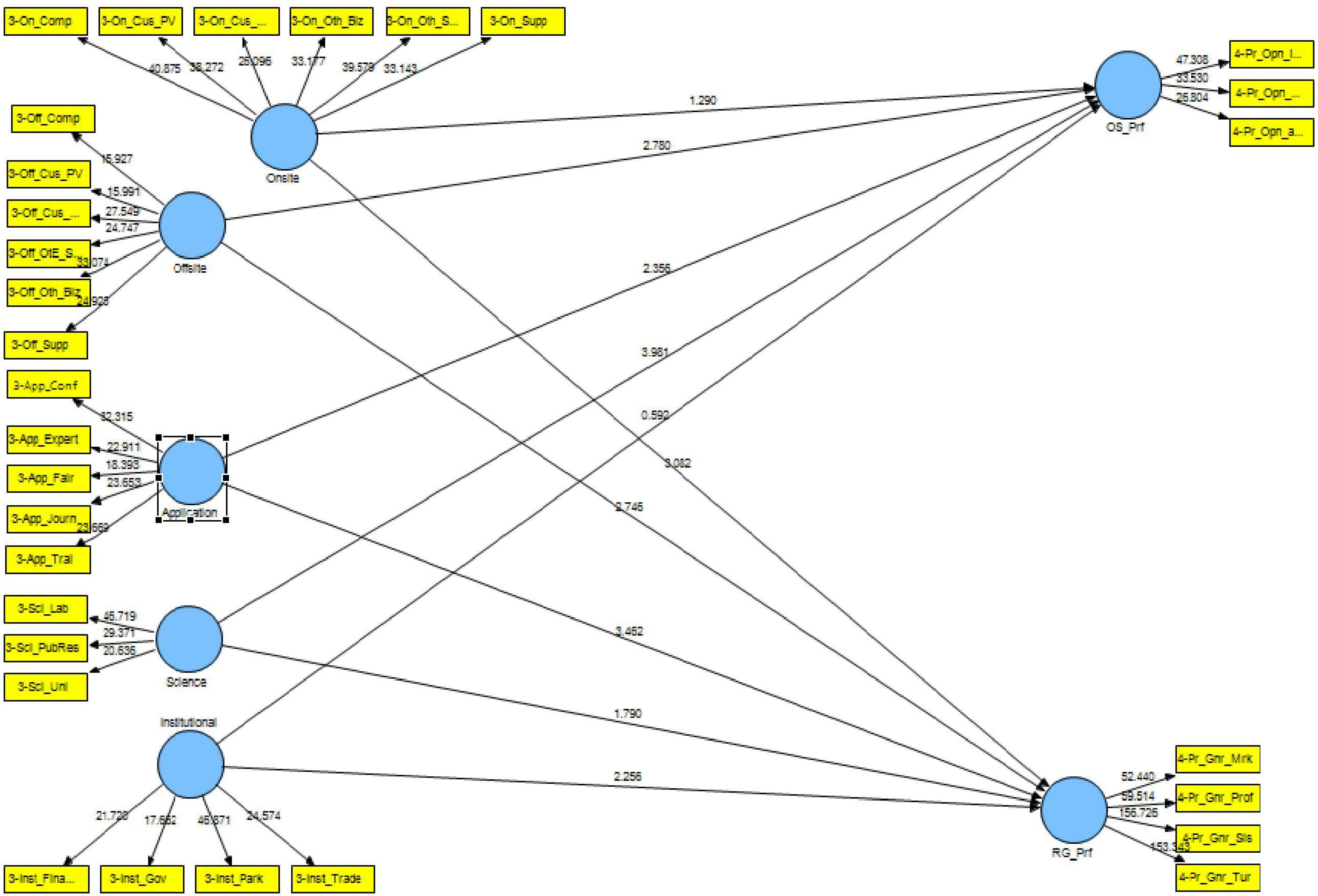


Fig. 2.3: Structural model results (bootstrapping results: t-values)

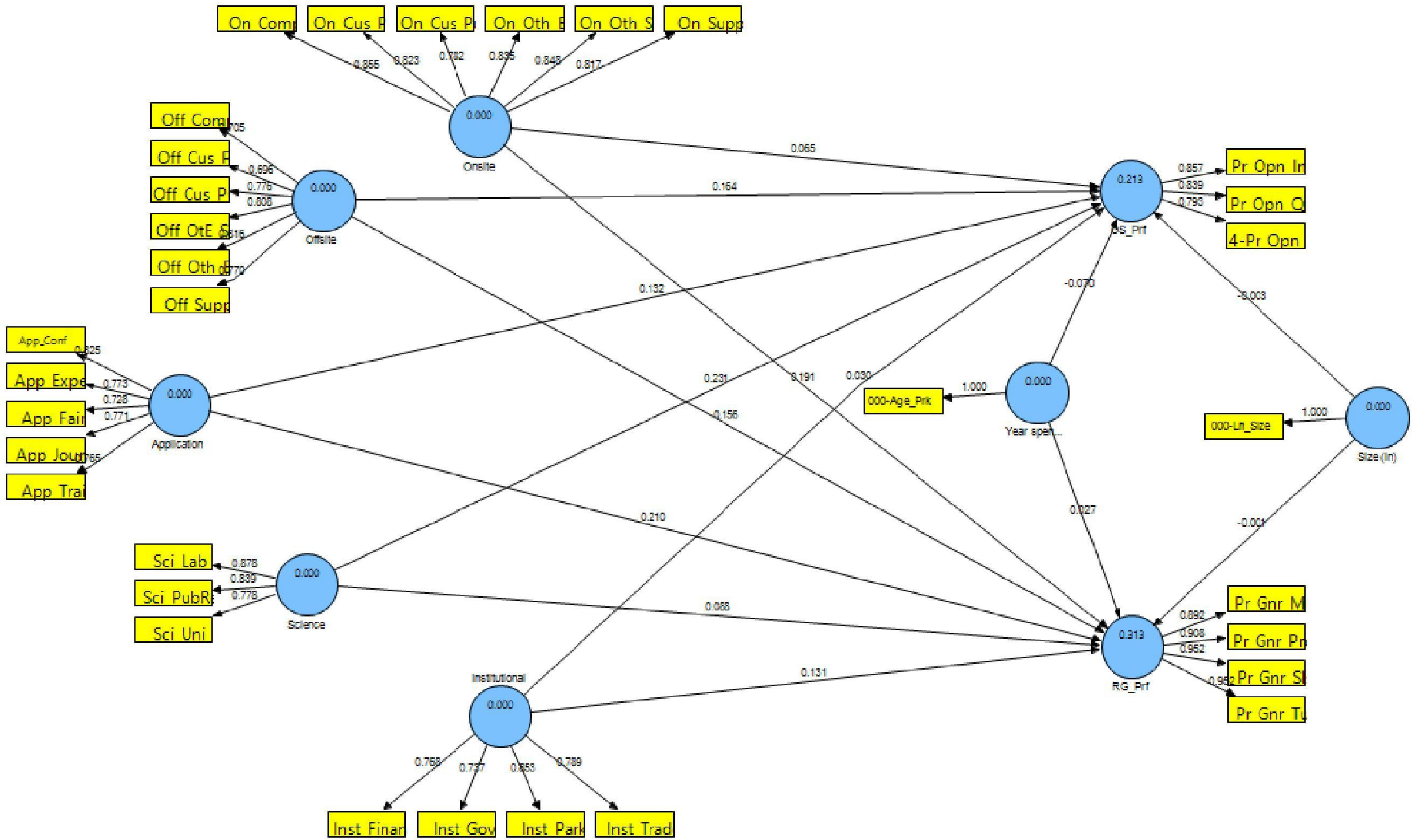


Fig. 2.4: Structural model results (base model with controls: entire sample – path diagram)

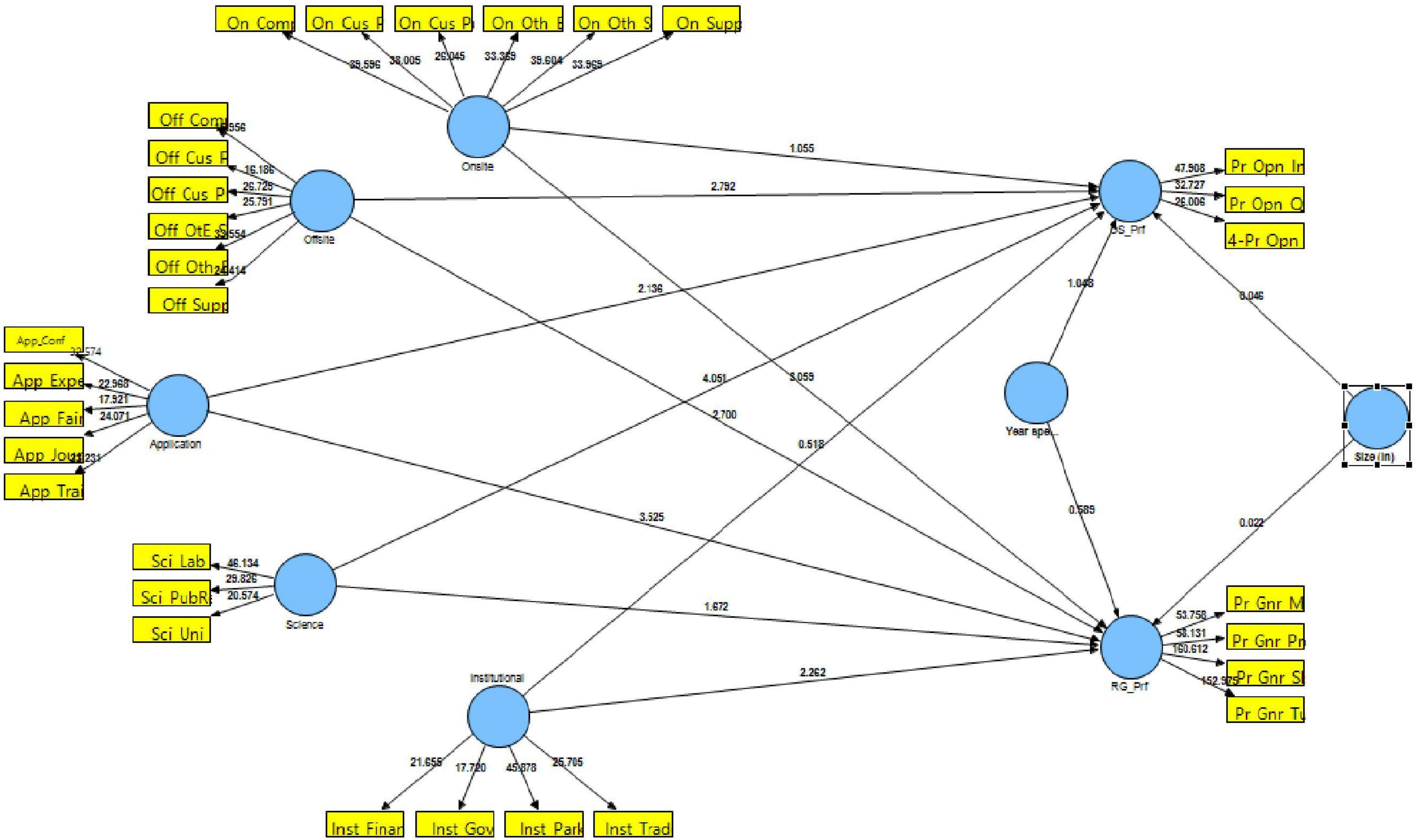


Fig. 2.5: Structural model results (base model with controls: entire sample – bootstrapping results - t-values)

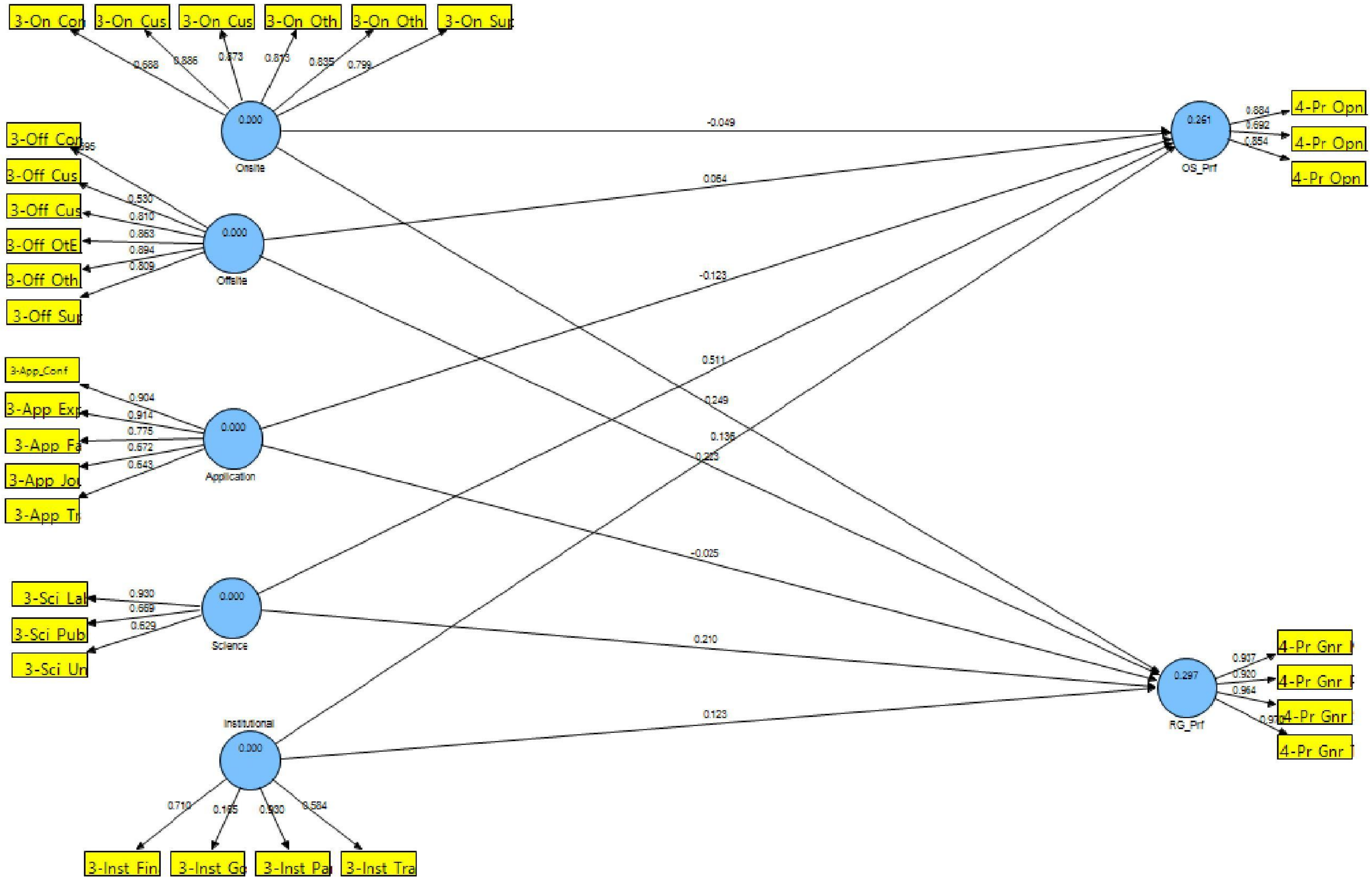


Fig. 2.6: Structural model results (Group differences: low internal capacity for research and development sample – path diagram)

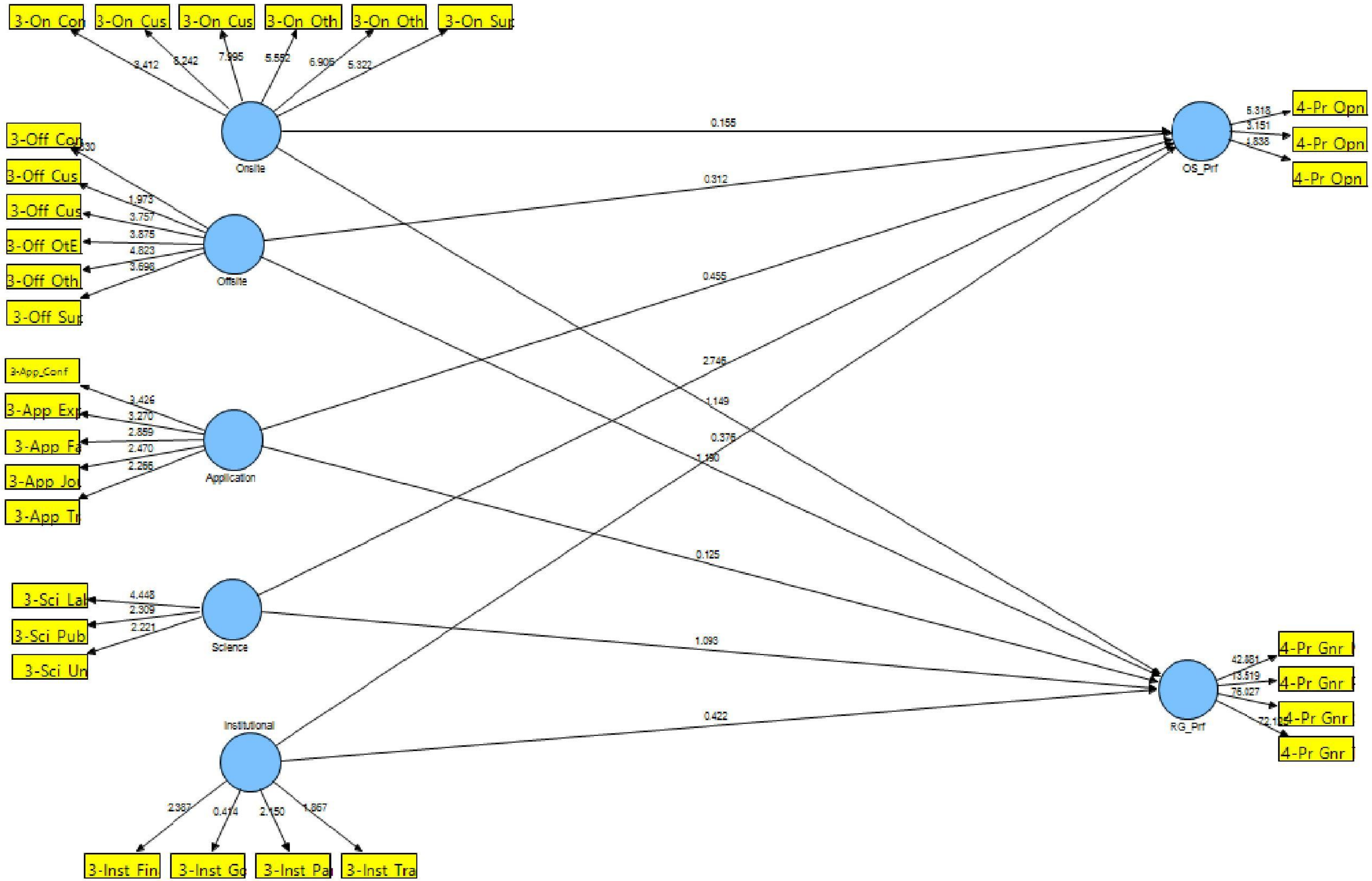


Fig. 2.7: Structural model results (Group differences: low internal capacity for research and development sample –bootstrapping results - t-values)

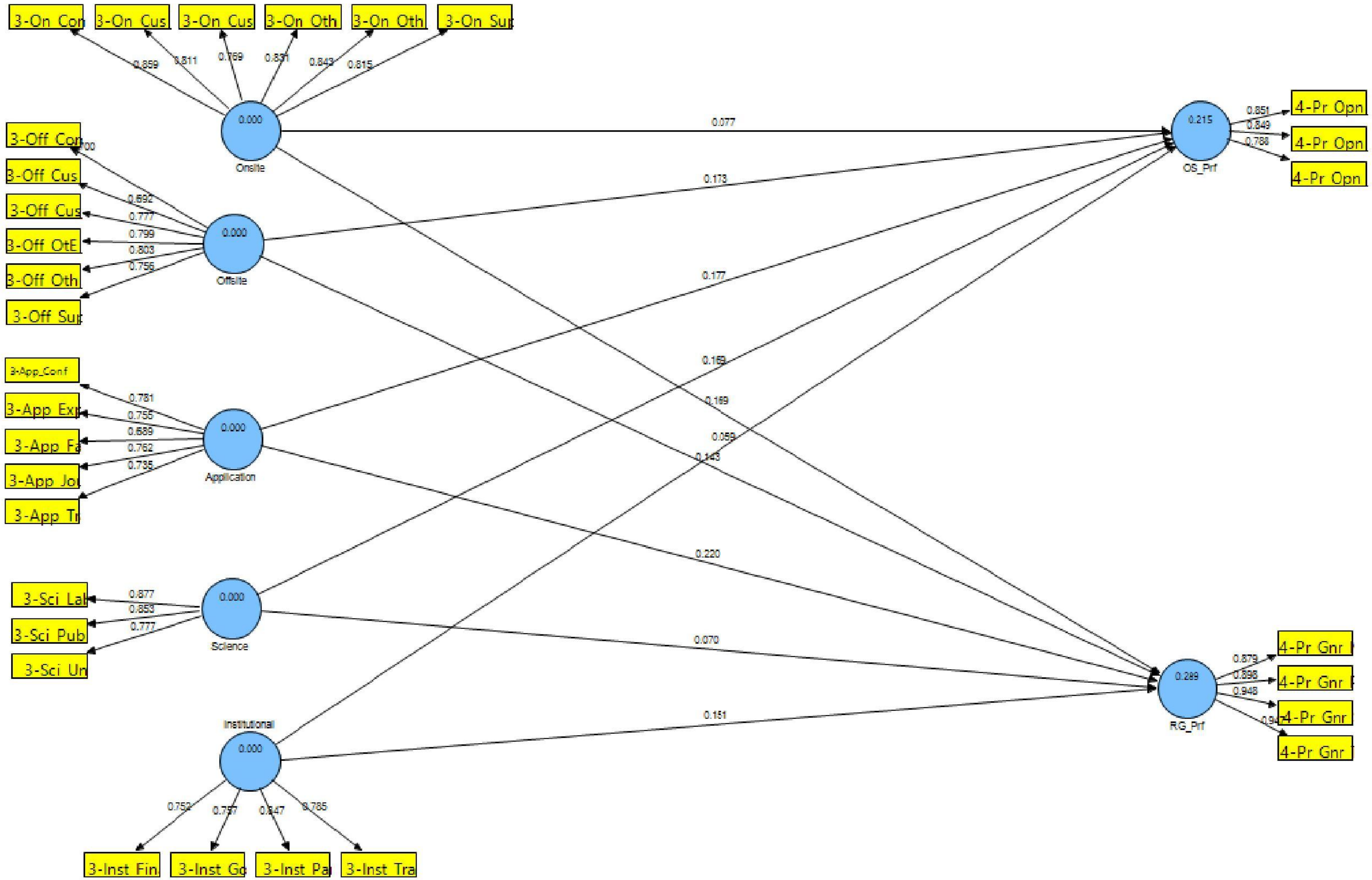


Fig. 2.8: Structural model results (Group differences: high internal capacity for research and development sample – path diagram)

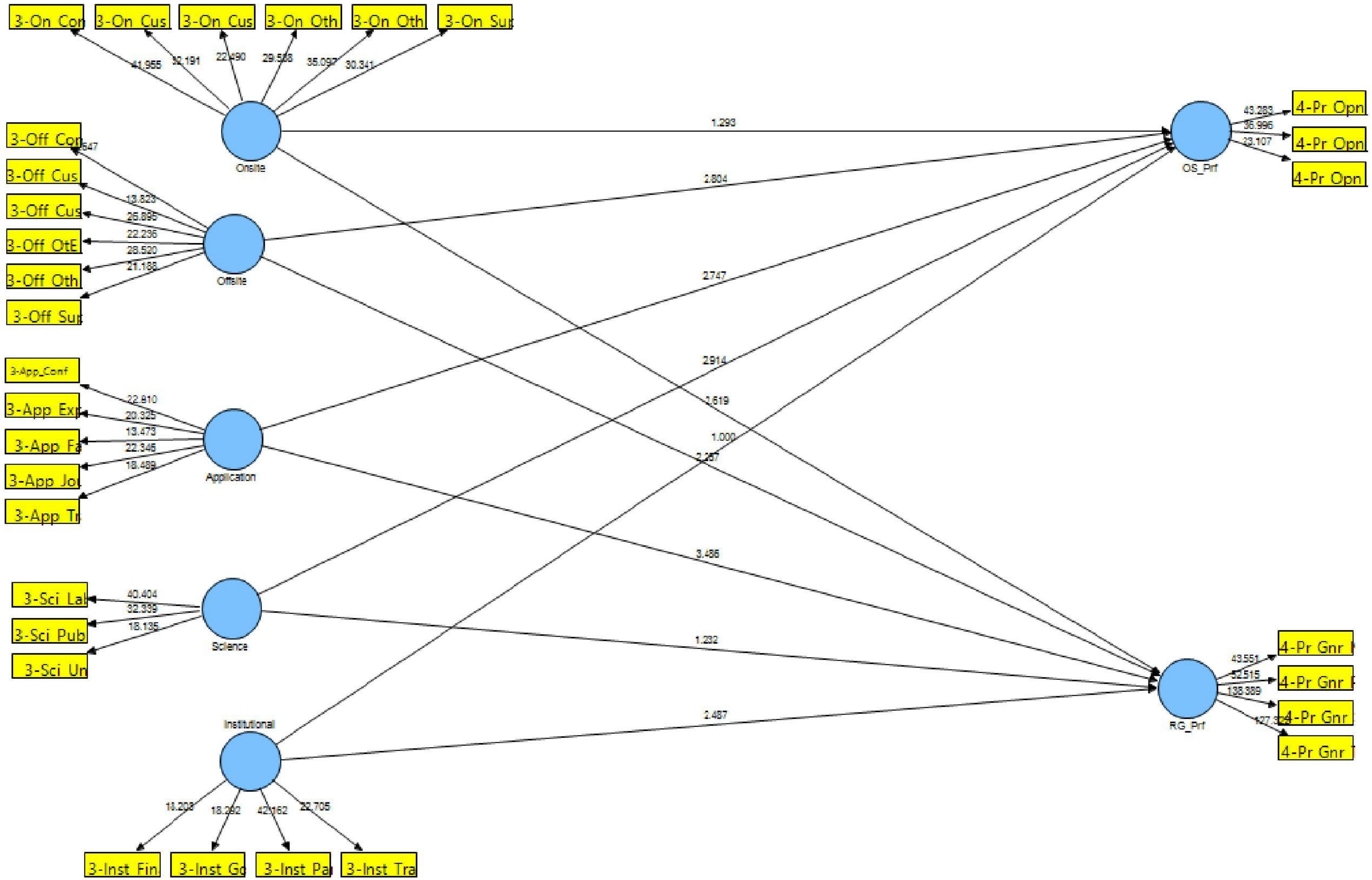


Fig. 2.9: Structural model results (Group differences: high internal capacity for research and development sample –bootstrapping results - t-values)

Chapter Three: Open Search Strategy, Appropriation and Co-evolution of Dynamic Capabilities

3.1. Introduction

The past few years have witnessed an exponential increase in studies investigating how network dynamics lead to generation and diffusion of knowledge and practices in innovation ecosystems (Brass & Galaskiewicz, 2004; Faems et al., 2008; Kogut, 2000; Tortoriello & Krackhardt, 2010). According to the paradigm of open innovation (Chesbrough, 2003a), in which experimentation with external knowledge is seen as an alternative path to market, the ecosystem of science and technology parks, by accommodating suitable mechanisms for diffusion of innovation and exploratory learning, provides the required structure and dynamics of an environment that is potentially supportive of open innovation (Khavandkar et al., 2014). Thus, it is expected that science and technology parks contribute to the regional development by fostering the growth of co-located firms, promoting collaboration between smaller firms and their larger rivals, and supporting interactions between universities and research institutions and onsite firms (Vanderstraeten & Matthyssens, 2012). Viewed from this perspective, the environment of a science and technology park resembles an ecosystem in which the focus is on building an extensive network of partners that can enable onsite firms to innovate faster, while providing them with enhanced access to tangible and intangible assets (Zahra & Nambisan, 2012), and creating new values through facilitated knowledge flows and services available to them (Peltoniemi, 2006). The ecosystem of science and technology parks, taking this stance, is a place in which firms are connected through a shared platform of knowledge and value propositions, and by creating co-evolution and co-specialisation opportunities for each other (Khavandkar & Khavandkar, 2016). Nevertheless, each firm individually acts as a niche player, value dominator or key stone in its parent ecosystem, or independently, and exploits market opportunities based on its innovation architecture, while being a part of the ecosystem of science and technology park. It is evident from the literature that smaller firms and their larger rivals share similarities in the way they develop their innovation architecture, however, they usually pursue different strategic goals, occupy different niches and use different time frames (Mole, Hart & Roper, 2014).

Firms, specifically smaller ones, traditionally have been thought to benefit from the economy of proximity. Spatial proximity increases their exposure to, and their involvement in exploratory learning and collaborative activities (Khavandkar, 2014; Huggins & Johnston, 2009), based on the presumption that it becomes easier for them to mobilise the complementary resources and knowledge when cognitive, social and organisational proximities are heightened between them (Boschma, 2005). Smaller firms, compared to their larger rivals, have been known to adopt new technologies and innovations, as soon as they become accessible (Porter, 2001).

Looking through the lens of the resource-based view paradigm, both the internal and external knowledge are essential resources for sustaining superior performance in the market (Chang et al., 2012). As evident from the literature, intellectual capitals are likely to be the key source for sustainable competitive advantage in smaller firms (European Commission, 2006). The stocks of intellectual capital would enhance the ability of firms to screen potential opportunities for exploiting external complementary knowledge and generating new combinations (Khavandkar, 2013). Further, a firm`s stocks of intellectual capital would heighten its attractiveness in the eyes of potential partners, as its openness, integration and experimentation capabilities become strengthened (Chang et al., 2012).

The open innovation literature suggests that a higher level of exposure to the external knowledge, a more frequent rate of contacts with external partners, and a systematic application of external knowledge would result in in acquisition of fine-grained know-how and development of capabilities in firms (Katila & Ahuja, 2002; Greco, Grimaldi & Cricelli, 2016; Monteiro, Mol & Birkinshaw, 2017). Nevertheless, these positive outcomes normally show themselves in the long run. This notion can shed some light upon the observed disparities between the tangible and intangible outcomes of open search activities in firms. The ecosystem of science and technology parks plays a key role in facilitating the knowledge spillovers among co-located firms (Vásquez-Urriago, Barge-Gil & Modrego Rico, 2016), by providing them with an access to further exploratory learning opportunities, which sets the foundations for their open search activities and accumulation of intellectual capital stocks (Khavandkar & khavandkar, 2015). The diffusion of intellectual capital creates an immense potential for co-specialisation and co-evolution within the ecosystem of science and technology parks (Khavandkar et al, 2016). Hence, drawing on the concept of innovation diffusion, this chapter seeks to build and empirically test a theoretical framework that could explain dynamics and synergies within the ecosystem of science and technology parks that are facilitating co-creation and accumulation of intellectual capital among the co-located tenant firms.

Nevertheless, as knowledge distance decreases between the co-located tenant firms, the chances of imitation and opportunism increase (Cassiman & Veugelers, 2002; Ben Letaifa & Rabeau, 2013). Hence, the costs associated with risking appropriability may negatively influence the firms` open search activities. Smaller firms are vulnerable to unintended knowledge spillovers as well as rent-seeking pressures from their external partners. An effective appropriation strategy could help them to overcome the disadvantages related to their liability of smallness (Brunswicker & Vanhaverbeke, 2015; Freel & Robson, 2016). The use of appropriation mechanisms is believed to "be interpreted by external parties as signalling the focal firm's possession of valuable technological knowledge and, consequently, its potential value as a collaborator (or an attractive investment object for a financier)" (Laursen & Salter, 2014: 870). Formal and informal appropriation mechanisms are expected to positively influence the smaller firms` open search activities. Moreover, they would help smaller firms to gain better bargaining power, which is known to be a key driving force for accumulation of social capital. Thence, this study addresses these priorities, by examining potential associations between firms` appropriation and open search strategies and accumulation of social, organisational and human capital in science and technology parks.

It aims to solve the long-standing problem of open innovation in smaller firms that is whether open search activities could bring about higher performance levels for them, and if so, how potential short-term and long-term benefits of open search activities should be differentiated from each other, as they could imply different meanings. Furthermore, if empirically tested, such potential associations could help in explaining the observed disparities between the tangible and intangible outcomes of open search activities, and moving toward a more nuanced understanding of open search activities in smaller firms. In addition, this study addresses an important question about the potential relationship between appropriability strategy and openness, by investigating how smaller firms` allocation of attention to different types of appropriation mechanisms affects their open search activities, and why its central to understanding how smaller firms capture the rents from their open innovation.

3.2. Theoretical Background

Ever since the Chesbrough`s book was published in 2003, exploring the interplay between the firms` open search activities and performance has been at the centre of attention in innovation studies (Un, Cuervo-Cazurra & Asakawa, 2010; Faems et al., 2010; Chiang & Hung, 2010; Santamaria & Surroca, 2011; Chang et al., 2012; Parida, Westerberg & Frishammar, 2012; Mina, Bascavusoglu-Moreau & Hughes, 2014; Cheng & Shiu, 2015; Martini, Neirotti & Appio, 2017; Miozzo, 2016; Hochleitner, Arbussà & Coenders, 2017). There is a general agreement in the literature that a firm`s exploratory learning and external search activities could improve innovation success (Huang & Rice, 2009; Chiang & Hung, 2010Cheng & Shiu, 2015), and bring about positive financial results (Noh, 2015). In a similar vein, the results obtained in the chapter two confirmed the potential associations between distinct types of open strategy and performance outcomes in smaller firms. Nevertheless, potential short-term and long-term benefits of open search activities should be differentiated from each other, as they could imply different meanings. Recent empirical studies reveal that performance growth resulting from the exploitation of potential exploratory learning opportunities may not follow a linear pattern (Laursen & Salter, 2006; Berchicci, 2013; Greco, Grimaldi & Cricelli, 2016). This notion raises many intriguing questions about the role played by open search activities in maximising the firms` ability to capture the rents from their exploratory missions, which is a grey area in the literature.

The long-term outcomes of open search activities are associated with a firm`s dynamic capabilities and its absorptive capacity, which are both intangible by nature. It has been suggested that studying these outcomes may provide insights into the underlying mechanisms of why similar exposure to external knowledge may yield different benefits and results, as portrayed by Escribano, Fosfuri & Tribó (2009). The short-term benefits of open search activities can be directly measured, as they can be tied to the tangible financial results, while the long-term outcomes can be less directly attributed to the open innovation activities, thus intangible and hard to measure. Hence, the key to this discussion is the distinctions between, on the one hand, the unique characteristics of external knowledge and innovation processes, and on the other hand, differences in organisational capabilities and needs (Castro, 2015).

When engaged in open search activities, firms develop a set of abilities that help them to screen, absorb, assimilate, and later commercialise further knowledge (Hughes et al., 2014). These abilities shape a firm`s absorptive capability (Cohen & Levinthal, 1990). Prior studies show that a firm`s absorptive capacity is directly related to its ability to capture the rents from external knowledge and innovation (Ahn, Mortara & Minshall, 2013). A firm`s absorptive capacity is comprised of two unique sets of abilities, namely potential absorptive capacity and realised absorptive capacity. A firm`s potential absorptive capacity "makes the firm receptive to acquiring and assimilating external knowledge ... a firm's capability to value and acquire external knowledge", on the other hand, "realised absorptive capacity is a function of the transformation and exploitation capabilities … [which] reflects the firm's capacity to leverage the knowledge that has been absorbed" (Zahra & George, 2002:190). This definition highlights the role of a firm`s organisational routines, process, practices, experiences and knowledge of its individuals in screening and understanding of external knowledge, as well as internalisation and assimilation and commercialisation of them (Lin, Che & Ting, 2012). While firms could develop these abilities internally, they could also learn them once exposed to the diffusion of knowledge and practices through exploratory learning. These knowledge and abilities are meant to shape a firm`s competitive advantage, once become institutionalised predict its ability to appropriate the rents from innovation (Chesbrough, 2003b).

Achieving a higher level of innovation novelty through open search activities requires a wider access to external knowledge, backed by a set of interrelated functioning capabilities. In other words, to succeed in its open search missions, a firm needs to know how to "search sources of innovation with external, distant and wider orientation rather than internal, local and narrow sources [openness capability], …. integrate and align the organisational connectedness and ambidexterity [integration capability], …. probe, experiment with, test, and commercialise [Experimentation capability]" (Chang et al., 2012: 444-445). These capabilities are derived from knowledge stored in an organisation's individuals or its systems, processes, routines and practices — which constitutes a firm's so-called intellectual capital (Harison & Koski, 2010). A firm`s accumulated stocks of intellectual capital are the key determinants of its innovation performance (Subramaniam & Youndt, 2005). Social, organisational and human capital are three components of intellectual capital (Edvinsson & Malone, 1997; Khavandkar et al., 2016). The Intellectual capital theory emerged in response to the need for a defining theoretical framework that can explain internal context which allows firms to obtain, develop, combine and apply new internal and external knowledge, and to enhance their knowledge creation and acquisition activities (Reed, Lubatkin & Srinivasan, 2006).

The key to success in open search activities is the ability to screen, absorb, integrate and accumulate external knowledge (Chesbrough, 2003b) that can complement a firm`s knowledge base. As complementarity between the external and internal knowledge reaches to its peak, the open search activities gain a momentum and yield more positives results. It is well documented that a firm's individuals, systems, routines, processes and procedures are influencing shapers of its knowledge culture and societal practices in reciprocal activities with its co-creation partners (Cabrera & Cabrera, 2005; Yang & Lin, 2009). The knowledge culture and societal practices, taken together, act as a platform for building external relationships, knowledge acquisition and integration in firms (Hillebrand & Biemans, 2004). On the other hand, the social context mediates the association between a firm`s openness and its performance (Lazzarotti, Manzini & Pellegrini, 2015). Exploratory learning helps firms to update their knowledge stored in individuals, systems, routines, processes and procedures and upgrade their societal practices to meet the new requirements (Petroni, Venturini & Verbano, 2012). Hence, beyond a certain threshold, it is reasonable to expect that the benefits deriving from the open search activities could be accumulated as additive capabilities in shapes of social, human and organisational capital. As geographical proximity would generate social buzz and could increase accessibility to, and the homogeneity of concentrated knowledge, these effects would become stronger as a result of the externalities of openness which are normally greater when firms are co-located (Breschi & Lissoni, 2009; Roper, Vahter, & Love, 2013; Bloom, Schankerman & Van Reenen, 2013). Presented by such networked configurations, knowledge can be easily communicated, organised and conveyed. Furthermore, the ecosystem would potentially facilitate both the creation of new knowledge and the optimisation of channels through which different co-creation partners exchange and apply the mutually generated or diffused knowledge (Khavandkar et al., 2016). Empirically testing such associations could shed light on the underlying driving forces of superior performance, and the observed disparities between tangible and intangible outcomes in open search activities.

Furthermore, there is a general agreement in the literature that a firm`s size is one of the main determinants of its innovation performance, knowledge creation and absorptive capacity (Forés & Camisón, 2016). Prior studies argue that intellectual capital is likely to be the key source of sustainable competitive advantage for smaller firms (European Commission, 2006). The stocks of intellectual capital would enhance the ability of firms to apply existing knowledge, and then generate further combinations (Khavandkar, 2013). These abilities are known to heighten the firms` level of attractiveness in the eyes of their potential partners. The ecosystem of science and technology parks, by its very nature, provides opportunities for knowledge dissemination and diffusion among tenant firms (Vásquez-Urriago, Barge-Gil & Modrego Rico, 2016). It presents a platform for developing shared knowhow between them. This thinking is in keeping with the traditional view that SMEs “benefit from collaborative knowledge-based activities within geographic regions, which is based on the presumption that it is easier to mobilise the complementary resources and capabilities embedded in localised networks” (Davenport, 2005:683). It is well documented in the literature that the potential dynamics of cooperation in the ecosystem of a science and technology park, being generated by a range of co-evolution and co-creation opportunities among active agents, potentially enhances the development of innovation architectures in onsite firms (Vásquez-Urriago, Barge-Gil & Modrego Rico, 2016; Khavandkar et al., 2016). Moreover, the ecosystem of science and technology parks can stimulate co-specialisation and exploratory learning between the tenant firms. Subsequently, it facilitates the diffusion of knowledge, ideas, innovation, technologies, business skills and management practices, and widens access to tangible and intangible resource (Khavandkar et al., 2014).

As evident in the literature, a systematic network of relationships that supports a more frequent rate of contacts with external partners would bring about a higher level of innovation performance, as it increases the chances of success in assimilation of fine-grained know-how and appropriation of the rents from open search activities (Katila & Ahuja, 2002; Brioschi, Brioschi & Cainelli, 2002; Laursen

& Salter, 2006; Nieto & Santamaría, 2007; Tsai & Wang, 2009; Faems et al., 2010; Chiang & Hung, 2010; Li & Tang, 2010; Dahlander & Gann, 2010; Leiponen & Helfat, 2010; Hwang & Lee, 2010; Inauen & Schenker-Wicki, 2011; Spithoven, Vanhaverbeke & Roijakkers, 2013; Mina, Bascavusoglu-Moreau & Hughes, 2014; Roper & Hewitt-Dundas, 2015; Cheng & Shiu, 2015; Greco, Grimaldi & Cricelli, 2016; Ferreras-Méndez, Fernández-Mesa & Alegre, 2016; Caputo et al., 2016; Martini, Neirotti & Appio, 2017; Monteiro, Mol & Birkinshaw, 2017). In practice, co-specialisation opportunities in science and technology parks widen the co-located firms` access to pool of possibilities to explore and experiment new knowledge. Thus, theoretically, the rate of transferability of knowledge between the co-located firms increases, as cognitive proximity between them increases, and knowledge distance decreases (Ben Letaifa & Rabeau, 2013). However, these proximities also increase the chances of unintended knowledge spillovers between them. This is an immense challenge for both the tenant firms and the ecosystem of science and technology parks. As Siegel, Waldman & Link, (2003) point out, in order to ensure the effectiveness of management and innovation initiatives "in the commercialisation process and the linking of science and technology park firms with higher education institutions, other tenants on the park, as well as firms located off-park, [the quality of managerial intermediaries] needs to be carefully monitored" (Siegel et al., 2003:181).

On the one hand, the costs of risking appropriability (Cassiman & Veugelers, 2002) may discourage the onsite firms form engaging in open search activities, specifically when the level of cognitive proximity is much higher due to due to a closer proximity with potential external actor. Firms located in science and technology parks may only invest in co-creation or co-specialisation activities with other onsite partners, if they can protect their intellectual property. On the other hand, without enough exposure to external knowledge and actors, the domain of efficiency of a firm`s societal practices would become limited, resulting in less accumulated social capital. The effective use of formal and informal appropriation mechanisms could serve as "a signal of a safe knowledge exchange and thereby promote the firm's internal expertise, and subsequently allow for the acquisition of new knowledge in return" (Veer, Lorenz & Blind, 2016: 1114). The co-located smaller firms show more vulnerability to rent-seeking pressures from their partners. Hence, it seems reasonable to expect that the use of appropriation mechanisms would yield more beneficial outcomes for them, and could even increase the level of their social status and legitimacy in the eyes of potential partners (Stefan &

Bengtsson, 2017). A firm`s social capital is one of the key components of its dynamic capability. Social capital helps a firm to gain legitimacy to successfully participate in the reciprocal activities with its co-creation partners, and to mitigate the risks associated with the rent-seeking pressure from them. Social capital further increases the level of awareness concerning the nuances of external knowledge and the activity specialisation of potential partners, thus, facilitates the integration of newly acquired knowledge by a firm`s employees (human capital), and within the organisational knowledge base (organisational capital) (Rothaermel & Deeds, 2004; Rothaermel, 2001).

3.3. Hypotheses

3.3.1. Open Search Strategy and Human Capital

As cited by many studies, the issues of `resource scarcity` and `lack of capitalisation on the multidisciplinary competence base` have risen to the fore as key challenges facing smaller firms in their reciprocal activities with co-creation partners (van de Vrande et al., 2009; Bianchi et al. 2010; Parida, Westerberg & Frishammar, 2012). A firm`s stocks of human capital present an overall picture of knowledge, skills, core competences and abilities of its employees. In other words, the stocks of human capital in a firm represent its individuals' specialised knowledge, ideas, experiences and practices, as well as their ability to generate further knowledge (Engelmanet et al., 2017). Human capital is "created by, and stored in, a firm's employees" (Reed, Lubatkin & Srinivasan, 2006: 869) and "may or may not stay within organisations and can change depending on the hiring, mobility, and turnover of employees" (Subramaniam & Youndt, 2005:451). In small firms, however, the hiring capacity is limited because of the financial constraints. Nevertheless, the degree of exposure to diverse knowledge domains is also known to be a major contributing factor to development of human capital in all firms (Subramaniam & Youndt, 2005). Exploratory learning is an integral part of the open search activities. From the perspective of organisational learning, the open search activities would widen a firm's exposure to external know-how and complementary knowledge (Xia & Roper, 2016).

Employees are at the front lines of a firm's reciprocal activities with external partners. External knowledge requires to be transferred into the firm. Hence, employees are the first contact points in dealing with learning issues (Todorova & Durisin, 2007). As individuals are responsible for screening activities, thus, their search activities would have positive consequences for themselves, as well as for their organisations. Similarly, a firm`s internal knowledge development capacity also depends on the ability of its employees (Bierly & Chakrabarti, 1996). Hence, employees which are "exposed to broad external networks will inherit greater knowledge and facility in both accumulating and taking advantage of new knowledge" (Dahlander, O'Mahony & Gann, 2016: 282). A more frequent rate of contacts with external partners would improve a firm`s capacity for research and development (Petroni, Venturini & Verbano, 2012), and would also facilitate the process of human resource management (Efendic, Mickiewicz & Rebmann, 2015). Furthermore, the reciprocal exchange of knowledge between the individuals of co-creation partners improves their core organisational knowledge bases and absorptive capacities (Lazzarotti, Manzini & Pellegrini, 2015). Hence, open search activities could help a firm to share the risks associated with `lack of multidisciplinary competency base` by speeding up its access to external human capital. Thus, it is expected that open search activities would principally influence the firm`s innovative capability at individual level, by enabling the firm to accumulate further human capital, and increasing possibilities to maintain the acquired expertise and individual skills through its openness. Therefore, in the light of the analysis above, it was hypothesised that:

Hypothesis 1. The higher the intensity of a firm`s open search strategy, the more likely it is to accumulate human capital.

3.3.2. Open Search Strategy and Organisational Capital

There is a tendency among smaller firms towards using less structured approaches to innovation, which is known to be one of the main challenges faced by them (Chesbrough & Crowther 2006). As it is the strategic direction of a firm that sets its open search agenda, unstructured or less structured approaches to innovation create difficulties for smaller firms, who wish to benefit from their open innovation activities. On the one hand, an effective external search strategy requires alignment with other organisational goals, and its needs expand beyond daily range of organisational tasks and systems (Dyer & Singh, 1998). On the other hand, external knowledge introduces the firm to a different, and probably new, set of organisational norms and practices, as it renews the firm`s knowledge base (Katila and Ahuja, 2002). Reciprocal exchange of knowledge with co-creation partners increases the chances of exposure to, and diffusion of routines, culture, practices, experiences and structures (Jolink & Dankbaar, 2010; Petroni, Venturini & Verbano, 2012). Once newly acquired stocks of knowledge are institutionalised and stored in a firm`s databases, manuals, structures, systems and processes, they shape its organisational capital (Youndt, Subramaniam & Snell, 2004). Organisational capital, by definition, is "knowledge, created by, and stored in, a firm's information technology systems and processes, that speeds the flow of knowledge through the organisation" (Reed, Lubatkin & Srinivasan, 2006:869).

Organisational capital is one of the key resources for higher-order innovation, and acts as a knowledge repository for firms. As explained earlier, exposure to external knowledge provides an integrated platform for communications and knowledge sharing between internally affiliated people and external partners. This platform, then, facilitates the accumulation of further knowledge (West & Bogers, 2014), by enhancing absorptive capacity of the firm (Cohen & Levinthal, 1990). The accumulated stocks of organisational capital "stay within organisations and do not change very easily" (Subramaniam & Youndt, 2005: 451), and guide its individuals and support their productive potential (Edvinsson & Malone, 1997).

In reciprocal open search activities, the success or failure of external knowledge cultivation depends on the both co-creation partners` ability to ensure mutual understanding (Dahlander, O'Mahony & Gann, 2016). The accumulated stocks of organisational capital form the foundation of organisational proximity between the co-creation partners and eliminate cognitive distance between them. Lack of cognitive proximity between the partners makes it impossible for them to understand, share, exchange, assimilate and apply knowledge (Nieto & Quevedo, 2005).

Innovation requires experimentation capability, which is "a subset of firms' ability to probe, experiment, test, and commercialise radical ideas and concepts across R&D, manufacturing and marketing activities" (Chang et al., 2012:449). To succeed in supporting experimentation with newly acquired knowledge through their open search activities, firms should have accumulated relevant stocks of organisational capital. Prior studies show that organisational proximity is a key factor in predicting the success or failure of collaborations (Pisano& Verganti, 2008). Thus, it is expected that a firm`s open search strategy would contribute to the accumulation of organisational capital - which are "leveraged through organisational structures, systems, processes, databases, manuals and patents"

(Swart & Kinnie, 2010: 66) -, and helps it to institutionalise its understandings of network needs. Hence, it was proposed that:

Hypothesis 2. The higher the intensity of a firm`s open search strategy, the more likely it is to accumulate organisational capital.

3.3.3. Open Search Strategy and Social Capital

Among problems faced by smaller firms are the lack of internal resources and competences (Grando & Belvedere, 2006) and the lack of technological assets to bargain with (Dahlander and Gann 2010) that prevent them from engaging in certain innovation networks (Kogut, 2000). These difficulties limit both the firm`s ability to exploit potential opportunities for socialisation and its access to sources of external and collaborative knowledge. Building capacity to utilise the social ties and links requires social capital, which denotes information about experiences, stories, norms, needs and strategies of the potential partners, as well as bargaining power, cultural and management skills.

In reciprocal co-creation activities, without continuous accumulation of social capital, "firms would be unable to sustain the flow of resources and information needed" (Blyler & Coff, 2003; 679). Social capital is defined as "the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships" (Nahapiet & Ghoshal, 1998:243), and it is also "utilised by interactions among individuals and their networks of interrelationships" (Subramaniam & Youndt, 2005:451). In other words, a firm`s social capital contains the map of its complex web of relationships, mirrors its social norms and portfolio of partners and its future direction (Phelps, Heidl & Wadhwa, 2012). A firm`s social capital stems from its collaborations, thus, frequent contacts with external partners help the firm to further its stocks of social capital.

Prior studies show that there are strong associations between a firm`s social capital and its absorptive capacity, as well as its experimentation capability (Chang et al., 2012; Savino, Messeni Petruzzelli & Albino, 2017). Open search activities widen both the firm`s web of relationships and its rate of interactions with potential external agents, both of which in turn facilitate the incorporation of new knowledge into the firm`s knowledge base. Firms with an enriched culture of openness show more flexibility to engage in open search activities, as the accumulated stocks of social capital tend to be largely preserved within organisations irrespective of changes in specific partner (Simonin, 1999; Lazzarotti, Manzini & Pellegrini, 2015). The accumulated social capital through open search activities are utilised to enhance their abilities to identify and draw from different terrains to create competitive advantages (Dahlander, O'Mahony & Gann, 2016). The breadth of external search activities helps a firm to improve its level of awareness about the market, actors and potential sources of knowledge. It was, therefore, hypothesised that:

Hypothesis 3. The higher the intensity of a firm`s open search strategy, the more likely it is to accumulate social capital.

3.3.4. Social Capital, Human Capital and Organisational Capital

Exploratory learning requires a firm`s individuals to have a shared platform of knowledge, insights and mental models to succeed in contributing to the evolution of organisational knowledge base through knowledge exchange and diffusion processes across various domains, which is social capital. (Dahlander, O'Mahony & Gann, 2016). Open innovation activities may not only increase the employees' individual knowledge and the firm`s human capital, but also help to further its social capital, which in turn could enhance the individuals` ability to build strong relationships with external partners and peers, and also could increase their potential for learning, innovation and accumulation of human capital. In other words, "as individuals learn and increase their human capital they may be creating knowledge that potentially forms the foundation for organisational learning and knowledge accumulation" (Youndt, Subramaniam & Snell, 2004:341).

As a firm accumulates further social capital, it would discover more opportunities for reciprocal open search activities with potential co-creation partners. On the other hand, social capital signals the firm`s capacity for accommodating heterogeneous knowledge (Teng, 2007). These positive effects facilitate the interactions with external partners and increase learning opportunities for the firm`s individuals. Exploratory learning and experimentation, at both individual and organisational levels, could help firms to respond to the challenges imposed by the lack of multidisciplinary competence bases - specifically in smaller firms - (Kelley, 2009; Lynn, Mohan Reddy & Aram, 1996).

The not-invented-here syndrome (Chesbrough & Crowther, 2006) limits the ability of firms and their individuals to explore new opportunities for learning. The accumulated stocks of social capital in the initial phases of operationalisation of open search strategy could enhance the overall ability of employees to understand external knowledge, and also could reduce the risks associated with the syndrome of not-invented-here (Katz & Allen, 1982) in organisations.

There is a general agreement in the literature that social interactions increase the employees' knowledge and creativity (Liu, 2013). As social capital fuels creativity and development of skills and competences among individuals (Nahapiet & Ghoshal, 1998), the accumulated stocks of social capital inside an organisation could increase the complementarities between its internal capabilities and external relationships in open search activities (Cassiman & Veugelers, 2006). The exploratory relationships contribute to the development of a firm's realised absorptive capacity (RACAP) (Xia & Roper, 2016). They also foster learning in firms, as the level of their employees` understanding of how, what and when to acquire new knowledge, skills and capabilities increases (Powell, Koput & Smith-Doerr, 1996). The accumulated stocks of social capital also help the employees to more precisely identify potential sources of complementary external knowledge, absorb them, and make informed decisions about the assimilation of them (Hsieh & Tidd, 2012). All of these, in turn, would lead to further accumulation of human capital. In light of the above insights, the following hypothesis was put forward:

Hypothesis 4. The higher the level of social capital accumulated by a firm engaged in open search activities, the more likely it is to accumulate human capital.

On the other hand, the accumulated stocks of social capital could extend the role played by a firm`s organisational capital in reinforcing and transferring knowledge along the business activities (Subramaniam & Youndt, 2005). Open search activities create opportunities for firms to find complementary knowledge, absorb and integrate them. A firm`s accumulated stocks of social capital work as conduits for driving collaborative approaches to learning and reinforcing knowledge, and thereby strengthen its ability to accumulate further organisational capital. The benefits firms gain from their exploratory relationships increase exponentially, as the accumulated stocks of social capital increase their exposure to a wide range of knowledge, information, experiences, practices, structure and relationships, and heighten the chances of experimentation and institutionalisation of external knowledge (Xia, 2013), that is organisational capital. Access to variety of external knowledge would enhance the firm`s assimilation and transformation capabilities (Leana & van Buren, 1999) and its absorptive capacity (Zahra & George, 2002). As explained earlier, the accumulated stocks of organisational capital are utilised to develop the organisational level innovative solutions for emerging demands and problems (Laursen, 2012). Without social capital, a higher degree of uncertainty in open search activities may lead to higher costs of enforcement and assimilation of knowledge (Sisodiya, Johnson & Grégoire, 2013), which in turn could hamper the firm's ability to accumulated organisational capital.

The societal capacity of a firm is the main determinant of its success in connecting external knowledge to its internal knowledge base (Laursen & Salter, 2006). As social capital and organisational capital are intrinsically linked (Reed, Lubatkin & Srinivasan, 2006), their joint productive potential could result in creation of an organisational culture supportive of experimentation, which in turn could potentially lessen the negative effects of `not invented here syndrome` inside the organisation, and enable the firm and its individuals to fully capture the anticipated rents form connecting internal and external resources (Blyler & Coff, 2003). Hence, it is expected that a higher level of social capital accumulated by a firm engaged in open search activities would result in further accumulation of organisational capital, thus, it was proposed that:

Hypothesis 5. The higher the level of social capital accumulated by a firm engaged in open search activities, the more likely it is to accumulate organisational capital.

3.3.5. Open Search Strategy, Appropriability Strategy and Social Capital

Labelled as the dark side of cooperation, smaller firms engaged in open innovation activities are exposed to risks associated with unintended knowledge spillovers, opportunistic behaviours of their partners and imitations (Veer, Lorenz & Blind, 2016), as well as appropriation costs and problems. This reflects the notion that open search activities could potentially heighten the costs of risking the firms` appropriation power (Chen, Chen & Vanhaverbeke, 2011; Henkel, Schöberl & Alexy, 2014). Firms normally use several appropriation mechanisms to limit the chances of unintended knowledge spillovers and retain the control of their key knowledge assets. The appropriability strategy denotes a firm`s strategic approach towards using “formal methods [of protection], such as patents or trademarks, as well as informal methods [of protection] such as secrecy or lead times" (Laursen & Salter, 2014:869) in order to capture the profits from its innovations. The ability of a firm to capture the rents from its innovations and protect them against unintended knowledge spillovers is among the key determinants of openness (Arora & Ceccagnoli, 2006).

Although appropriability and openness are two separate concepts, but both go hand in hand (Laursen & Salter, 2014). In recent years, two conflicting views have emerged about how a firm`s appropriability and openness strategies are related (Arora, Athreye & Huang, 2016). In one view, it is argued that as appropriability strategy has its roots in the will to achieve a maximum level of protection through excessive use of strong formal appropriation mechanisms, it reduces the chances of imitation and knowledge leakages, and subsequently stimulates collaboration on innovation between the co-creation partners (Pisano and Teece, 2007; Hagedoorn & Zobel, 2015). The alternative view holds that strong appropriation mechanisms could hamper the ability of firms to collaborate (von Hippel & Von Krogh, 2006; Baldwin & von Hippel, 2011).

Both formal and informal appropriation mechanisms have their own advantages and disadvantages. Formal appropriation mechanisms provide firms with strong legal grounds to protect their intellectual property against the opportunistic behaviours of partners. On the other hand, formal mechanism may obstruct the knowledge transfer between partners from being implemented. Informal mechanisms provide less security against unintended knowledge spillovers (Hurmelinna, Kyläheiko & Jauhiainen, 2007). The paradox of appropriability-openness relationship presents a challenge for shaping open search strategy in firms. Nonetheless, a firm's decision about what type of appropriation mechanisms to choose, or how much to protect depends on several factors, such as: its size, industry, sector (Levin et al. 1987), nature of its core knowledge (Teece, 1998) and institutional protection factors (Driffield, Mickiewicz & Temouri, 2016).

The size of firm is one of the key determinants of its appropriation choice (Neuhäusler, 2012). It is evident from the literature that as smaller firms are often faced with resource constraints, they tend to use informal appropriation mechanism more often than formal mechanisms (Leiponen & Byma, 2009; Love & Roper, 2015). Suffering from the liability of smallness, smaller firms could have different motives for protecting their intellectual property. They may use the appropriation mechanisms to enhance their market position, to legitimise their technological superiority, to improve their image, or to signal their qualities (Freel & Robson, 2004; Spithoven, Vanhaverbeke & Roijakkers, 2013; Love & Roper, 2015). Hence, it could be argued that the use of appropriation mechanisms is an integral part of the open search activities in smaller firms (Freel & Robson, 2016). For smaller firms, an effective appropriability strategy, given the likelihood that it could reduce perceived risks of unintended knowledge leakages (Thomä & Bizer, 2013), would increase the propensity of external partners to enter into the reciprocal knowledge exchange activities with them, thus, potentially would yield better innovation outputs for them (Revilla & Fernández, 2012). Hence, the following hypothesis was put forward:

Hypothesis 6. The intensity of a firm`s overall appropriability strategy has a positive association with the intensity of its open search strategy.

Conceptualised over two decades ago, the concept of relational capital (Burt, 1992; Sveiby, 1998; Sánchez, Chaminade & Olea, 2000; Reed, Lubatkin & Srinivasan, 2006) has derived to explain how organisations mobilise their resources through social structures (Hsu & Wang, 2012). Acting as a key component of a firm`s social capital, relational capital is defined as a set of implicit knowledge of organisational practices (Shipilov & Danis, 2006) which, at its core, evolves through interactions between internal and external agents and organisations (Kostova & Roth, 2003) and dictates itself as guiding codes to autochthonously manage the stages of exploration, acquisition, development, retainment, exploitation and disclosure of available knowledge resources (Khavandkar, Khavandkar, & Motaghi, 2013). Lack of significant technological assets and limited stock of knowledge are among the main difficulties faced by smaller firms in attracting external partners (Dahlander & Gann, 2010), as they limit the smaller firms` bargaining powers. Limited bargaining power restricts their ability to leverage relational capital, leading to less collaborative ties and lack of legitimacy.

On the other hand, smaller firms suffer from “less complex governance structures with external partners” (Wang, Tang & Park; 2017: 256) and having only a limited number of legally protected stock of knowledge (Agostini and Nosella, 2017), which taken together, make them vulnerable to knowledge leakage, actions of their partners and changes in the collaboration protocols (Hyvattinen, 2006). Use of appropriation mechanisms, specifically in smaller firms, signals the user`s innovative capabilities to the potential partners (Miozzo, 2016). In addition, it helps them to increase their level of control over key assets, and signal their assets to external partners, thus, facilitating the initiation of collaborative arrangements with potential partners. When a firm suffers from insufficient capacity to individually manage the whole innovation process, the signalling dimension of appropriation mechanism could increase the visibility of its valuable assets and innovations in the eyes of potential partners (Gronum, Verreynne & Kastelle, 2012; Miozzo, 2016). Hence, an effective appropriability strategy would enhance the firms` lobbying power and shape reciprocal obligations in collaborative settings (Blyler & Coff, 2003), specifically when a firm is engaged in open search activities. Subsequently, the enhanced bargaining power would result in better understanding of the both actual and potential partners` moves and discovering further opportunities to acquire and integrate external resources (Xia and Roper, 2016). For that reason, it is expected that a firm`s appropriability strategy would expedite the accumulation of social capital in open search activities, as it strengths relational capitalisation. Thus, it was anticipated that:

Hypothesis 7. The higher the intensity of a firm`s overall appropriability strategy, the more likely it is to accumulate social capital.

Fig. 3.1 illustrates all hypothesised relationships between research variables.

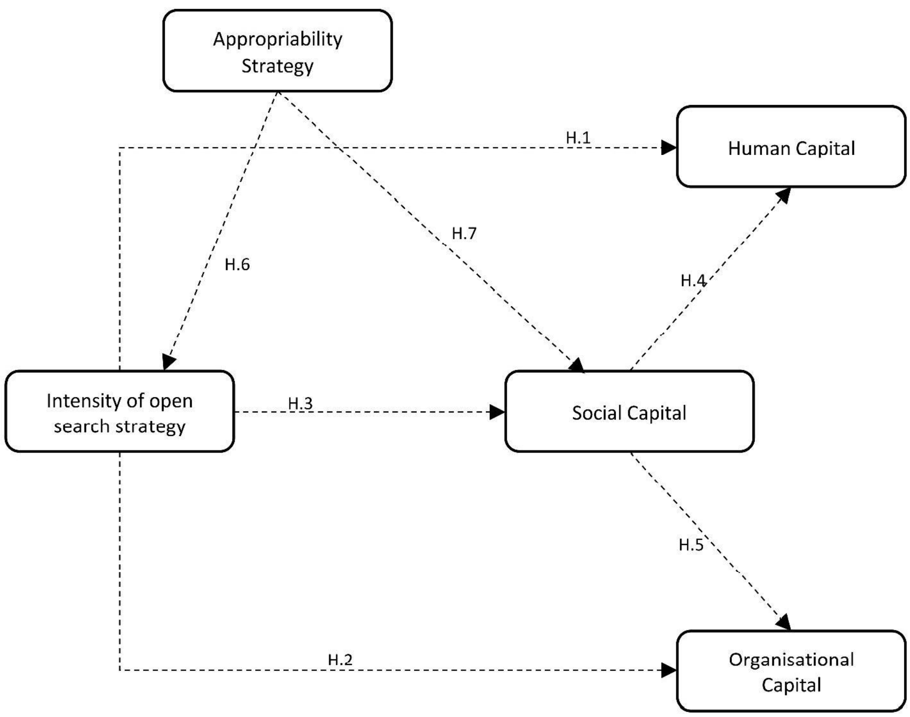


Fig. 3.1: Research model

3.4. Methods

3.4.1. Sample and Data Collection

To test the hypotheses, this study focused on firms located on science and technology parks in the United Kingdom. In this study, the UKSTPC database was used as the sampling frame. The UKSTPC database provides a comprehensive list of firms ranging from micro to large enterprises in different science and technology parks in the United Kingdom. The survey was based on a stratified (by region) sample of firms located in science and technology parks in the United Kingdom. The survey data[6] were collected from the highest-ranking official (single person from each company) via an online survey hosted by surveymonkey.com and on the project`s official website[7], between 1 June to 20 October 2015. The highest-ranking officials were selected as they play a central role in the day-to-day management of these business and their cognitive maps represent the essential aspects of all the members of the organisation (Lyles & Schwenk, 1992; Real, Roldán & Leal, 2014). In total, this study received responses from 385 firms located in science and technology parks in 12 different regions of United Kingdom. In the final dataset, 43 firms with missing and incomplete data were exclude. This yielded a final sample of 342 firms.

3.4.2. Variable Definition and Measurement

3.4.2.1. Independent and Dependent Variables

Intensity of open search strategy: A careful reading of the literature on open innovation revealed that the researchers had applied three different approaches to operationalising the concept of open search in their studies. Laursen & Salter (2006) defined two new constructs, namely external search breadth and external search depth. For the external search breadth, they simply created a counting measure of the total number of knowledge sources used by each firm based on the UK innovation survey. In order to operationalise the concept of search depth, Laursen & Salter (2006) applied another counting measure, but this time the total

---

[6] The dataset underlying this analysis is drawn from the UKSTP Survey which was first launched in 2015 and its purpose is to provide a means to measuring the levels and types of innovation activities among companies located in science and technology parks in the United Kingdom.
[7] www.ukstpsurvey.org

number of knowledge sources which were used to a high degree by each firm. These two measures have been widely used in open innovation studies as a proxy for firm level openness (Tether & Tajar, 2008; Grimpe & Sofka, 2009; Leiponen & Helfat, 2010; Lee et al., 2010; Garriga, von Krogh & Spaeth, 2013; Laursen & Salter, 2014; Terjesen & Patel, 2015; Ferreras-Méndez, Fernández-Mesa & Alegre, 2016; Ardito & Messeni Petruzzelli, 2017).

On the other hand, Lazzarotti & Manzini (2009), Lazzarotti, Manzini & Pellegrini (2011) and Lazzarotti, Manzini & Pellegrini (2015) applied a different variety of the measure created by Laursen & Salter (2006) and named it the `openness degree`. They measured the firms` openness using two variables: the partner variety and the average intensity of collaboration. The partner variety measure is almost similar to the search depth measure created by Laursen & Salter (2006). The second measure, average intensity of collaboration, was created by obtaining the collaboration depth score for each source on a 7-point Likert scale during the four phases of Idea generation, experimentation, engineering, manufacturing set up, commercialisation and then calculating the average measure by dividing the aggregated score by the number of partner types in each phase.

However, a limitation of the results obtained through non-Likert scales, as used in different waves of the community innovation survey, is that it does not allow for the analysis of the intensity and importance of open search strategy. Moreover, the items on the CIS questionnaire are normally broad and non-exclusive. For instance, the 4th UK Innovation Survey only included 10 possible external sources, out of which only 6 sources were used by Laursen & Salter (2014). Therefore, the limitations of commonly used data originated from the large-scale surveys such as Community Innovation Survey, and arithmetically constructed indicators of openness in measuring firms` open search strategy explain the need for a wider perception-based scale. As such, Laursen & Salter (2006:147) calls for development of "fine-grained items for each of the knowledge sources". Hence, this study developed and used a proxy variable for firm's open search strategy. Inspired by Katila & Ahuja (2002), the intensity of open search strategy was defined as new variable that reflected the extent to which firms draw from external sources or search channels in its innovative activities.

The process by which the open search strategy scale developed was explained in the earlier chapter. The survey listed twenty-four possible external sources and firms were asked to indicate the importance (on a seven-point Likert scale, 1=`very unimportant` to 7=`very important`) of each of these sources to their innovation activities. The list reflected a wide range of sources, twenty-four possible external sources, associated with the innovation ecosystem of science and technology parks and grouped into five distinct categories of: offsite market-based, onsite market-based, science-based, technical and application-based and institutional sources. In this study, a new variable was introduced reflecting overall intensity of firms` open search strategy. The overall intensity variable was constructed as a second order (reflective-reflective) multi-dimensional construct. The variable had five dimensions, each of which represented the intensity of a particular type of the open search strategy (i.e., offsite market-driven, onsite market-driven, science-driven, technical and application-driven and institutional open search strategies).

An exploratory factor analysis (EFA) using principal factors extraction with an oblique rotation on the items suggested that, a final set of 24 items loaded on five factors with eigenvalues greater than one. Together, these factors accounted for 64.12 percent of the variance. Factor loadings for the 24 items are shown in Table 3.1. Confirmatory factor analysis (CFA) on the 24 items showed that the five-factor structure, consisting of offsite market-driven, onsite market-driven, science-driven, technical and application-driven and institutional open search strategies, exhibited excellent fit $\chi^2_{247} = 432.269, CFI = 0.95, RMSEA = 0.047, SRMR = 0.0490$. Each dimension exhibited high reliability (α=0.86, 0.91, 0.78, 0.83, 0.80).

Moreover, to ensure the reliability and validity of measures of open search strategy, the fitness of the hypothesised structure of the construct-in which the five underlying dimensions were considered independent and distinct-was reassessed by comparing it with a competing structure-in which the five dimensions were hypothesised to converge into a single dimension. Following the recommendations of Bollen (1989) and Hu & Bentler (1995), first fit indices were compared across two rival models (Table. 3.2). Comparing the χ^2, p-value, CFI, GFI, AGFI, SRMR, RMSEA, PCLOSE, TLI, BIC and AIC criterion across two competing models indicated that the five-dimensional model fitted data better than the unidimensional model. Moreover, the five-dimensional model had a good fit, $RMSEA = 0.047$, while the unidimensional model had an unacceptable $RMSEA = 0.136$(Browne & Cudeck, 1993). Finally, the results of chi-square difference test, $\Delta\chi^2_5 = 1402.557$, confirmed that the five-dimensional model had a significantly better fit compared to the unidimensional model, reaffirming its superiority over the alternative model.

Table 3.1: Exploratory factor analysis and construct-level reliability: Overall intensity of open search strategy scale

	(1)	(2)	(3)	(4)	(5)	Cronbach`s Alpha
Offsite market-driven open search strategy						
Offsite suppliers of equipment, materials, components, or software	0.738					
Other external offsite businesses in your sector that are not direct competitors	0.797					
Offsite competitors	0.753					0.855
Offsite clients or customers from the public sector	0.762					
Other offsite enterprises in other sectors	0.773					
Offsite clients or customers from the private sector	0.73					
Onsite market-driven open search strategy						
Other onsite enterprises in other sectors		0.911				
Other onsite businesses in your sector that are not direct competitors		0.919				
Onsite competitors		0.876				0.906
Onsite suppliers of equipment, materials, components, or software		0.797				
Onsite clients or customers from the private sector		0.742				
Onsite clients or customers from the public sector		0.679				
Technical and application-driven search strategy						
Conferences and meetings			0.877			
Trainings or external sources of professional know-how			0.714			0.828
Fairs and exhibitions			0.751			
Scientific journals and trade/technical publications			0.726			
Experts, consultants or advisors			0.742			
Science-driven search strategy						
Commercial laboratories or R&D enterprises				0.872		0.779
Public research organisations				0.804		
Universities or local academics				0.773		
Institutional search strategy						
Financial institutions and banks					0.807	
Local and national government					0.79	0.798
Park management or centre management					0.696	
Professional and industry/trade associations					0.766	

Table 3.2: Competing measurement models – overall intensity of open search strategy scale

		Five-dimensional Measurement Model			***Unidimensional Measurement Model***	
		Standardized Regression Weights			*Standardized Regression Weights*	
Conferences and meetings	<---	Application	0.769	<---	OSS	0.436
Experts, consultants or advisors	<---	Application	0.714	<---	OSS	0.479
Fairs and exhibitions	<---	Application	0.657	<---	OSS	0.416
Scientific journals and trade/technical publications	<---	Application	0.622	<---	OSS	0.48
Trainings or external sources of professional know-how	<---	Application	0.69	<---	OSS	0.483
Financial institutions and banks	<---	Institutional	0.642	<---	OSS	0.461
Local and national government	<---	Institutional	0.666	<---	OSS	0.459
Park management or centre management	<---	Institutional	0.789	<---	OSS	0.625
Professional and industry/trade associations	<---	Institutional	0.718	<---	OSS	0.531
Offsite competitors	<---	Offsite	0.66	<---	OSS	0.444
Offsite clients or customers from the public sector	<---	Offsite	0.696	<---	OSS	0.488
Offsite clients or customers from the private sector	<---	Offsite	0.594	<---	OSS	0.39
Other offsite enterprises in other sectors	<---	Offsite	0.79	<---	OSS	0.557
Other external offsite businesses in your sector that are not direct competitors	<---	Offsite	0.804	<---	OSS	0.552
External offsite suppliers of equipment, materials, components, or software	<---	Offsite	0.688	<---	OSS	0.489
Onsite competitors	<---	Onsite	0.838	<---	OSS	0.725
Onsite clients or customers from the public sector	<---	Onsite	0.704	<---	OSS	0.675
Onsite clients or customers from the private sector	<---	Onsite	0.748	<---	OSS	0.709
Other onsite businesses in your sector that are not direct competitors	<---	Onsite	0.832	<---	OSS	0.698
Other onsite enterprises in other sectors	<---	Onsite	0.843	<---	OSS	0.716
Onsite suppliers of equipment, materials, components, or software	<---	Onsite	0.773	<---	OSS	0.712
Commercial laboratories or r&d enterprises	<---	Science	0.794	<---	OSS	0.448
Public research organisations	<---	Science	0.786	<---	OSS	0.45
Universities or local academics	<---	Science	0.634	<---	OSS	0.365

Fit Indices

	Five-dimensional Measurement Model	***Unidimensional Measurement Model***
χ^2	432.269	1834.826
df	247	252
ρ $value$	0	0
CFI	0.95	0.576
GFI	0.897	0.593
$AGFI$	0.875	0.515
$SRMR$	0.0490	0.1156
$RMSEA$	0.047	0.136
$PCLOSE$	0.752	0.0
TLI	0.945	0.535
BIC	741.507	2114.8962
AIC	538.262	1930.826

Human capital: In keeping with seminal conceptualisations of human capital and intellectual capital (Edvinsson & Malone, 1997; Stewart, 1997; Nahapiet & Ghoshal, 1998; Sveiby,1998) and in line with the knowledge-based view of the firm (Grant, 1996), this study used a context-oriented definition of human capital. Hence, human capital defined as the sum of all knowledge, skills, experiences, capabilities and abilities of the creative, bright and skilled employees which denotes the knowledge resources and assets created by, and retained by people of the organisation rather than the organisation itself (Youndt, Subramaniam & Snell, 2004), and needed to be leveraged to be considered as intellectual capital (Subramaniam & Youndt, 2005). As Argyris & Schon (1978) argue, it is considered as the origin of all organisational knowledge, yet it requires capacity utilisation to become a competitive advantage for the hosting organisation (Edvinsson & Malone, 1997).

While human capital can be accumulated internally, but its development is mainly subjected to the extent of renting and borrowing capabilities which an organisation holds (Stewart, 1997). Therefore, human capital represents a key operational factor to drive value creation dynamics over the time (Engelman et al., 2017). However, according to Blyler & Coff (2003), human capital, solely, may not add a new layer of new to the organisational knowledge resources unless it is equipped with social networks. In fact, the strength of an organisation`s human capital involved in open search activities could influence organisational learning and knowledge accumulation and predict future directions of its collaborative innovation activities. While it is the employees` relationships building capabilities that creates the necessary platform for knowledge transactions for open innovation activities, it is the relational capital of an organisation that legitimises the relationship creation process and leads to greater human capital. In turn, the higher an organisation`s human capital, the more likely it is to absorb, accumulate, assimilate and apply knowledge through open search sourcing strategies (Cohen & Levinthal, 1990).

Human capital was measured via five items adopted from the scale developed (refined to assess the extent of the readability of the representative measurement items for micro, small and medium sized enterprises located in science and technology parks) by Youndt, Subramaniam & Snell (2004) and Subramaniam & Youndt (2005). Respondents answered on a seven-point scale ranging from 1=`strongly disagree` to 7=`strongly agree` to a set of five questions asking for the extent to which they agree or disagree with each of the statements. An exploratory factor analysis on the items suggested that, all 5 items loaded (loadings >.50) on one factor (eigenvalues>1) that accounted for 72.87 percent of the variance. Coefficient α for the scale was .904 (Table 3.3).

Table 3.3: Exploratory factor analysis: Human capital

Items	*Loadings*
Our employees are highly skilled.	0.89
Our employees are experts in their particular jobs and functions.	0.89
Our employees are on par with the best in our industry.	0.84
Our employees are keen to explore new ideas by thinking outside the box.	0.83
Our employees are creative and bright.	0.81
% of Variance	72.87
Cronbach's alpha	0.90

Social Capital: refers to the type of capital that neither resides at the organisational nor the individual level (Youndt, Subramaniam & Snell, 2004). Yet, a firm`s social capital is a key determinant of its knowledge acquisition and exchange capabilities (Forés & Camisón, 2016) and an important part of its absorptive capacity that makes external and internal resources connected (Bierly & Chakrabarti, 1996). Thus, as Nahapiet and Ghoshal (1998) explain, social capital is defined as an intermediary form of intellectual capital that resides in, and simultaneously is derived from, internal and external networks of relationships (Burt, 1992). The definition, which was used in this study, denotes that different types of relationships and resources - employed through reciprocal channel of relationships - by their nature and their role could have different impacts on development of social capital (Lavie, Haunschild & Khanna, 2012; Massingham, 2016). In turns, once the reciprocal channels of relationships are established, the organisational routines will be inaugurated. Furthermore, when organisational capital developed, organisations will be better able to leverage relation-idiosyncratic aspects of assets; this will enable organisations to counterweight the risks of dependency on bilateral arrangements, at both interpersonal and interorganisational levels (Teece, 1986). Under such conditions, firm`s accumulated organisational knowledge will be strengthened, and reciprocal obligations will be enforced, as partner-specific relationships mutually develop (Reuer, Zollo & Singh, 2002).

This study measured relational capital using five items drawn in principle from Youndt, Subramaniam & Snell (2004) and Edvinsson & Sullivan (1996). Youndt, Subramaniam & Snell (2004) initially developed and tested a five-item scale to assess the social capital aspect of intellectual capital exclusively. Further items were also generated deductively (Hinkin, 1998) from a review of existing literature on internal and external social capital, relational capital and intellectual capital (Edvinsson & Sullivan, 1996; Teece, 1986; Lavie, 2006; Van Wijk, Jansen & Lyles, 2008; Hormiga, Batista-Canino, & Sánchez-Medina, 2011; Lavie, Haunschild & Khanna, 2012; Khavandkar, Khavandkar, & Motaghi, 2013). This scale was refined to assess the extent of the readability of the representative measurement items for micro, small and medium sized enterprises located in science and technology parks. Firms were asked to indicate the extent to which they agree or disagree with each of the statements, using a seven-point scale ranging from 1=`strongly disagree` to 7=`strongly agree`. An exploratory factor analysis on the items suggested that all 6 items loaded on single factor (eigenvalues > 1). Together, these factors accounted for 63.89 percent of the variance. Cronbach's alpha for the scale was .854 (Table 3.4).

Table 3.4: Exploratory factor analysis: Social capital

Items	*Loadings*
Our employees interact and exchange ideas with people from different areas of the company.	0.81
Our employees are skilled at collaborating with each other to diagnose and solve problems.	0.84
Our employees share information and learn from one another.	0.82
Our employees cultivate and utilise variety of sources for new ideas, knowledge and solutions.	0.81
Our employees partner with stakeholders to develop solutions and obtain new ideas.	0.71
% of Variance	63.89
Cronbach's alpha	0.85

Organisational Capital: represents a firm's stock of knowledge which is highly institutionalised and codified (Youndt, Subramaniam & Snell, 2004), in other words the stock of knowledge that is owned by the firm, and is leveraged for gaining competitive advantages. According to Swart & Kinnie (2010) and Reed, Lubatkin & Srinivasan (2006), a firm`s organisational culture, structures, databases, systems, routines, manuals and processes are repositories of organisational capital. Thus, a firm`s accumulated organisational capital is the principal driver in explaining its knowledge assimilation and integration capabilities. Besides, the process by which these forms of knowledge are accumulated reflects even more deeply the organisational aspect of firm`s absorptive capacity (Lane & Lubatkin, 1998) that entails a set of abilities required to transform and exploit the new knowledge in order to drive commercial outputs. This study measured organisational capital using a six-item scale. Three items were drawn from Youndt, Subramaniam & Snell (2004), and further items were generated deductively (Hinkin, 1998) from a review of existing literature on organisational capital and intellectual capital (Hsu & Wang, 2012; Swart & Kinnie, 2010; Reed, Lubatkin & Srinivasan, 2006; Subramaniam & Youndt, 2005; Nahapiet & Ghoshal, 1998; Sveiby, 1998; Stewart, 1997; Edvinsson & Malone, 1997; Edvinsson & Sullivan, 1996). This scale was refined to assess the extent of the readability of the representative measurement items for micro, small and medium sized enterprises located in science and technology parks. Firms were asked to indicate the extent to which each of the six statements descried their organisations, using a seven-point scale ranging from 1=`strongly disagree` to 7=`strongly agree`. An exploratory factor analysis on the items suggested that all 6 items loaded on single factor (eigenvalues > 1). Together, these factors accounted for 63.89 percent of the variance. Cronbach's alpha for the scale was .854 (Table 3.5). Confirmatory factor analysis (CFA) on the 6 items showed that the unidimensional structure exhibited good fit $\chi^2_7 = 21.710, CFI = .983, RMSEA = .079, SRMR = .0298.$

Table 3.5: Exploratory factor analysis: Organisational capital

Items	***Loadings***
Our organisation systematically monitors the value of its stock of knowledge, and its fitness for purpose.	0.87
Our organisation effectively communicates the value of its stock of knowledge to the stakeholders.	0.80
Much of our organisation's knowledge and information is contained in manuals, databases, etc.	0.72
Our organisation's culture (stories, rituals) contains ways of doing business, valuable ideas etc.	0.74
Our organisation periodically embeds much of its knowledge and information in structures, systems, and processes.	0.73
Our organisation actively uses management initiatives to monitor development of new information, knowledge, practices etc.	0.72
% of Variance	58.48
Cronbach's alpha	0.855

Appropriability Strategy: refers to the perceived effectiveness of informal appropriation mechanisms, such as lead time, complexity and secrecy product, and formal appropriation mechanisms patents, trademarks, copyrights, and design rights, as ways to appropriate the value from the innovation and protect firm`s core-knowledge and innovation from imitation (Laursen & Salter, 2014). The measure of appropriability strategy has been widely used in the previous empirical research with regards to the firms' open innovation activities (Laursen & Salter, 2014; Freel & Robson, 2016; Zobel, Lokshin, & Hagedoorn, 2017, amongst others). Firms were asked to indicate: how effective was each of the appropriation mechanisms for maintaining or increasing the competitiveness of their product and process innovations, on a seven-point Likert scale ranging from not at all (1) to very extremely important (7) to measure this construct. In this study, as determinants of firms` overall (both formal and informal) perceived effectiveness of appropriability strategy, a new variable was introduced. The overall perceived effectiveness of appropriability strategy variable was constructed as a second order (reflective-reflective) multi-dimensional construct. The variable had two dimensions, each of which represented the intensity of a particular set of the appropriation mechanisms (i.e., formal and informal appropriation mechanism). An exploratory factor analysis (EFA) using principal factors extraction with an oblique rotation on the items suggested that, a final set of 7 items loaded on two factors with eigenvalues greater than one. Together, these factors accounted for 48.92 percent of the variance. Cronbach's alpha for the scale was .81. Factor loadings for the 7 items are shown in Table 3.6.

Table 3.6: Exploratory factor analysis: Appropriability strategy

Items	***Loadings***	
	(1)	***(2)***
Design registration	0.88	
Patents	0.80	
Trademarks	0.88	
Copyright	0.83	
Complexity of goods or services introduced by your company		0.77
Secrecy (include non-disclosure agreements)		0.81
Lead time advantages		0.80
% of Variance		48.92
Cronbach's alpha		0.81

3.4.2.2. Control Variables

Over the past two decades, considerable research has been devoted to identifying contextual factors that could facilitate or hinder firms` open search endeavours. The majority of work on external knowledge sourcing, that has attempted to study the links among different degrees of openness, strategic orientations of firms, and innovation performance, argue that innovative activity depends on the firms` internal contextual factors. On the other hand, literature on intellectual capital and dynamic capability have also highlighted the unquestionable roles exerted by contextual factors in explaining the success or failure of firms` innovation performance. Given that many studies of open innovation have found that a key source of difference between firms' open search performance is their firm-specific characteristics, a set of commonly used firm-specific control variables were included in the analysis.

Size: Prior research has shown that firms' innovation performance in part depends on the type(s) of internal and external knowledge source that is being utilised (Ritala & Hurmelinna-Laukkanen, 2013; Cantner, Joel & Schmidt, 2011). On one hand, as Teece (1986) argue, large firms have superior access to resources and enjoy wider access to complementary assets, and better capability to exploit external knowledge sources than their smaller rivals. On the other hand, it is conceived that lack of recourses in small firms, difficulties in building absorptive capacity (Roper & Hewitt-Dundas, 2013), and lack of multidisciplinary competence bases (Parida, Westerberg & Frishammar, 2012) are among the main barriers that preventing them from accessing the wider networks and reaching their growth potential. Yet, prior studies argue that small firm could outperform their larger rivals in terms of learning ability, creativity, flexibility and speed (Christensen & Bower, 1996). Researchers have also proposed that open search strategies could accelerate small firms` acquisition capability and enhance their innovativeness (Forés & Camisón, 2016; Dahlander & Gann 2010; van de Vrande et al, 2009; Camisón-Zornoza et al., 2004; Damanpour, 1992). In keeping with other open innovations studies (van de Vrande et al., 2009; Lee et al., 2010; Parida, Westerberg & Frishammar, 2012; Spithoven, Vanhaverbeke & Roijakkers, 2013; Colombo, Croce & Murtinu, 2014; Vahter, Love & Roper, 2014), this study therefore examined the role of firm size, by the natural logarithm of number of employees. Out of 342 firms, 65.8 percent were micro enterprises; 28.9 percent small enterprises; 5.3 percent medium size enterprises. The average number of employees was 14.65.

Years spent in park: Lynn, Morone & Paulson (1996) argues that the process of understanding the radical innovation`s markets is in essence an experimental one. Chang et al. (2012) define the experimentation capability as a set of probing abilities and extensive experimenting capabilities of a firm in dealing with radical innovation, which are strongly associated with innovation performance. However, successful innovation requires access to complementary know-how from the external environment. Lane & Lubatkin (1998) show that a firm`s learning depends on the similarity of both, the focal firm and partner firm, knowledge bases. In fact, if a firm attends to external knowledge without a previously generated knowledge base, it will lack the key mechanism behind knowledge integration. The above reasoning indicates that a firm`s knowledge base and its social capital are key determinants in shaping its ability to acquire, transform and assimilate external knowledge. Hence, firms require time to build these capabilities and their knowledge base, establish their positions in, and familiarise themselves with the conditions of ecosystem and active partners. Drawing on the innovation literature, older firms possess more refined capabilities and resource that could facilitate the process of knowledge acquisition and exploitation (Sinkula, 1994; Huergo & Jaumandreu, 2004; Parida, Westerberg & Frishammar, 2012). Thus, the number of years a firm spent in a science and technology park, may interfere with the relationships being studied. The median of number of years firms had spent in science and technology parks was 5 years. The variable, years spent in park, was operationalised using the natural log of the number of years each firm had spent in a science and technology park at the time of survey.

Industry Effect: Prior research has highlighted the differences between open innovation in manufacturing and services industries. van de Vrande et al., (2009) argue that firms in manufacturing industries are more prone to engage in open innovation activities due to their technology intensity and nature of their offerings. Moreover, previous studies suggest appropriability regimes varies across industry sectors (Hall et al., 2014), such that manufacturing firms depend more on the use of formal appropriation mechanism to protect their innovation due to the nature of their products (Hertzfeld, Link & Vonortas, 2006). To control for industry differences, two industry dummies based on two-digit NACE classes were created dividing the sample into service industry and manufacturing firms. In the sample, 84.8 percent represented businesses in the service sector and 22.3 percent were businesses in the manufacturing sector.

Internationalisation: Firms that want to remain competitive in the market need to access distant knowledge. Chang et al., (2012) define a firm`s open search capability as the ability to search for both external and distant knowledge, rather than solely relying on internal and local knowledge. Similarly, Rosenkopf & Nerkar (2001) highlight the importance of participation in boundary spanning relationships beyond the local search as an effective means to avoid the competence traps. To Phene et al. (2006), the technological proximate knowledge of international origins could foster innovation and create opportunities for making novel linkages. Besides, the open innovation literature also confirms that the relationship between openness and firm performance could take different forms depending on geographical context of market it operates in (Spithoven, Vanhaverbeke &

Roijakkers, 2013). In this study, a firm`s strategic focus on operating in international markets was captured using a dummy variable that took value of 1 if the firm had served foreign markets and 0 if the firm had only served the regional or national markets. In terms of market dispersion, 42.7% of the sample firm were only active in the national market, while 57.3% of them were actively engaged in selling products and services internationally.

3.4.2.3. Variables for Multi-Group Analyses

To explore the effects of firm radical innovation and Efficacy of internal sources of know-how, this study followed a different approach based on the multi group analysis. In this study PLS based multi-group analysis was adopted to investigate the impact of two categorical variables on the influence of independent variables towards the dependent variable. The objective of performing multi-group analysis was to confirm that whether the paths between groups were significantly different or not. The presence of significant difference among the different groups (e.g. firms with radical innovation vs. firm without radical innovation and low efficacy vs. high efficacy of internal sources of know-how) suggests that each of these less explored factors may or may not have effect on the path strength and direction.

Radical Innovation: Radicalness, or the ability to introduce new products or services to market that involve radical changes in technology for the firm (Atuahene-Gima, Slater & Olson, 2005), requires firms to engage actively in the pursuit of new knowledge (Laursen & Salter, 2006) and exploratory learning (March, 1991). Hence, a firm`s ability to develop radical inventions, in turn, could reflect its acquisition capability (Kang, Morris & Snell, 2007) and the efficacy of firm` external search strategy (McGrath, 2001). The above reasoning indicates that success rate in radical innovation performance may vary as firms` exploration, flexibility-enhancing, and adaptive capacities could differ from each other (March, 1991). Likewise, as Chang et al. (2012) argue, firms reflect different levels of transformation capabilities when involved in different types of innovation, radical innovation and incremental innovation. Generally speaking, Firms with greater transformation capabilities are more successful with radical innovations, as their success in integrating the newly obtained knowledge into the pre-existing knowledge base and internal processes depends on the transformation capability (Zahra & George, 2002). To account for the radicalness of the product or service introduced by firms, a dummy variable was introduced that took on the value of 1 if the firm had introduced a new product (covering both goods and services) to the market and received a value of 0 if the company had not introduced any new products to the market. The measure of radicalness has been widely used in the previous empirical research (Laursen & Salter, 2006; Leiponen & Helfat, 2010, amongst others). About 48.5% of the firms in the sample indicated that their firms had introduced at least one new product or service innovation into the market.

Efficacy of internal sources of know-how: According to Jiménez-Jiménez & Sanz-Valle (2008), a firm`s knowledge accumulation capability has two sides to it: the ability to absorb external knowledge and the ability to create knowledge internally. Laursen (2012) argues that a firm`s external search strategy in combination with its stocks of knowledge stored in the internal knowledge base lead firm to acquire competitive advantage by developing unique solutions for emerging problems. In a similar vein, Smith, Collins & Clark (2005) also show that frequent contact with the external environment can increase the rate of internal knowledge creation. However, Lane & Lubatkin (1998) point out that similarity between the focal firm`s knowledge base and its partner`s knowledge base is a key determinant of learning success in collaborative settings. In fact, firms need to develop an enhanced organisational knowledge base to reduce the costs of external knowledge integration. On the other hand, Mention (2011) shows that the use of internal know-how is positively associated with firms` innovation outputs. In fact, firms` reliance on internal knowledge sources is an important determinant of its ability to acquire external knowledge because it increases cognitive proximity. To explore the role of efficacy of internal sources of know-how, the importance of drawing on internal sources of specialist know-how (from the focal firm`s own business or enterprise group) over the last three years (2012 to 2015) was measured on a 7-point Likert scale where 1 denoted `very unimportant` and 7 denoted `very important`. In order to observe the impact of internal sources of know-how on hypothesised relationships, a dichotomous variable (1 = low <5.24 and 2 = high > 5.24) was created based on the arithmetic mean (5.24) of the firms` overall scores on the questions. Based on the obtained mean value, firms were divided into two groups: firms with low efficacy of internal sources of know-how (45 percent of firms, mean = 3.75) and firms with high efficacy of internal sources of know-how (55 percent of firms, mean = 6.51) groups.

3.5. Data analysis and Results

3.5.1. Tests for Potential Biases

To assess sample representativeness, Mann–Whitney U tests for non-response bias (Armstrong & Terry, 1977) were conducted by comparing the mean figures on human capital, social capital, organisational capital, open search strategy between a first and second wave of the survey. Details of the Mann–Whitney U test are presented in Table 3.7. No significant differences between means were detected.

Table 3.7: Non-response survey bias test: Mann–Whitney U Tests

All firms (n=384)	Early respondents (n=178)		Late respondents (n=206)		Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Variable	Mean	S.D.	Mean	S.D.				
Human Capital	6.34	0.73	6.39	0.66	13929.5	24660.5	-0.428	0.669
Organisational Capital	4.72	1.17	4.87	1.14	13319.5	24050.5	-1.094	0.274
Social Capital	5.99	0.84	6.04	0.82	13592	24323	-0.797	0.426
Open Search Strategy	4.14	1.00	4.11	0.96	13838.5	33144.5	-0.519	0.604
Appropriability Strategy	3.58	1.43	3.54	1.41	14079	33385	-0.253	0.8

This study relies on self-reported measures. In addition, data were collected from a single source. Hence, it was necessary to take all steps towards mitigating the possible influences of common method variance (CMV) or common method variance (CMV). As explained in Chapter Two, considerable steps were taken before and during the survey in order to minimise any bias that common method variance can introduce into the study. Furthermore, the Harmon's one-factor test (Podsakoff & Organ, 1986) was applied to test ex-post for the presence of common method bias. Table. 3.8 presents the results of Harmon's one-factor test. The single-factor solution contributed to only 29.59 percent of variance, thus, common method bias was not likely to be a significant issue.

Table 3.8: Common method variance or bias test: Harman's one-factor test

	Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %
1	13.907	29.59	29.59

In addition, the common latent factor (CLF) method was also applied to check for common method variance (Podsakoff et al., 2003). Comparing the standardised weights with and without CLF revealed that all values were below the recommended threshold of 0.2 (Table 3.9). Overall, the results suggested that common method was not present (Malhotra, Kim & Patil, 2006).

Table 3.9: Common method variance or bias test: Common latent factor test

Variables	**Standardised Regression Weights with CLF**	**Standardised Regression Weights without CLF**	**Difference**
Other Onsite Enterprises in other Sectors	0.808	0.842	0.034
Other Onsite Businesses in Your Sector that are not Direct Competitors	0.796	0.832	0.036
Onsite Competitors	0.821	0.838	0.017
Onsite Suppliers of Equipment, Materials, Components, or Software	0.751	0.771	0.02
Onsite Clients or Customers from the Private Sector	0.773	0.749	-0.024
Onsite Clients or Customers from the Public Sector	0.771	0.706	-0.065
Our employees are highly skilled.	0.851	0.881	0.03
Our employees are experts in their particular jobs and functions.	0.852	0.87	0.018
Our employees are on par with the best in our industry.	0.78	0.801	0.021
Our employees are keen to explore new ideas by thinking outside the box.	0.752	0.769	0.017
Our employees are creative and bright.	0.719	0.745	0.026
Offsite Suppliers of Equipment, Materials, Components, or Software	0.691	0.694	0.003
Other Offsite Businesses in Your Sector that are not Direct Competitors	0.811	0.802	-0.009
Offsite Competitors	0.656	0.658	0.002
Offsite Clients or Customers from the Public Sector	0.705	0.694	-0.011
Other Offsite Enterprises in other Sectors	0.798	0.79	-0.008
Offsite Clients or Customers from the Private Sector	0.59	0.592	0.002
Our organisation systematically monitors the value of its stock of knowledge, and its fitness for purpose.	0.881	0.882	0.001
Our organisation effectively communicates the value of its stock of knowledge to the stakeholders.	0.771	0.773	0.002
Much of our organisation’s knowledge and information is contained in manuals, databases, etc.	0.65	0.653	0.003
Our organisation’s culture (stories, rituals) contains ways of doing business, valuable ideas etc.	0.667	0.67	0.003
Our organisation periodically embeds much of its knowledge and information in structures, systems, and processes.	0.612	0.621	0.009
Our organisation actively uses management initiatives to monitor development of new information, knowledge, practices etc.	0.633	0.639	0.006
Design registration	0.839	0.834	-0.005
Patents	0.74	0.743	0.003
Trademarks	0.847	0.851	0.004
Copyright	0.762	0.758	-0.004
Our employees interact and exchange ideas with people from different areas of the company.	0.726	0.737	0.011
Our employees are skilled at collaborating with each other to diagnose and solve problems.	0.79	0.81	0.02
Our employees share information and learn from one another.	0.755	0.771	0.016

Table3.9: Common method variance or bias test: Common latent factor test

Variables	**Standardised Regression Weights with CLF**	**Standardised Regression Weights without CLF**	**Difference**
Our employees cultivate and utilize variety of sources for new ideas, knowledge and solutions.	0.762	0.762	0
Our employees partner with customers, suppliers, alliance partners, etc., to develop solutions and obtain new ideas.	0.611	0.623	0.012
Conferences and Meetings	0.76	0.766	0.006
Experts, Consultants or Advisors	0.693	0.686	-0.007
Fairs and Exhibitions	0.652	0.662	0.01
Scientific Journals and Trade/Technical Publications	0.629	0.628	-0.001
Trainings or External Sources of Professional Know-How	0.695	0.711	0.016
Financial Institutions and Banks	0.631	0.644	0.013
Local and national Government	0.647	0.66	0.013
Park Management or Centre Management	0.813	0.793	-0.02
Professional and Industry/Trade Associations	0.709	0.718	0.009
Commercial Laboratories or R&D Enterprises	0.788	0.804	0.016
Public Research Organisations	0.741	0.764	0.023
Universities or Local Academics	0.629	0.647	0.018
Complexity of goods or services introduced by your company	0.517	0.53	0.013
Secrecy (include non-disclosure agreements)	0.81	0.812	0.002
Lead time advantages	0.654	0.655	0.001

3.5.2. Tests for Normality and Homoscedasticity

Normality, homoscedasticity and multicollinearity were tested to ensure that the underlying assumptions of structural equation modelling were satisfied. First, the Kolmogorov-Smirnov and Shapiro-Wilk (K-S) tests (Shapiro & Wilk, 1965) were applied to examine normality (Table. 3.10`). These findings indicated that normality was violated. However, it is evident from the literature that the Kolmogorov-Smirnov and Shapiro-Wilk (K-S) statistics are very sensitive to the size of sample (Pallant, 2013). Hence, the violation of the normality assumption may not be a major issue stage.

Table 3.10: Normality Test: Kolmogorov–Smirnov and Shapiro–Wilk tests

Construct	Kolmogorov-Smirnov Test			Shapiro-Wilk Test		
	Statistic	*df.*	*sig.*	*Statistic*	*df.*	*sig.*
Human Capital	0.18	342	0	0.846	342	0
Organisational Capital	0.078	342	0	0.979	342	0
Social Capital	0.137	342	0	0.917	342	0
Open search Strategy	0.068	342	0.001	0.989	342	0.012
Appropriability Strategy	0.048	342	0.056	0.982	342	0

Furthermore, the distributions of variables were examined using skewness and kurtosis measures (Pallant, 2013). Skewness statistics ranged between -1.20 and 0.03. Kurtosis statistics ranged between -0.68 and 1.14. thus, none of them exceeded the recommended threshold (<±2.58) (Hair et al., 2014).

Table 3.11: Normality test: Skewness and Kurtosis values

Construct	n	Mean	S.D.	Skewness		Kurtosis	
				Statistic	*S.E.*	*Statistic*	*S.E.*
Human Capital	342	6.37	0.69	-1.20	0.13	1.14	0.26
Organisational Capital	342	4.81	1.15	-0.51	0.13	0.24	0.26
Social Capital	342	6.02	0.83	-0.97	0.13	1.13	0.26
Open search Strategy	342	4.12	0.98	-0.29	0.13	-0.23	0.26
Appropriability Strategy	342	3.55	1.42	0.03	0.13	-0.68	0.26

To assess the multivariate normality assumption, Mardia's coefficient or Multivariate Kurtosis value was estimated. As shown in Table. 3.12, the coefficient value and the critical ratio were 283.41 and 38.61, respectively. These findings indicated that the assumption of multivariate normality was violated (critical value>1.96) (Brwon, 1982).

Table 3.12: Multivariate Normality test: Mardia's test

Variable	skew	c.r.	kurtosis	c.r.
Lead time advantages	-0.31	-2.32	-1.35	-5.08
Secrecy (include non-disclosure agreements)	-0.45	-3.42	-1.27	-4.81
Complexity of goods or services introduced by your company	-0.86	-6.51	-0.49	-1.85
Universities or Local Academics	-0.54	-4.04	-0.80	-3.03
Public Research Organisations	0.02	0.12	-1.20	-4.54
Commercial Laboratories or R&D Enterprises	-0.02	-0.13	-1.32	-5.00
Professional and Industry/Trade Associations	-0.34	-2.54	-1.15	-4.35
Park Management or Centre Management	-0.19	-1.40	-1.15	-4.33
Local and national Government	-0.59	-4.42	-0.91	-3.44
Financial Institutions and Banks	-0.10	-0.74	-1.05	-3.98
Trainings or External Sources of Professional Know-How	-1.07	-8.06	1.11	4.19
Scientific Journals and Trade/Technical Publications	-0.92	-6.92	0.09	0.34
Fairs and Exhibitions	-1.01	-7.65	0.53	2.01
Experts, Consultants or Advisors	-0.95	-7.17	0.28	1.07
Conferences and Meetings	-1.40	-10.58	1.84	6.94
Our employees partner with customers, suppliers, alliance partners, etc., to develop solutions and obtain new ideas.	-1.43	-10.80	3.33	12.56
Our employees cultivate and utilize variety of sources for new ideas, knowledge and solutions.	-1.32	-9.93	2.31	8.72
Our employees share information and learn from one another.	-0.95	-7.17	0.18	0.69
Our employees are skilled at collaborating with each other to diagnose and solve problems.	-1.20	-9.03	1.51	5.69
Our employees interact and exchange ideas with people from different areas of the company.	-0.94	-7.08	0.70	2.63
Copyright	0.45	3.42	-1.19	-4.50
Trademarks	0.44	3.30	-1.21	-4.55
Patents	0.58	4.41	-1.20	-4.53
Design registration	0.86	6.49	-0.54	-2.02
Our organisation actively uses management initiatives to monitor development of new information, knowledge, practices etc.	-0.66	-4.98	-0.02	-0.07
Our organisation periodically embeds much of its knowledge and information in structures, systems, and processes.	-0.61	-4.63	0.05	0.19
Our organisation's culture (stories, rituals) contains ways of doing business, valuable ideas etc.	-0.89	-6.73	0.79	2.98
Much of our organisation's knowledge and information is contained in manuals, databases, etc.	-0.45	-3.39	-0.66	-2.49
Our organisation effectively communicates the value of its stock of knowledge to the stakeholders.	-0.54	-4.07	0.01	0.02
Our organisation systematically monitors the value of its stock of knowledge, and its fitness for purpose.	-0.52	-3.94	-0.29	-1.10
Offsite Clients or Customers from the Private Sector	-1.05	-7.93	1.29	4.86
Other Offsite Enterprises in other Sectors	-0.66	-5.00	0.06	0.22
Offsite Clients or Customers from the Public Sector	-0.71	-5.32	-0.15	-0.55
Offsite Competitors	-0.72	-5.43	-0.09	-0.35
Other Offsite Businesses in Your Sector that are not Direct Competitors	-0.77	-5.78	0.04	0.17
Offsite Suppliers of Equipment, Materials, Components, or Software	-0.74	-5.62	-0.38	-1.42
Our employees are creative and bright.	-1.27	-9.61	0.99	3.73
Our employees are keen to explore new ideas by thinking outside the box.	-1.36	-10.29	2.61	9.86
Our employees are on par with the best in our industry.	-1.13	-8.50	0.47	1.77
Our employees are experts in their particular jobs and functions.	-1.13	-8.55	0.61	2.31
Our employees are highly skilled.	-1.30	-9.78	0.98	3.69
Onsite Clients or Customers from the Public Sector	0.30	2.25	-1.17	-4.40
Onsite Clients or Customers from the Private Sector	0.00	-0.02	-1.32	-4.98
Onsite Suppliers of Equipment, Materials, Components, or Software	0.19	1.44	-1.13	-4.26
Onsite Competitors	0.46	3.49	-0.90	-3.40
Other Onsite Businesses in Your Sector that are not Direct Competitors	0.17	1.27	-1.20	-4.52
Other Onsite Enterprises in other Sectors	0.15	1.10	-1.21	-4.57
Multivariate Kurtosis Value (Mardia's coefficient)				283.41
Critical Ratio Value				38.61

The Levene`s test of homogeneity of variances was used to check for homoscedasticity. As presented in Table 3.13, all scores were higher than the minimum significant value, i.e. ρ<0.05, (Field, 2013).

Table 3.13: Homogeneity of variances test: Levene`s test

	Levene Statistic	df1	df2	Sig.
Human Capital	0.62	1	340	0.43
Organisational Capital	0.37	1	340	0.54
Social Capital	0.01	1	340	0.93
Open Search strategy	0.07	1	340	0.80
Appropriability strategy	0.00	1	340	0.97

Finally, the presence of multicollinearity was examined using the bivariate and multivariate correlation matrix, and variance inflation factors (VIF) and tolerance impact (Pallant, 2013; Tabachnick & Fidell, 2013). The results presented in Table 3.14 revealed that the bivariate correlations were above 0.8, VIF values were all less than the recommended threshold of 10, and tolerance values were all greater than 0.1 (Tabachnick & Fidell, 2013). Hence, these findings indicated no sign of multicollinearity.

Table 3.14: Collinearity test

	Human Capital		Organisational Capital		Social Capital	
	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
Social Capital	0.796	1.256	0.796	1.256	---	---
Open search Strategy	0.796	1.256	0.796	1.256	0.498	2.008
Appropriability Strategy	---	---	---	---	0.498	2.008

3.5.3. Statistical Method

To test the hypotheses presented in the earlier section, the partial least squares (PLS) technique was employed. As explained earlier, the partial least squares technique is a nonparametric approach to structural equation modelling that provides a flexible means to model latent constructs with multiple indicators when the conventional assumptions of covariance-based methods are not tenable. In this study, the assumption of multivariate normality was violated. However, the partial least squares technique can handle non-normal data (Fornell & Bookstein, 1982). In addition, this study had a set of exploratory objectives. There is a general agreement in the literature that the partial least squares technique is a powerful technique in assessing complex predictive models (Chin & Newsted, 1999). Thus, the partial least squares technique deemed to be the most suitable approa

3.5.3.1. Measurement Model

As recommended by Henseler & Fassott (2010), this study followed a two-step approach in evaluating the research model and the hypothesised relationships. First, four parameters of internal consistency reliability, indicator reliability, convergent validity, and discriminating validity were assessed (Hair et al., 2014). Then, using path analytic procedures and bootstrapping approach the significance of hypothesised relationships between variables were examined (Hair et al., 2017a).

Absolute correlations or standardised outer loadings were estimated to ensure the internal consistency of measurement model (Hair et al., 2014). As shown in Table. 3.15, almost all indicators possessed significant loadings - with only few borderline values of < 0.70- (Churchill, 1979; Hair et al., 2014). These results confirmed the item-level internal consistency of measurement model.

Cronbach's (α) (Cronbach, 1951) and composite reliability measure (ρc) (Fornell & Larcker, 1981) were estimated for each construct to examine the construct-level reliability of measurement model. As depicted in Table 3.16, all coefficient values ranged between 0.81 and 0.91, greater than the recommended threshold value of 0.7. In addition, all composite reliability measures were well well above the acceptable level of 0.7 (Nunnally & Bernstein, 1994). These findings supported the construct-level reliability of measurement model.

As suggested by Nunnally & Bernstein (1994), the average variance extracted measure (AVE) was estimated for each construct to evaluate the convergent validity of measurement model. Table 3.16 shows that all AVE values were higher than the recommended threshold value of 0.5 (Fornell & Larcker, 1981), ranging from 0.52 to 0.52. In addition, each construct`s composite reliability measure was greater than the relevant AVE value (Nunnally & Bernstein, 1994; Hair et al., 2014), supporting convergent validity of measurement model.

Finally, the Fornell & Larcker (1981) criterion and the Chin (1998) criterion were used to assess the construct-level discriminant validity and the item-level discriminant validity of measurement model. The statistical results compiled in Table 3.16 suggested that each construct`s square-root of AVE was greater than the inter-construct correlation values. Moreover, all cross-loadings were lower than the recommended threshold of 0.4 (Chin, 1998), providing evidence of discriminant validity.

Table 3.15: Internal consistency tests

Items	Formal Appropriability Strategy	Human Capital	Organisational Capital	Social Capital	Technical and application-driven open search strategy	Institutional open search strategy	Informal Appropriability Strategy	science-driven open search strategy	Offsite market-driven open search strategy	Onsite market-driven open search strategy
Copyright	0.82	0.19	0.35	0.21	0.28	0.28	0.30	0.27	0.24	0.16
Design registration	0.88	0.21	0.35	0.25	0.23	0.28	0.31	0.29	0.25	0.13
Patents	0.81	0.23	0.31	0.26	0.28	0.31	0.35	0.37	0.31	0.16
Trademarks	0.88	0.28	0.38	0.24	0.29	0.26	0.38	0.28	0.30	0.13
Our employees are on par with the best in our industry.	0.21	0.84	0.36	0.49	0.23	0.13	0.24	0.23	0.20	0.20
Our employees are keen to explore new ideas by thinking outside the box.	0.20	0.84	0.33	0.48	0.24	0.23	0.28	0.24	0.27	0.27
Our employees are creative and bright.	0.25	0.82	0.30	0.50	0.27	0.22	0.25	0.23	0.18	0.16
Our employees are experts in their particular jobs and functions.	0.23	0.88	0.37	0.46	0.28	0.19	0.22	0.20	0.23	0.18
Our employees are highly skilled.	0.27	0.89	0.40	0.46	0.27	0.18	0.24	0.29	0.25	0.24
Our organisation actively uses management initiatives to monitor development of new information, knowledge, practices etc.	0.33	0.26	0.74	0.33	0.31	0.30	0.27	0.27	0.28	0.24
Much of our organisation's knowledge and information is contained in manuals, databases, etc.	0.34	0.31	0.73	0.35	0.26	0.27	0.24	0.27	0.26	0.23
Our organisation systematically monitors the value of its stock of knowledge, and its fitness for purpose.	0.33	0.36	0.88	0.40	0.34	0.34	0.35	0.27	0.30	0.32
Our organisation periodically embeds much of its knowledge and information in structures, systems, and processes.	0.31	0.29	0.73	0.27	0.31	0.26	0.30	0.25	0.22	0.27
Our organisation's culture (stories, rituals) contains ways of doing business, valuable ideas etc.	0.26	0.28	0.73	0.30	0.32	0.20	0.23	0.13	0.27	0.17
Our organisation effectively communicates the value of its stock of knowledge to the stakeholders.	0.30	0.38	0.79	0.34	0.29	0.24	0.28	0.18	0.21	0.22
Our employees are skilled at collaborating with each other to diagnose and solve problems.	0.19	0.49	0.37	0.84	0.30	0.17	0.25	0.22	0.25	0.20
Our employees cultivate and utilize variety of sources for new ideas, knowledge and solutions.	0.26	0.49	0.37	0.82	0.33	0.24	0.37	0.23	0.32	0.28
Our employees interact and exchange ideas with people from different areas of the company.	0.27	0.39	0.32	0.80	0.30	0.24	0.32	0.19	0.23	0.17
Our employees partner with customers, suppliers, alliance partners, etc., to develop solutions and obtain new ideas.	0.21	0.43	0.32	0.72	0.32	0.33	0.29	0.29	0.26	0.28
Our employees share information and learn from one another.	0.20	0.46	0.35	0.81	0.30	0.23	0.23	0.24	0.26	0.24
Conferences and meetings	0.22	0.24	0.28	0.34	0.83	0.30	0.24	0.30	0.29	0.25
Trainings or external sources of professional know-how	0.18	0.26	0.29	0.33	0.78	0.34	0.24	0.33	0.28	0.32
Fairs and exhibitions	0.34	0.20	0.30	0.30	0.72	0.28	0.30	0.28	0.28	0.25
Experts, consultants or advisors	0.24	0.22	0.35	0.27	0.77	0.38	0.22	0.31	0.28	0.31
Scientific journals and trade/technical publications	0.24	0.25	0.31	0.26	0.77	0.38	0.13	0.29	0.30	0.28
Financial institutions and banks	0.31	0.14	0.29	0.21	0.34	0.75	0.27	0.28	0.29	0.29
Park management or centre management	0.26	0.23	0.37	0.31	0.38	0.84	0.29	0.38	0.34	0.48
Professional and industry/trade associations	0.28	0.19	0.24	0.25	0.32	0.80	0.28	0.38	0.28	0.39
Local and national government	0.21	0.14	0.22	0.16	0.33	0.77	0.24	0.36	0.27	0.28

Table 3.15: Internal consistency tests (cont'd)

Item	Formal Appropriability Strategy	Human Capital	Organisational Capital	Social Capital	Technical and application-driven open search strategy	Institutional open search strategy	Informal Appropriability Strategy	science-driven open search strategy	Offsite market-driven open search strategy	Onsite market-driven open search strategy
Lead time advantages	0.28	0.17	0.28	0.22	0.25	0.31	0.80	0.22	0.32	0.35
Secrecy (include non-disclosure agreements)	0.44	0.27	0.33	0.35	0.25	0.30	0.87	0.35	0.30	0.29
Complexity of goods or services introduced by your company	0.15	0.25	0.25	0.30	0.17	0.20	0.68	0.28	0.32	0.21
Commercial laboratories or r&d enterprises	0.35	0.26	0.30	0.28	0.34	0.34	0.32	0.86	0.23	0.31
Public research organisations	0.26	0.21	0.22	0.22	0.35	0.40	0.25	0.86	0.27	0.29
Universities or local academics	0.28	0.23	0.24	0.23	0.28	0.37	0.33	0.77	0.20	0.21
Offsite clients or customers from the private sector	0.15	0.22	0.23	0.26	0.24	0.21	0.21	0.16	0.68	0.23
Offsite clients or customers from the public sector	0.25	0.29	0.26	0.29	0.30	0.33	0.33	0.27	0.77	0.29
Offsite competitors	0.20	0.15	0.23	0.23	0.24	0.27	0.25	0.16	0.73	0.28
Other offsite enterprises in other sectors	0.25	0.20	0.29	0.25	0.30	0.32	0.30	0.20	0.82	0.39
Other offsite businesses in your sector that are not direct competitors	0.29	0.17	0.23	0.24	0.30	0.33	0.31	0.23	0.83	0.38
Offsite suppliers of equipment, materials, components, or software	0.33	0.20	0.32	0.26	0.31	0.25	0.36	0.25	0.75	0.32
Onsite competitors	0.12	0.17	0.25	0.25	0.29	0.40	0.27	0.23	0.35	0.86
Onsite clients or customers from the private sector	0.16	0.30	0.33	0.30	0.37	0.42	0.34	0.27	0.33	0.81
Onsite clients or customers from the public sector	0.13	0.25	0.27	0.28	0.27	0.43	0.31	0.34	0.34	0.78
Other onsite businesses in your sector that are not direct competitors	0.12	0.17	0.20	0.20	0.26	0.35	0.28	0.20	0.34	0.85
Other onsite enterprises in other sectors	0.12	0.15	0.23	0.19	0.28	0.35	0.29	0.26	0.34	0.86
Onsite suppliers of equipment, materials, components, or software	0.20	0.17	0.32	0.25	0.33	0.37	0.30	0.31	0.37	0.81

Table 3.16: Descriptive statistics, simple correlations, convergent validity, construct-level reliability and discriminant validity

	Mean	S.D.	Cronbach's α	Composite Reliability (ρ_c)	AVE	Fornell- Larcker Criterion	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Offsite market-driven open search strategy	4.63	1.15	0.86	0.89	0.58	0.76	---															
(2) Onsite market-driven open search strategy	3.19	1.55	0.91	0.93	0.69	0.83	0.42	---														
(3) Technical and application-driven open search strategy	4.93	1.16	0.83	0.88	0.60	0.77	0.37	0.36	---													
(4) Science-driven open search strategy	3.93	1.60	0.80	0.87	0.67	0.82	0.28	0.33	0.39	---												
(5) Institutional open search strategy	3.91	1.45	0.78	0.87	0.69	0.83	0.38	0.47	0.44	0.44	---											
(6) Overall Open search strategy	4.12	0.98	0.91	0.92	0.53	0.73	0.72	0.78	0.71	0.61	0.74	---										
(7) Human Capital	6.37	0.69	0.91	0.93	0.73	0.85	0.26	0.25	0.30	0.28	0.22	0.37	---									
(8) Organisational Capital	4.81	1.15	0.86	0.89	0.58	0.76	0.34	0.32	0.40	0.30	0.36	0.48	0.41	---								
(9) Social Capital	6.02	0.83	0.86	0.90	0.64	0.80	0.33	0.30	0.39	0.29	0.30	0.45	0.58	0.44	---							
(10) Formal Appropriation Mechanisms	2.89	1.72	0.87	0.91	0.72	0.85	0.32	0.17	0.31	0.36	0.33	0.40	0.27	0.41	0.28	---						
(11) Informal Appropriation Mechanisms	4.44	1.68	0.70	0.83	0.72	0.85	0.39	0.36	0.29	0.36	0.34	0.49	0.29	0.36	0.37	0.39	---					
(12) Overall Appropriability Strategy	3.55	1.42	---	---	---	---	0.41	0.28	0.36	0.42	0.40	0.51	0.33	0.46	0.37	0.92	0.73	---				
(13) Size(Ln)	1.84	1.20	---	---	---	---	0.11	-0.02	0.09	0.05	0.03	0.07	0.05	0.14	-0.01	0.11	0.08	0.12	---			
(14) Years spent in parks(Ln)	1.53	0.78	---	---	---	---	-0.04	-0.15	-0.12	0.06	-0.14	-0.12	-0.03	0.01	-0.01	-0.04	-0.02	-0.04	0.09	---		
(15) Industry Effect	---	---	---	---	---	---	0.07	0.00	0.09	0.19	0.04	0.09	0.07	0.13	0.06	0.29	0.17	0.29	0.05	0.02	---	
(16) Internationalisation	---	---	---	---	---	---	0.03	-0.11	0.02	0.17	-0.02	0.00	0.00	-0.04	0.06	0.20	0.18	0.23	0.01	0.11	0.18	---

3.5.3.2. Structural Model

The partial least squares technique offers its own set of non-parametrical statistical tests to evaluate the predictive and explanatory power of a structural model (Hair et al., 2017a). In this study, the bootstrapping method was employed to assess the significance of hypothesised paths. In addition, using the blindfolding procedure (Chin, 1998; Geisser, 1975; Stone, 1974; Hair et al., 2014), criteria of R^2 (determination coefficients; Chin, 1998; Hair et al., 2014), f^2 (effect size criterion; Hair et al., 2017a), Q^2 (cross-validated redundancy measure) and q^2 (Stone-Geisser`s criterion; Geisser, 1975; Stone, 1974) were estimated. Finally, the overall robustness of model was evaluated using the Tenenhaus et al.`s (2005) criterion of goodness-of-fit (GoF).

3.5.3.3. Model Fit

As shown in Table 3.17, the estimated determination coefficients (R^2) for intensity of overall open search strategy, human capital, organisational capital and social capital were 0.259, 0.348, 0.291 and 0.231, respectively. These figures ranged from weak to moderate (Chin, 1998). Introducing the control variables into the base model slightly increased these values. In addition, the estimated cross-validated redundancy values (Q^2) for intensity of overall open search strategy, human capital, organisational capital and social capital were 0.082, 0.250, 0.168, and 0.143, respectively. The results showed that all values were above the critical threshold of zero (Hair et al. 2017a). Adding the control variables to the base model did not significantly change these values, and all cross-validated redundancy values remained above the recommended threshold.

The goodness-of-fit measure was calculated by obtaining the geometric mean of all estimated R^2 values and the average community of the measures (Esposito Vinzi et al., 2010). The GoF value of 0.41 confirmed that the base model had a remarkably good fit. In addition, introducing the control variables into the base model slightly improved the overall fit (GoF=0.45) (Hair et al. 2017a).

Table 3.17: Communalities, determination coefficients, cross-validated redundancy measures and goodness-of-fit criterion (Base model vs. model with control variables)

	Communality		*R^2 Value*		*Redundancy*		*Q^2 Value*	
	Model 1	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*
Overall open search strategy	0.33	0.33	0.259	0.259	0.083	0.083	0.082	0.082
Human capital	0.73	0.73	0.348	0.351	0.057	0.002	0.250	0.253
Organisational capital	0.58	0.58	0.291	0.317	0.124	0.009	0.168	0.183
Social capital	0.64	0.64	0.231	0.231	0.067	0.067	0.143	0.145
Overall appropriability strategy	0.49	0.49	---	---	---	---		
Size(ln)	---	1.00	---	---	---	---	---	---
Years spent in parks(ln)	---	1.00	---	---	---	---	---	---
Industry effect	---	1.00	---	---	---	---	---	---
Internationalisation	---	1.00	---	---	---	---	---	---
GoF	0.41	0.45						

3.5.3.4. Test of Hypotheses

The standardised path coefficients and their statistical significance levels were estimated using nonparametric bootstrapping analyses (5000 subsamples; 342 cases; individual sign change). The statistical results compiled in Table 3.18 showed that the first Hypothesis which anticipated a positive association between the intensity of a firm's overall open search strategy and accumulation of human capital was supported (β= 0.13, t-value= 2.73). Paralleling to this, the results also supported Hypotheses 2 and 3 by demonstrating that the intensity of a firm's overall open search strategy positively influenced both the accumulation of organisational capital (β= 0.35, t-value= 6.52) and social capital (β= 0.35, t-value= 5.82). Both the explanatory and predictive power of overall open search strategy on human capital (f^2*=0.020,* q^2*=0.013*) were relatively small. In contrast, its explanatory and predictive power on organisational capital (f^2*=0.140,* q^2*=0.069*), social capital (f^2*=0.121,* q^2*=0.067*) were moderate. These findings confirmed that as the intensity of a firm`s open search strategy increases, the more likely it becomes for the firm to accumulate further human capital, organisational capital and social capital.

On the other hand, the statistical results derived from path analyses also showed that social capital was positively related to both human capital (β= 0.52, t-value=11.77) and organisational capital (β=0.28, t-value=4.72), providing empirical evidence for the Hypotheses 4 and 5. Social capital exerted strong explanatory and predictive power on human capital (f^2=0.326, q^2=0.203). However, its explanatory and predictive power on organisational capital (f^2=0.084, q^2=0.042) were relatively weak. Thus, It was confirmed that as the level of accumulated social capital by a firm engaged in open search activities increases, the more likely it becomes for the firm to accumulate further human capital and organisational capital.

Hypothesis 6 anticipated a positive association between the intensity of a firm`s appropriability strategy and the intensity of its open search strategy. The statistical results revealed a statistically strong, positive and significant association between them (β=0.51, t-value=12.10). Hypothesis 6, thus, was supported. The explanatory and predictive power values revealed a strong effect of appropriability strategy on open search strategy (f^2= *0.350,* q^2= *0.089*). Hence, it could be argued that the intensity of a firm`s overall appropriability strategy positively influences its open search strategy.

Finally, the results also supported Hypothesis.7 by demonstrating that the higher the intensity of a firm`s overall appropriability strategy gets, the more likely it becomes for the firm to accumulate social capital (β= 0.19, t-value= 3.50). It also showed strong explanatory and predictive power on social capital (f^2= *0.034,* q^2= *0.019*). The structural models are presented in Fig. 3.2 and Fig. 3.3 (Appendix.3).

As mentioned previously, four control variables were deemed to have potential effects on human capital and organisational capital. To confirm these assumptions, all hypothesised paths were simultaneously tested, while controlling for firm size, years spent in park, industry effect and internationalisation. As shown in Table 3.18, it was revealed that two control variables of firm size (β=0.11, t-value=2.36) and industry effect (β=0.09, t-value=1.79) were significantly and positively related to organisational capital. The results confirmed that larger onsite firms, compared to their smaller rivals, are more likely to have the required capacity to accumulate organisational capital through their reciprocal open search activities with co-creation partners. Similarly, it was also revealed that manufacturing onsite firms have a better propensity to accumulate organisational capital through their open search activities. Two other control variables, years spent in park (β=0.05, t-value=1.04) and internationalisation (β=-0.08, t-value=1.61) exerted no significant impact on organisational capital. In addition, none of the control variables were found to be significantly, positive or negative, associated with human capital. The graphical representations of paths are presented in Fig. 3.4 and Fig. 3.5 (Appendix.3).

Table 3.18: Structural model results (Base model vs. model with control variables)

Hypothesis No.	Path Direction	β		t-value		S.E.		Δ R2		Δ Q2		f2		q2		Supported/Not Supported
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	
H.1.	Overall Open search strategy -> Human Capital	0.13^{***}	0.12^{***}	2.73	2.43	0.05	0.05	0.013	0.011	0.010	0.009	0.020	0.017	0.013	0.011	Supported
H.2.	Overall Open search strategy -> Organisational Capital	0.35^{***}	0.34^{***}	6.52	6.06	0.05	0.06	0.099	0.091	0.057	0.052	0.140	0.132	0.069	0.063	Supported
H.3.	Overall Open search strategy -> Social Capital	0.35^{***}	0.35^{***}	5.82	5.90	0.06	0.06	0.093	0.093	0.057	0.057	0.121	0.121	0.067	0.067	Supported
H.4.	Social Capital -> Human Capital	0.52^{***}	0.52^{***}	11.77	11.87	0.04	0.04	0.212	0.214	0.153	0.153	0.326	0.330	0.203	0.205	Supported
H.5.	Social Capital -> Organisational Capital	0.28^{***}	0.28^{***}	4.72	4.71	0.06	0.06	0.060	0.060	0.035	0.036	0.084	0.088	0.042	0.044	Supported
H.6.	Appropriability Strategy -> Overall Open search strategy	0.51^{***}	0.51^{***}	12.10	11.81	0.04	0.04	0.259	0.259	0.082	0.082	0.350	0.350	0.089	0.089	Supported
H.7.	Appropriability Strategy -> Social Capital	0.19^{***}	0.19^{***}	3.50	3.56	0.05	0.05	0.027	0.027	0.016	0.018	0.034	0.034	0.019	0.021	Supported
Control	Size(Ln) -> Human Capital	---	0.04	---	0.94	---	0.05	---	0.002	---	0.002	---	0.003	---	0.002	nonsignificant
Control	Size(Ln) -> Organisational Capital	---	0.11^{***}	---	2.36	---	0.05	---	0.011	---	0.007	---	0.017	---	0.008	Significant
Control	Years spent in parks(Ln) -> Human Capital	---	-0.01	---	0.30	---	0.05	---	0.000	---	0.000	---	0.000	---	0.000	nonsignificant
Control	Years spent in parks(Ln) -> Organisational Capital	---	0.05	---	1.04	---	0.05	---	0.002	---	0.001	---	0.004	---	0.002	nonsignificant
Control	Industry Effect -> Human Capital	---	0.02	---	0.64	---	0.04	---	0.001	---	0.001	---	0.001	---	0.001	nonsignificant
Control	Industry Effect -> Organisational Capital	---	0.09^{*}	---	1.79	---	0.05	---	0.007	---	0.004	---	0.011	---	0.005	Significant
Control	Internationalisation -> Human Capital	---	-0.03	---	0.66	---	0.05	---	0.001	---	0.001	---	0.001	---	0.001	nonsignificant
Control	Internationalisation -> Organisational Capital	---	-0.08	---	1.61	---	0.05	---	0.005	---	0.003	---	0.008	---	0.004	Significant

Notes: *** p<0.001, ** p<0.001, * p<0.05;

3.5.3.5. Multi-group Analyses

The multi-group analysis helps to simultaneously examine the potential effects of an external variable across all hypothesised relationships. In order to evaluate the potential effects of radicalness and efficacy of internal sources of know-how on the hypothesised relationships, a series of partial least squares-based multi-group analyses were conducted. Hence, based the cut-point value of each multi-group variable two subsamples (i.e. radical innovators vs. non-radical innovators; low efficacy vs. high efficacy) were created. Then, the research model was separately estimated for each subsample. First, total sample was divided into two subsamples using the cut-point values of each multi-group variable (i.e. radical innovators vs. non-radical innovators; low efficacy vs. high efficacy). Then, the research model was separately estimated for each subsample. Finally, differences between the estimated path coefficients of hypothesised relationships across two subsamples were evaluated for significance (Qureshi & Compeau, 2009). In addition, four parameters of internal consistency, indicator reliability, convergent validity and discriminating validity were separately assessed using each subsample (Hair et al., 2014; 2017a).

3.5.3.5.1. Multi-group Analysis: Radicalness

As discussed in the earlier sections, the ability of a firm to develop radical inventions associates with its knowledge acquisition capability (Kang, Morris & Snell, 2007). In other words, a firm` approach to innovation may be a reflection of its exploration, transformation, flexibility-enhancing, and adaptive capacities (March, 1991; Chang et al., 2012).

On the questionnaire, firms were asked to indicate whether they had introduced any new to market products, services or processes between 2012 and 2015. To examine whether the patterns of reciprocal open search activities and their rates of success in helping firms to accumulate social, human and organisational capital differ as approaches to innovation may vary in onsite firms, the sample was divided into two subsamples of radical innovators (firms with at least one newly introduced product, service or process to the market in the last three years), non-radical innovators (firms with no newly introduced product, service or process to the market in the last three years). Due to the binary nature of the radicalness variable, no further refinement or tests between two subsamples were deemed to be necessary.

The statistical results compiled in Table 3.19 suggested that each construct`s square-root of AVE was greater than the associated inter-construct correlation values across two groups, providing evidence of discriminant validity (Fornell & Larcker, 1981). Construct-level reliability of the measurement model across two groups was examined using Cronbach`s coefficient and composite reliability measure. As shown in Table 3.20, Cronbach`s coefficients ranged from 0.851 to 0.923 for the `not a radical innovator` group, and from 0.828 to 0.928 for the `radical innovators` group, all above the acceptable level of 0.7 (Cronbach, 1951). Moreover, composite reliability measures were also greater than 0.8 across two groups (Fornell & Larcker, 1981), supporting the construct-level reliability of measurement model across two groups.

Finally, convergent validity of the measurement model across two groups was examined. Across both groups, AVE values, ranged from 0.509 to 0.706 for the `not a radical innovator` group, and from 0.502 to 0.696 for the `radical innovators`, were all above the recommended threshold of 0.5, (Table 3.19 and 3.20). In addition, composite reliability measures were found to be greater than the associated AVEs (Nunnally & Bernstein, 1994; Hair et al., 2014), confirming the convergent validity of the measurement model across two groups.

The determination coefficients (R^2) were slightly higher for the radical innovators group, compared to the other group (except for social capital). Nevertheless, the explanatory power across both groups was relatively moderate (Chin, 1998). Similarly, the predictive relevance (Q^2) across both groups was found to be relatively moderate (Stone, 1974; Geisser, 1975). The goodness-of-fit measure was also calculated for each group. The examination of the goodness-of-fit (GoF) criterion confirmed that the base model had a remarkably good fit across two groups (Table 3.20).

Table 3.19: Descriptive statistics, simple correlations and convergent validity tests (Group differences: radicalness)

Not a radical innovator (n=176) ***Constructs***	***Mean***	***S.D.***	***AVE***	***(1)***	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***	***(7)***	***(8)***	***(9)***	***(10)***	***(11)***	***(12)***
(1) Offsite market-driven open search strategy	4.31	1.16	0.539	0.734*											
(2) Onsite market-driven open search strategy	2.78	1.50	0.702	0.379	0.838*										
(3) Technical and application-driven open search strategy	4.67	1.24	0.597	0.350	0.354	0.773*									
(4) Science-driven open search strategy	3.54	1.59	0.671	0.228	0.306	0.344	0.819*								
(5) Institutional open search strategy	3.64	1.44	0.621	0.375	0.428	0.395	0.335	0.788*							
(6) Overall Open search strategy	3.79	0.95	0.509	0.693	0.782	0.700	0.543	0.708	0.713*						
(7) Human Capital	6.18	0.73	0.706	0.183	0.172	0.238	0.189	0.149	0.265	0.840*					
(8) Organisational Capital	4.35	1.17	0.564	0.262	0.313	0.294	0.213	0.348	0.416	0.309	0.751*				
(9) Social Capital	5.79	0.90	0.633	0.322	0.291	0.373	0.243	0.274	0.436	0.502	0.348	0.796*			
(10) Formal appropriation mechanisms	2.29	1.53	0.705	0.273	-0.045	0.259	0.257	0.196	0.234	0.195	0.303	0.290	0.840*		
(11) Informal appropriation mechanisms	3.88	1.75	0.626	0.357	0.264	0.276	0.226	0.312	0.415	0.212	0.316	0.306	0.340	0.791*	
(12) Overall appropriability strategy	2.97	1.31	0.562	0.368	0.083	0.319	0.298	0.287	0.363	0.244	0.370	0.359	0.910	0.698	0.750*
Radical innovator (n=166) ***Constructs***	***Mean***	***S.D.***	***AVE***	***(1)***	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***	***(7)***	***(8)***	***(9)***	***(10)***	***(11)***	***(12)***
(1) Offsite market-driven open search strategy	4.98	1.03	0.600	0.774*											
(2) Onsite market-driven open search strategy	3.62	1.50	0.641	0.358	0.801*										
(3) Technical and application-driven open search strategy	5.20	1.01	0.566	0.297	0.292	0.752*									
(4) Science-driven open search strategy	4.34	1.52	0.696	0.230	0.252	0.375	0.834*								
(5) Institutional open search strategy	4.20	1.41	0.614	0.314	0.449	0.452	0.503	0.783*							
(6) Overall Open search strategy	4.48	0.88	0.597	0.661	0.726	0.687	0.612	0.767	0.772*						
(7) Human Capital	6.58	0.57	0.722	0.221	0.202	0.291	0.273	0.215	0.342	0.850*					
(8) Organisational Capital	5.29	0.91	0.502	0.242	0.154	0.437	0.245	0.267	0.382	0.379	0.709*				
(9) Social Capital	6.27	0.67	0.593	0.216	0.185	0.308	0.238	0.266	0.346	0.616	0.413	0.770*			
(10) Formal appropriation mechanisms	3.52	1.68	0.690	0.215	0.208	0.254	0.336	0.380	0.388	0.180	0.314	0.107	0.830*		
(11) Informal appropriation mechanisms	5.04	1.38	0.538	0.246	0.348	0.158	0.396	0.294	0.408	0.203	0.169	0.309	0.307	0.733*	
(12) Overall appropriability strategy	4.17	1.26	0.532	0.268	0.299	0.268	0.422	0.422	0.470	0.223	0.321	0.201	0.939	0.617	0.730*

* square roots of AVE

Table 3.20: Construct-level reliability, discriminant validity tests, communalities, determination coefficients, cross-validated redundancy measures and goodness-of-fit criterion (Group differences: radicalness)

Not a radical innovator (n=176) ***Constructs***	***Composite Reliability (pc)***	***Cronbach's α***	***Communality***	***Redundancy***	***R^2***	***Q^2***
(1) Offsite market-driven open search strategy	0.874	0.827	0.539	0.257	0.480	---
(2) Onsite market-driven open search strategy	0.934	0.915	0.702	0.429	0.611	---
(3) Technical and application-driven open search strategy	0.881	0.831	0.597	0.288	0.489	---
(4) Science-driven open search strategy	0.859	0.753	0.671	0.198	0.295	---
(5) Institutional open search strategy	0.867	0.796	0.621	0.310	0.501	---
(6) Overall Open search strategy	**0.913**	**0.900**	**0.309**	**0.038**	**0.132**	**0.036**
(7) Human Capital	**0.923**	**0.895**	**0.706**	**0.019**	**0.255**	**0.179**
(8) Organisational Capital	**0.886**	**0.845**	**0.564**	**0.092**	**0.207**	**0.112**
(9) Social Capital	**0.896**	**0.856**	**0.633**	**0.069**	**0.237**	**0.140**
(10) Formal Appropriation Mechanisms	0.905	0.859	0.705	---	---	---
(11) Informal Appropriation Mechanisms	0.832	0.704	0.626	---	---	---
(12) Overall Appropriability Strategy	**0.851**	**0.791**	**0.462**	**0.385**	**1.000**	---
GoF	0.471					
Radical innovator (n=166) ***Constructs***	***Composite Reliability (pc)***	***Cronbach's α***	***Communality***	***Redundancy***	***R^2***	***Q^2***
(1) Offsite market-driven open search strategy	0.900	0.866	0.600	0.260	0.437	---
(2) Onsite market-driven open search strategy	0.915	0.888	0.641	0.330	0.527	---
(3) Technical and application-driven open search strategy	0.866	0.806	0.566	0.264	0.471	---
(4) Science-driven open search strategy	0.873	0.783	0.696	0.258	0.374	---
(5) Institutional open search strategy	0.863	0.789	0.614	0.359	0.588	---
(6) Overall Open search strategy	**0.909**	**0.895**	**0.297**	**0.064**	**0.221**	**0.061**
(7) Human Capital	**0.928**	**0.903**	**0.722**	**0.057**	**0.398**	**0.278**
(8) Organisational Capital	**0.856**	**0.799**	**0.502**	**0.066**	**0.235**	**0.117**
(9) Social Capital	**0.878**	**0.827**	**0.593**	**0.010**	**0.121**	**0.065**
(10) Formal Appropriation Mechanisms	0.899	0.849	0.690	---	---	---
(11) Informal Appropriation Mechanisms	0.771	0.586	0.538	---	---	---
(12) Overall Appropriability Strategy	**0.828**	**0.753**	**0.432**	**0.386**	**1.000**	---
GoF	0.488					

Table 3.21 presents the estimated path coefficients, t-values, and p-values for each group. Hypotheses 2 to 7 were supported for the other group, while Hypothesis 1 was reject (β= 0.06, t-value = 0.80). Individuals play a significant role in accelerating the rate of innovation in firms. Firms with a radical approach to innovation are more actively engaged in the reciprocal exchange of knowledge with their co-creation partners. Hence, the higher the intensity of a firm`s open search strategy gets, the more likely it becomes for its individuals to accumulate human capital. In contrast, firms with an incremental approach to innovation rely more on their internal capacity to innovate.

On the other hand, Hypotheses 1 to 6 were supported for the radical innovators group. However, this study could not find statistical evidence to support hypothesis 7 (β= 0.05, t-value = 0.58). It is evident from the literature that there is a positive association between the use of appropriation mechanisms, specifically formal appropriation mechanisms, and the rate of radical innovation in firms. For instance, Arora, Athreye & Huang (2016) indicate that the radical innovators register more patents than their rival firms which innovate incrementally. Firms normally use several appropriation mechanisms to limit the chances of unintended knowledge spillovers and retain the control of their key knowledge assets. Formal appropriation mechanisms provide radical innovators with strong legal grounds to protect their intellectual property against the opportunistic behaviours of partners. Hence, it could be argued that the role of appropriability strategy in smaller firms with radical approaches to innovation is principally defensive.

Besides, the pair-wise parametric t-test (t-value = 1.75) also confirmed the above reasoning by showing the significance of difference between two groups. The anticipated association between the intensity of overall appropriability strategy and the accumulation of social capital was found to be significant for the group of firms which were not involved in radical innovation activities (β=0.23, t-value = 3.33). In contrast, this was not the case for radical innovators. No other significant differences were found between the two groups. The graphical representations of paths are presented in Fig 3.6 to 3.9 (Appendix.3).

Table 3.21: Structural model results (Group differences: radicalness)

Hypothesis No.	Path Direction	Combined dataset (n=342)		Not a radical innovator (n=176)		Radical innovator (n=166)		Test of difference		Results
		β	***t value***	***β***	***t value***	***β***	***t value***	***t value***	***p-value***	
H.1.	Overall Open search strategy -> Human Capital	0.13	2.73***	0.06	0.80	0.15	2.22**	0.90	0.37	No significant difference
H.2.	Overall Open search strategy -> Organisational Capital	0.35	6.38***	0.33	4.09***	0.27	3.33***	0.46	0.65	No significant difference
H.3.	Overall Open search strategy -> Social Capital	0.35	5.92***	0.35	4.80***	0.32	3.59***	0.31	0.76	No significant difference
H.4.	Social Capital -> Human Capital	0.52	11.77***	0.48	8.12***	0.56	8.66***	0.94	0.35	No significant difference
H.5.	Social Capital -> Organisational Capital	0.28	4.65***	0.20	2.30**	0.32	3.92***	0.98	0.33	No significant difference
H.6.	Appropriability Strategy -> Overall Open search strategy	0.51	11.88***	0.36	4.61***	0.47	5.91***	0.90	0.37	No significant difference
H.7.	Appropriability Strategy -> Social Capital	0.19	3.47***	0.23	3.33***	0.05	0.58	1.75*	0.08	significant difference

Notes: *** p<0.001, ** p<0.001, * p<0.05;

3.5.3.5.2. Multi-group Analysis: The efficacy of internal sources of know-how

Although a firm`s ability to absorb external knowledge and its ability to generate knowledge internally may seem to be two separate concepts, but both go hand in hand, and taken together define its accumulation capacity (Jiménez-Jiménez & Sanz-Valle, 2008). The complementarity between external and internal knowledge is one of the key determinants of successful reciprocal open search activities, as it increases the level of cognitive proximity between the partners. The higher the level of cognitive proximity between a firm engaged in open search activities and its partner, the more likely it becomes for the firm to succeed in integrating external knowledge (Lane & Lubatkin, 1998).

Multi group analysis was used to explore the potential interplay between the firm`s internal sources of know-how and its ability to accumulate human, organisational and social capital through reciprocal open search activities. On the questionnaire, respondents were asked to evaluate the importance of their internal sources of specialist know-how for their innovation activities on a 7-point Likert scale, ranging from "very unimportant" to "very important". First, the metric scale was transformed into a dichotomous scale. Then, using the cut-point value of 5.24, two subsamples were created. The first group consisted of firms which showed a low level of efficacy of internal sources of know-how (less than 5.24, n=157, mean= 3.75). The second group consisted of firms with a higher level of efficacy of internal sources of know-how (greater than 5.24, n=185, mean= 6.51). The results of F-test showed that two groups were significantly different from each other (F=617.084, p<0.000).

The statistical results compiled in Table 3.22 suggested both acceptable levels of convergent validity and discriminant validity across two groups. All AVEs were greater than the recommended threshold of 0.5 (Fornell & Larcker, 1981), all composite reliability measures were greater than the associated AVEs (Nunnally & Bernstein, 1994; Hair et al., 2014), and each construct`s square-root of AVE was greater than the associated inter-construct correlation values across two groups, providing evidence of discriminant validity (Fornell & Larcker, 1981). In addition, the Cronbach`s alpha and composite reliability values (Table 3.23) for all constructs exceeded the recommended values of 0.7 (Cronbach, 1951) and 0.8 (Fornell & Larcker, 1981), respectively, supporting the reliability of model across two groups.

Table 3.22: Descriptive statistics, simple correlations and convergent validity tests (Group differences: efficacy of internal sources of know-how)

Low efficacy *(n=157)* **Constructs**	***Mean***	***S.D.***	***AVE***	***(1)***	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***	***(7)***	***(8)***	***(9)***	***(10)***	***(11)***	***(12)***
(1) Offsite market-driven open search strategy	4.48	1.08	0.567	0.753											
(2) Onsite market-driven open search strategy	3.10	1.53	0.715	0.406	0.845										
(3) Technical and application-driven open search strategy	4.66	1.11	0.563	0.264	0.283	0.751									
(4) Science-driven open search strategy	3.73	1.54	0.685	0.236	0.344	0.373	0.828								
(5) Institutional open search strategy	3.67	1.46	0.658	0.362	0.508	0.386	0.380	0.811							
(6) Overall Open search strategy	**3.95**	**0.93**	**0.517**	**0.680**	**0.812**	**0.605**	**0.587**	**0.751**	**0.719**						
(7) Human Capital	**6.31**	**0.66**	**0.729**	**0.248**	**0.271**	**0.217**	**0.229**	**0.220**	**0.343**	**0.854**					
(8) Organisational Capital	**4.46**	**1.16**	**0.595**	**0.417**	**0.356**	**0.292**	**0.309**	**0.380**	**0.506**	**0.321**	**0.772**				
(9) Social Capital	**5.88**	**0.83**	**0.610**	**0.337**	**0.332**	**0.332**	**0.328**	**0.298**	**0.462**	**0.480**	**0.383**	**0.781**			
(10) Formal appropriation mechanisms	2.52	1.58	0.703	0.252	0.175	0.194	0.324	0.321	0.343	0.257	0.370	0.237	0.838		
(11) Informal appropriation mechanisms	4.16	1.71	0.647	0.344	0.344	0.225	0.296	0.316	0.444	0.262	0.433	0.440	0.399	0.804	
(12) Overall Appropriability Strategy	**3.22**	**1.37**	**0.498**	**0.347**	**0.290**	**0.246**	**0.374**	**0.378**	**0.457**	**0.310**	**0.471**	**0.383**	**0.896**	**0.765**	**0.705**
High efficacy *(n=185)* **Constructs**	***Mean***	***S.D.***	***AVE***	***(1)***	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***	***(7)***	***(8)***	***(9)***	***(10)***	***(11)***	***(12)***
(1) Offsite market-driven open search strategy	4.76	1.19	0.592	0.769											
(2) Onsite market-driven open search strategy	3.26	1.57	0.665	0.423	0.815										
(3) Technical and application-driven open search strategy	5.16	1.16	0.608	0.424	0.423	0.780									
(4) Science-driven open search strategy	4.10	1.64	0.701	0.300	0.308	0.378	0.837								
(5) Institutional open search strategy	4.12	1.43	0.590	0.377	0.434	0.448	0.482	0.768							
(6) Overall Open search strategy	**4.28**	**0.99**	**0.531**	**0.735**	**0.767**	**0.754**	**0.604**	**0.716**	**0.728**						
(7) Human Capital	**6.42**	**0.70**	**0.727**	**0.270**	**0.225**	**0.357**	**0.304**	**0.211**	**0.377**	**0.853**					
(8) Organisational Capital	**5.10**	**1.06**	**0.540**	**0.243**	**0.293**	**0.425**	**0.261**	**0.288**	**0.422**	**0.495**	**0.735**				
(9) Social Capital	**6.14**	**0.81**	**0.656**	**0.314**	**0.264**	**0.397**	**0.243**	**0.274**	**0.419**	**0.662**	**0.466**	**0.810**			
(10) Formal appropriation mechanisms	3.20	1.77	0.726	0.348	0.155	0.350	0.358	0.303	0.404	0.259	0.265	0.278	0.852		
(11) Informal appropriation mechanisms	4.68	1.62	0.591	0.403	0.371	0.305	0.392	0.332	0.497	0.306	0.265	0.277	0.374	0.768	
(12) Overall appropriability strategy	**3.83**	**1.40**	**0.515**	**0.433**	**0.269**	**0.395**	**0.436**	**0.370**	**0.514**	**0.324**	**0.397**	**0.327**	**0.930**	**0.688**	**0.717**

Table 3.23: Construct-level reliability, discriminant validity tests, communalities, determination coefficients, cross-validated redundancy measures and goodness-of-fit criterion (Group differences: efficacy of internal sources of know-how)

Low efficacy (n=157) ***Constructs***	***Composite Reliability (ρc)***	***Cronbach's α***	***Communality***	***Redundancy***	***R^2***	***Q^2***
(1) Offsite market-driven open search strategy	0.874	0.827	0.539	0.257	---	---
(2) Onsite market-driven open search strategy	0.934	0.915	0.702	0.429	---	---
(3) Technical and application-driven open search strategy	0.881	0.831	0.597	0.288	---	---
(4) Science-driven open search strategy	0.859	0.753	0.671	0.198	---	---
(5) Institutional open search strategy	0.867	0.796	0.621	0.310	---	---
(6) Overall Open search strategy	**0.913**	**0.900**	**0.309**	**0.038**	**0.132**	**0.036**
(7) Human Capital	**0.923**	**0.895**	**0.706**	**0.019**	**0.255**	**0.179**
(8) Organisational Capital	**0.886**	**0.845**	**0.564**	**0.092**	**0.207**	**0.112**
(9) Social Capital	**0.896**	**0.856**	**0.633**	**0.069**	**0.237**	**0.140**
(10) Formal Appropriation Mechanisms	0.905	0.859	0.705	0.000	---	---
(11) Informal Appropriation Mechanisms	0.832	0.704	0.626	0.000	---	---
(12) Overall Appropriability Strategy	**0.851**	**0.791**	**0.462**	**0.385**	**---**	**---**
GoF	0.471					
High efficacy (n=185) ***Constructs***	***Composite Reliability (ρc)***	***Cronbach's α***	***Communality***	***Redundancy***	***R^2***	***Q^2***
(1) Offsite market-driven open search strategy	0.900	0.866	0.600	0.260	---	---
(2) Onsite market-driven open search strategy	0.915	0.888	0.641	0.330	---	---
(3) Technical and application-driven open search strategy	0.866	0.806	0.566	0.264	---	---
(4) Science-driven open search strategy	0.873	0.783	0.696	0.258	---	---
(5) Institutional open search strategy	0.863	0.789	0.614	0.359	---	---
(6) Overall Open search strategy	**0.909**	**0.895**	**0.297**	**0.064**	**0.221**	**0.061**
(7) Human Capital	**0.928**	**0.903**	**0.722**	**0.057**	**0.398**	**0.278**
(8) Organisational Capital	**0.856**	**0.799**	**0.502**	**0.066**	**0.235**	**0.117**
(9) Social Capital	**0.878**	**0.827**	**0.593**	**0.010**	**0.121**	**0.065**
(10) Formal Appropriation Mechanisms	0.899	0.849	0.690	0.000	---	---
(11) Informal Appropriation Mechanisms	0.771	0.586	0.538	0.000	---	---
(12) Overall Appropriability Strategy	**0.828**	**0.753**	**0.432**	**0.386**	**---**	**---**
GoF	0.488					

The estimated determination coefficients (R^2) were slightly higher for the group with higher levels of efficacy on overall open search strategy (0.221 vs. 0.132), human capital (0.398 vs. 0.255), organisational capital (0.235 vs. 0.207), and slightly lower on social capital (0.121 vs. 0.237). Overall, these findings suggested that the explanatory power across both groups was relatively moderate (Chin, 1998). Similarly, the predictive relevance (Q^2) across both groups was found to be relatively moderate (Stone, 1974; Geisser, 1975). The goodness-of-fit measure was also calculated for each group. The examination of the goodness-of-fit (GoF) criterion confirmed that the base model had a remarkably good fit across two groups (Table 3.20). The examination of the goodness-of-fit (GoF) criterion for each group (low efficacy`s GoF=0.471 and high intensity`s GoF=0.488) indicated the base model had a remarkably good fit across two groups (Table 3.23).

Table 3.24 presents the estimated path coefficients, t-values, and p-values for each group. Overall, using the pair-wise parametric t-tests only the anticipated association between social capital and human capital was found to be statistically different. Nevertheless, the hypothesised association was positive and significant for both groups, however, slightly stronger for the group with high efficacy (β=0.61, t-value=13.37 vs. β=0.41, t-value=4.57). These findings indicated that the higher the level of social capital accumulated by a firm engaged in open search activities gets, the more likely it becomes to the firm to accumulate organisational capital (Gassmann, Enkel & Chesbrough, 2010). In other words, social capital fosters learning in firms, as the level of their employees` understanding of how, what and when to acquire new knowledge, skills and capabilities increases (Powell, Koput & Smith-Doerr, 1996).

All anticipated relationships between the independent variables and dependent variables were found to be significant for the group with high efficacy. However, the hypothesised associations between social capital and organisational capital (β=0.19, t-value=1.56), and between open search strategy and human capital (β=0.15, t-value=1.51) were not significant for the group with low efficacy. These findings reconfirmed the importance of complementarity between internal and external knowledge in reciprocal open search activities with co-creation partners. Firms with strong internal knowledge bases are more efficiently absorb and assimilate external knowledge to drive superior innovation performance (Gassmann, Enkel & Chesbrough, 2010). The graphical representations of paths are presented in Fig. 3.10 to Fig. 3.13 (Appendix.3).

Table 3.24: Structural model results (Group differences: efficacy of internal sources of know-how)

Hypothesis No.	Path Direction	Combined dataset (n=342)		Low efficacy (n=157)		High efficacy (n=185)		Test of difference		Results
		β	***t value***	***β***	***t value***	***β***	***t value***	***t value***	***p-value***	
H.1.	Overall Open search strategy -> Human Capital	0.13	2.73^{***}	0.15	1.51	0.12	2.46^{***}	0.25	0.80	No significant difference
H.2.	Overall Open search strategy -> Organisational Capital	0.35	6.38^{***}	0.42	3.99^{***}	0.28	4.34^{***}	1.17	0.24	No significant difference
H.3.	Overall Open search strategy -> Social Capital	0.35	5.92^{***}	0.36	3.26^{***}	0.34	4.79^{***}	0.14	0.89	No significant difference
H.4.	Social Capital -> Human Capital	0.52	11.77^{***}	0.41	4.57^{***}	0.61	13.37^{***}	2.11^{**}	0.04	significant difference
H.5.	Social Capital -> Organisational Capital	0.28	4.65^{***}	0.19	1.56	0.35	5.87^{***}	1.30	0.19	No significant difference
H.6.	Appropriability Strategy -> Overall Open search strategy	0.51	11.88^{***}	0.46	4.98^{***}	0.51	9.81^{***}	0.54	0.59	No significant difference
H.7.	Appropriability Strategy -> Social Capital	0.19	3.47^{***}	0.22	1.89^{*}	0.15	2.53^{***}	0.50	0.62	No significant difference

Notes: *** $p<0.001$, ** $p<0.001$, * $p<0.05$;

3.6. Discussion and Conclusions

The findings of chapter two confirmed that the smaller firms do benefit from engaging in open search activities. Nevertheless, prior studies conclude that there are substantial differences between the smaller and larger firms` innovation strategies. It is generally believed that due to availability of additional resources in large firms, they outperform the smaller firms in terms of breadth and depth of external interactions. In addition, the observed disparities in the open search performance of firms exposed to the same sourcing opportunities, raises an important question about how open search strategy manipulates the innovation capacity. In other word, how does a firm`s allocation of attention to its internal abilities affect the level of knowledge receptivity, and subsequently, its open search strategy and performance? This chapter attempted to find an answer to this question. Therefore, this study was conducted to better understand the effects of open search and appropriability strategies on the accumulation of intellectual capital. After obtaining the results for the hypothesised relationships between the dependent and independent variables, this study is in position to address the key question about how open search strategy influences a firm`s dynamic capabilities, posed at the introduction section.

In this chapter, a conceptual model was developed to examine the accumulation of social capital, organisational capital and human capital as functions of firms` open search activities and appropriability strategy. More precisely, through which open search strategy relates to social capital, as well as the role social capital plays in strengthening the process of human capital and organisational capital accumulation. Using data collected from 342 firms located in science and technology parks in the United Kingdom, this study attempted to explore direct effects of the firms` overall open search strategy and appropriability strategy on social, human and organisational capital. In keeping with expectations, the results demonstrated that the intensity of open search strategy influences the accumulation of social, organisational and human capital in firms.

It is well-documented in the literature that a firm`s human capital is the key source of its organisational innovation (Chen, Chen, & Vanhaverbeke, 2011). Once a firm`s open search strategy is operationalised, its employees are the only sources of contact with the external partners. In fact, a firm`s employees are responsible for the tasks, such as: scanning external sources and transferring them into the organisation. Individuals are the frontline warriors of the organisation`s knowledge war; they experiment the external knowledge first handily. As contacts with the external knowledge creators become more and more frequent, individuals take their own stakes of knowledge by learning, which in turn makes it possible to maintain the externally acquired knowledge and develop awareness about them and the required skills on how to utilise them. As individuals learn more about the newly acquired knowledge, the organisation`s readiness level to integrate and apply the knowledge increases. At this point, the stock of previously accumulated knowledge act as a set of institutionalised guiding practices for the process of integrating new knowledge.

On the other hand, as organisational processes, systems, routines, culture and structure become more frequently used to digest the stocks of externally acquired knowledge, they also become updated. In this scenario, the earlier stocks of organisational capital act as knowledge repository. They provide an integrated platform for further contacts and communications with external partners. In order to assimilate and commercialise the externally acquired knowledge, firms need to possess a set of dynamic capabilities. These capabilities shape a firm`s absorptive capacity. In fact, the accumulated stocks of organisational capital from the earlier open search activities make it possible to institutionalise understandings and traditions new to the firm. On the other hand, they contribute to the process of reducing knowledge distance with new external partners. Hence, as the firm accumulates more organisational capital through operationalising its open search strategy, the level of familiarity with the outside knowledge sources increases. The increased level of familiarity of the firm later facilitates its access to a broad range of new knowledge. This helps to accumulate further human capital, as new skills start to diffuse around the organisation (Nahapiet & Ghoshal, 1998).

On the other hand, a firm`s social capital, as argued earlier, provides a societal platform for knowledge acquisition and integration. It operates as a coordinating platform, based on which, the focal firm communicate with its partners (Teng, 2007). By interacting with external partners, firms increase their awareness about external environment, potential partners and new knowledge, which in turn leads to the accumulation of further social capital. The findings of this chapter confirmed that the frequent and in-depth interactions with external partners positively affect the accumulation of social capital and facilitate incorporation of it into the organisation's knowledge base. Moreover, the results showed that social capital enhances the ability of firm`s employees to store further knowledge, that is human capital. Hence, beyond a certain threshold, it is reasonable to expect that the benefits deriving from open search activities are accumulated as additive capabilities in shapes of social, human and organisational capital.

Traditionally, studies on interorganisational networks has focused on how purposeful external sourcing can foster innovation performance by increasing the chance of accessing external resources that could complement the focal firm`s internal resources (Harrison et al., 2001). The results of this study confirmed that open search strategy can positively help firms to find missing knowledge and complement their knowledge base, from a wide variety of sources.

While finding statistically significant supports for the direct impacts of appropriability strategy on social capital, and open search strategy on social, organisational and human capital, this study also predicted that social capital is a potentially relevant intervening variable in the relationships among open search strategy, appropriability strategy and human capital and organisational capital. This possibility suggests that in addition to positive learning effects that can benefit individuals, and contribute to the development of internal knowledge base, social capital can also build an active societal context to enhance intra-organisational and interorganisational learnings and foster creation of self-set goals and skills to encourage employees to support organisational creativity more often and more broadly.

The results represent an important theoretical contribution because they illustrated that social capital offers an alternative explanation about whether a firm`s open search strategy could lead to better results for the focal firm or not. Whether the open search strategy triggers the development of knowledge assets within the organisation depends not only on whether it is strategically aligned with other organisational priorities or contextually adjusted to attain the organisational goals, but also on whether the focal firm can develop further social capital out of it, to continuously communicate external sources with its internal sources. Moreover, a firm`s social capital seems to be a meaningful predictor of the success of failure of its knowledge assimilation, and an interpreter of its externally sourced knowledge.

The findings confirmed that a firm`s social capital provides the required societal capacity to communicate different external knowledge sources with internally. Moreover, the findings revealed that social capital facilitates interfirm learning by enabling the acquisition of resources and providing a key mechanism to support knowledge integration from diverse sources. The findings are consistent with prior studies (Forés & Camisón, 2016), as it seems that social capital is playing an important role in knowledge acquisition and exchange in open search activities. It could be argued that open search activates are supported through utilising social capital, which helps individuals to figure out how, what and when to acquire new knowledge, transfer it and assimilate it. Hence, social capital present itself as an integral part of the organisational efforts to build internal knowledge base (organisational capital), and gain skills and competencies (human capital). The developed stock of social capital helps individuals to understand their external environment and identify potential sources of external know-how, in the meantime, it enables the organisation to absorb and integrate new knowledge to complement its knowledge base (Hsieh & Tidd, 2012).

Nevertheless, the results of multi-group analyses revealed that the impact of social capital on human capital is significantly higher for the firms that extensively rely on internal sources of know-how. A possible explanation is that because their human capital is the key driver of innovativeness, they utilise their human capital more frequently, thus, extract more benefits through the association between social capital and human capital. Similarly, the findings showed that the impact of open search strategy on human capital is non-significant for the group of firms that rely less on internal sources of know-how. It seems that as individuals in those firms are not actively engaged in the process of knowledge creation, they accumulate less human capital though operationalisation of their open search strategies. Surprisingly, it was revealed that the hypothesised relation between social capital and organisational capital for this type of firms is also non-significant. A possible explanation is that these firm have certain codes of conduct for open search strategies and unique strategic orientations. Another explanation is that for these organisations, it is more likely that social capital mediates the direct relation between open search strategy and human capital. Hence, they may only engage in open innovation activities with a particular set of external actors. Similar results were obtained for the firms with incremental innovation orientation, where the relation between open search strategy and human capital was non-significant

In addition, the results indicated that a firm`s appropriability strategy associated with the development of social capital. Specifically, this study found that a firm`s developed stock of social capital could yield positive effects that in turn helps the firm to accumulate further human capital and organisational capital. The results of this study directly support the recent arguments for greater attention to appropriability strategy in open innovation (e.g. Laursen & Salter, 2014; Arora, Athreye & Huang, 2016; Zobel, Balsmeier, & Chesbrough, 2016; Stefan & Bengtsson, 2017). Traditionally, the open innovation literature has focused on how openness can affect firms` appropriability strategy, by setting explicit goals and boundaries for proprietary, defensive, and leveraging strategies. These suggestions implicitly portray a firm`s appropriability strategy as a relatively reactive defence mechanism. This view fails to recognise the interplay between open search strategy and appropriability strategy of firms. The results of this study showed that appropriability strategy can actively stimulate the accumulation of social capital in forms, by signalling focal firm`s quality to potential partners, increasing its lobbying power and creating reciprocal obligations in collaborative settings. Hence, this study added to the open innovation literature by testing a model that examined how open search strategy and appropriability strategy simultaneously contribute to innovation capacity of firms. Nevertheless, it worth noting that while being open brings lots of advantages, in the same time, it poses serious challenges and increases the chance of unintended knowledge spillovers. This issue will be investigated in the chapter four.

Overall, the findings highlighted a different conceptualisation of the role of open search strategy in producing outcomes. Open search strategy has traditionally been depicted as a strategy that helps firms to conform to the competitive norms dominant in their volatile environments (Forés & Camisón, 2016). By linking the intensity of open search strategy to social capital, human capital and organisational capital and by relating appropriability strategy to social capital, and social capital to human and organisational capital, this study`s findings highlighted that a firm`s open search strategy and appropriability strategy can help it to achieve a variety of outcomes, including enhanced stocks of accumulated social, human and organisational capital that may deviate from their environment in positive way. Such an extension of the scope of open innovation research was suggestive of potential new research emphases in the opens search literature based in recent research in the field of absorptive capacity (e.g. Roper & Hewitt-Dundas, 2013; Lazzarotti, Manzini & Pellegrini, 2015). This perspective motivates a shift from excelling in, to fitting in open search activities, as a priority for small firms.

The findings of this chapter extended the open innovation literature in several ways. First and foremost, the model tested here provided a new theoretical perspective on how the disparity between expected outcomes of the implementation of open search strategy and observed outcomes in different firms, and in particular in smaller firms, could be explained. The findings suggested that the extent to which a firm develops and accumulated stocks of social capital, human capital and organisational capital through its open search activities may predict the chance of success of failure of its open search strategy. This framework built on previous intellectual capital (e.g. Nahapiet & Ghoshal, 1998; Youndt, Subramaniam & Snell, 2004; Subramaniam & Youndt, 2005; Reed, Lubatkin & Srinivasan, 2006; Lazzarotti, Manzini & Pellegrini, 2015) and absorptive capacity research (Cohen & Levinthal, 1990; Zahra & George, 2002), and was different from the main stream of the open innovation research that solely focuses on the performance-related measures to explain the relevance of, and the success or failure of open search endeavours in smaller firms. The stream of research that has solely focused on financial or solid non-financial indicators of open innovation performance is at odds, form a theoretical point of view, with research suggesting resource complementarity is a prominent driver of higher performance in acquisitions (Harrison et al., 2001) and absorptive capacity is a key driving force behind success of open search activities (Cepeda-Carrion, Cegarra-Navarro & Jimenez-Jimenez, 2012; Xia & Roper, 2016), where the roles of antecedents of open search capacity of organisation seems to be excluded from investigating the innovation achievements. Using intellectual capital theory as a starting point, the findings of this study suggested that the development and accumulation of social, organisational and human capital are, in part, functions of both firms` open search strategies and appropriability strategies, and further highlighted when and why resources are likely to become, at least partly, unconnected or open search opportunities could go unrealized in absence of social capital in firms, as argued by Blyler & Coff (2003).

Nevertheless, worth noting that this study was not intended to suggest that the research relying solely on `performance consequences` are wrong, but rather that their models may not represent the antecedents and performance consequences of open search success sufficiently and precisely in and of themselves. Indeed, taking together the results obtained in chapters two (particularly, where a performance consequences view was adopted) and the findings of this chapter contribute to the open search literature, specifically in smaller firms – although the effects of open search strategy primarily seemed to be that it renders firms more prone to building social capital. Thus, it seems that a firm`s intellectual capital could mediate the relationship between its open search strategy and performance, and its open search strategy affects performance in ways other than directly influencing the performance. It is likely that if the potential mediating effects of social capital, human capital and organisational capital on the relationship between the intensity of open search strategy and performance are tested, these effects-at least in part-could be statistically significant ones. In demonstrating these effects, this study provided an enriched account of the potential antecedents in which open it is predicted that search activities, appropriability strategy and intellectual capital play a joint-role in influencing the emergence of positive performance outcome.

By building on and extending past open search (Xia & Roper, 2016; Brunswicker & Vanhaverbeke, 2015; Parida, Westerberg & Frishammar, 2012; van de Vrande et al., 2009) and intellectual capital research (Subramaniam & Snell, 2004; Subramaniam & Youndt, 2005; Reed, Lubatkin & Srinivasan, 2006) involving smaller firms, this study simultaneously contributes to the open innovation literature as a whole. Consistent with absorptive capacity studies which suggest that the availability of similar internal knowledge base can foster exploratory learning (Cohen & Levinthal, 1990; Zahra & George, 2002; Lane, Koka & Pathak, 2006), previous work has shown that poor open search performance is directly related to the difficulties in building absorptive capacity (Roper & Hewitt-Dundas, 2013) in smaller firms. The absorptive capability is developed over time as the organisation develops. The development of firms` absorptive capacity and knowledge base happens in parallel (Cohen & Levinthal, 1990). However, the extant literature lacks theoretical specification regarding how open innovation activities contribute to the development of absorptive capacity or its antecedents in long-run (Lazzarotti, Manzini & Pellegrini, 2015). As a result, it was little known about how firms accumulated further stocks of social, human and organisation capital through their open search activities, in particular smaller firms. This study addressed these outstanding issues, and the findings are flexible to extend beyond the small firms. Moreover, the findings added another layer of support to the idea that the resource heterogeneity stimulates cognitive proximity, social proximity and organisational proximity. While all these proximities foster learning, communication, knowledge creation and cooperation, and even can yield an upsurge in the use of interorganisational ties in science and technology parks.

Appendix.3

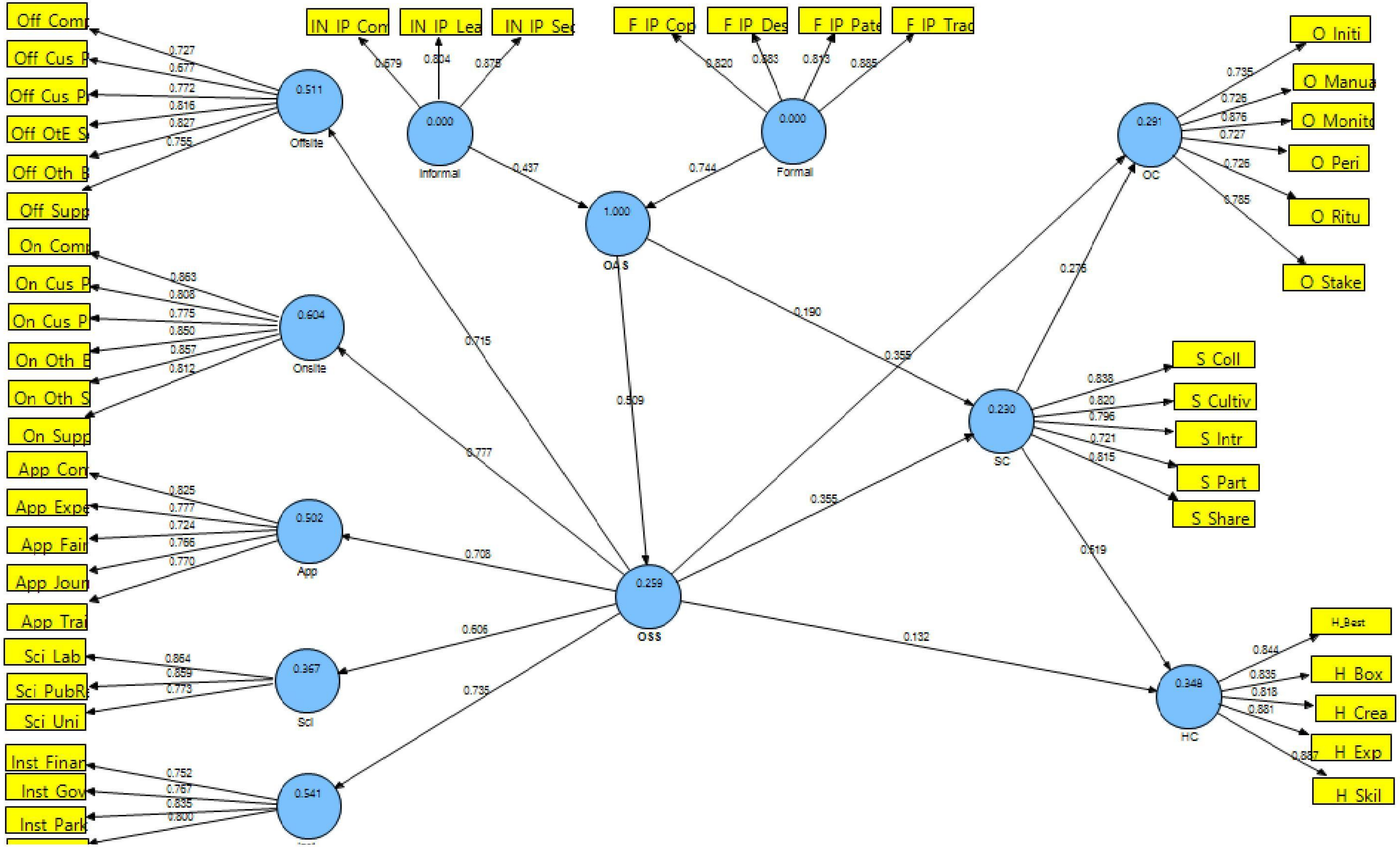


Fig. 3.2: Structural model results (base model: entire sample – path diagram)

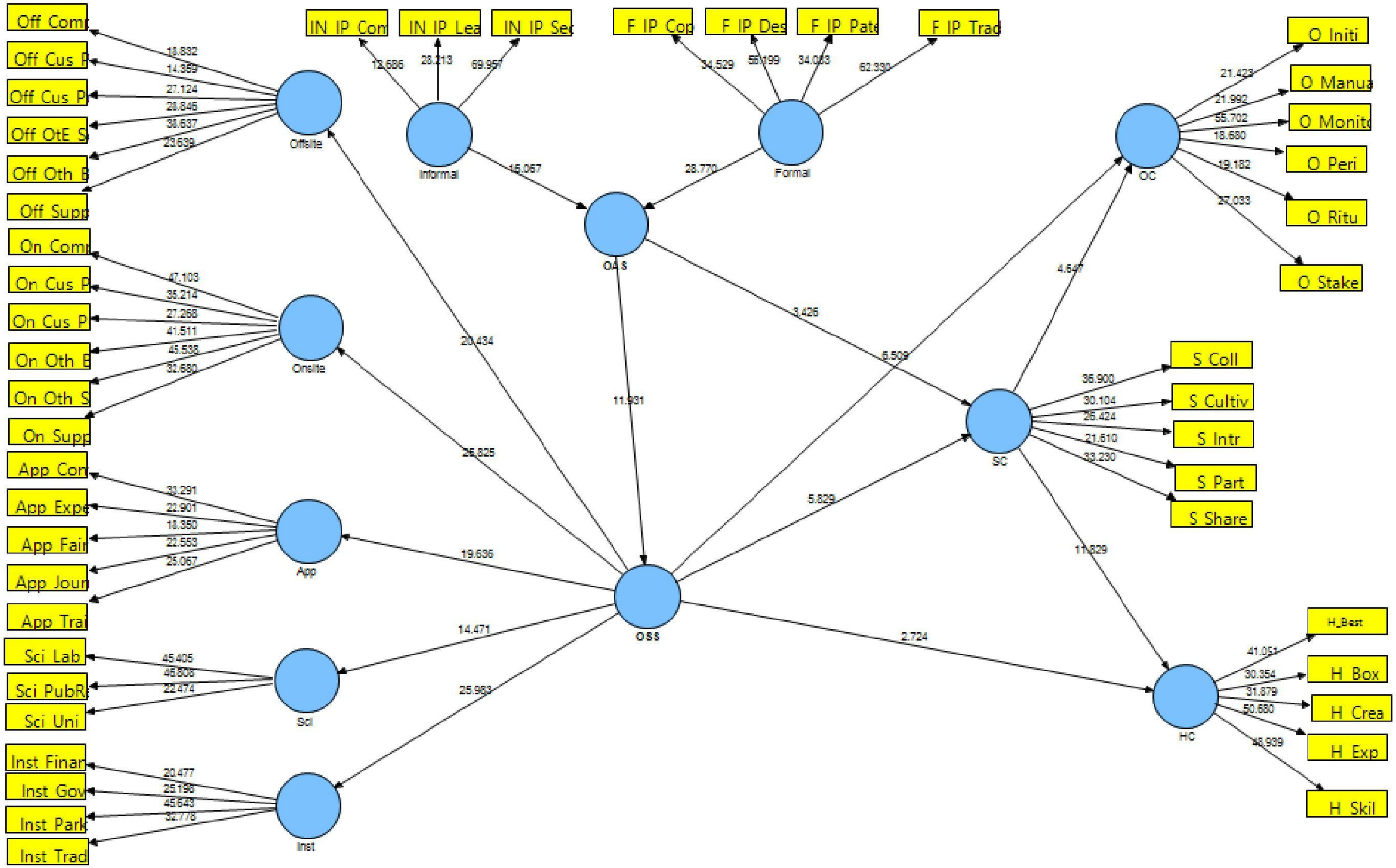


Fig. 3.3: Structural model results (base model: entire sample – bootstrapping results - t-values)

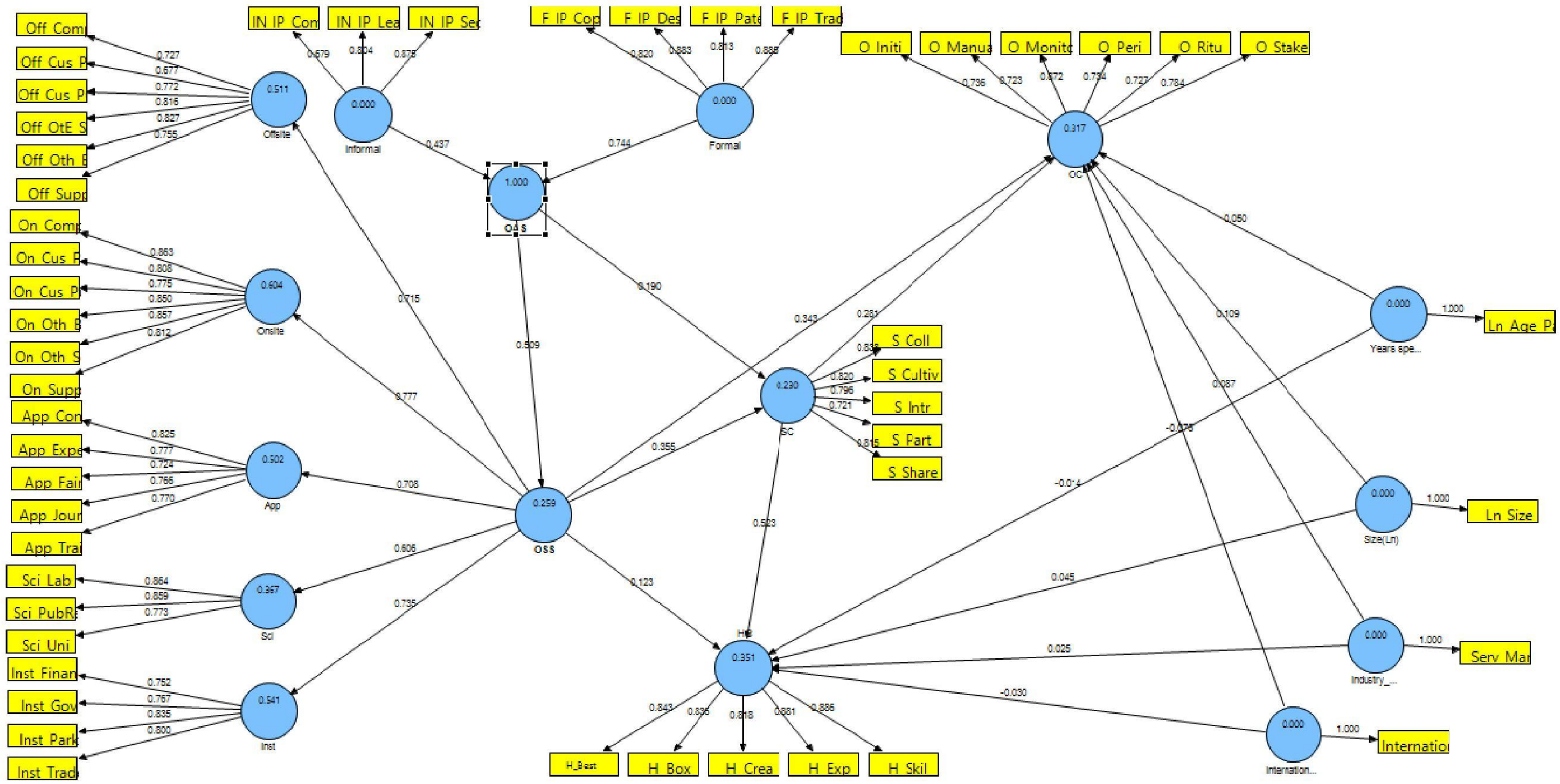


Fig. 3.4: Structural model results (base model with controls: entire sample – path diagram)

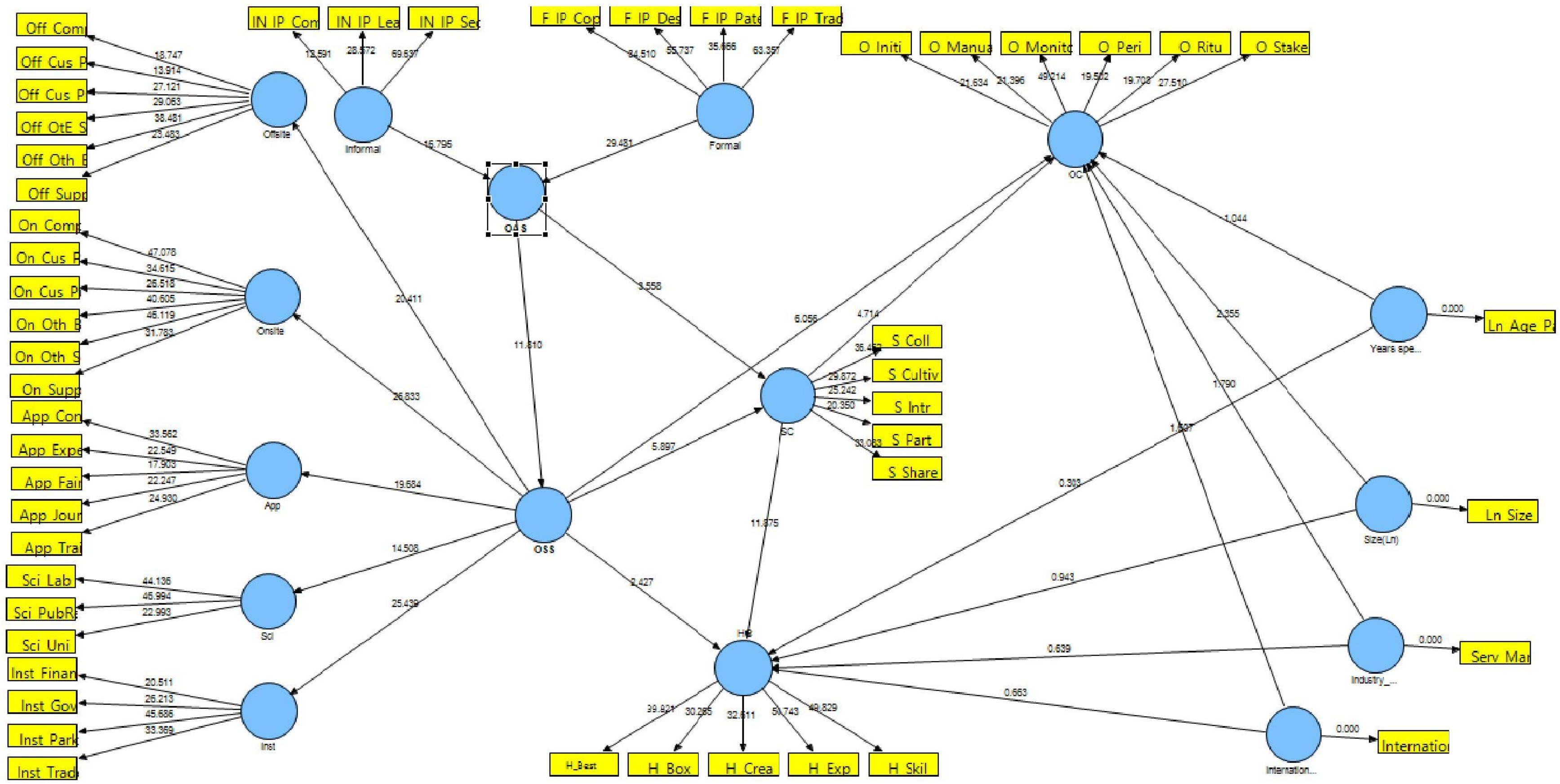


Fig. 3.5: Structural model results (base model with controls: entire sample – bootstrapping results - t-values)

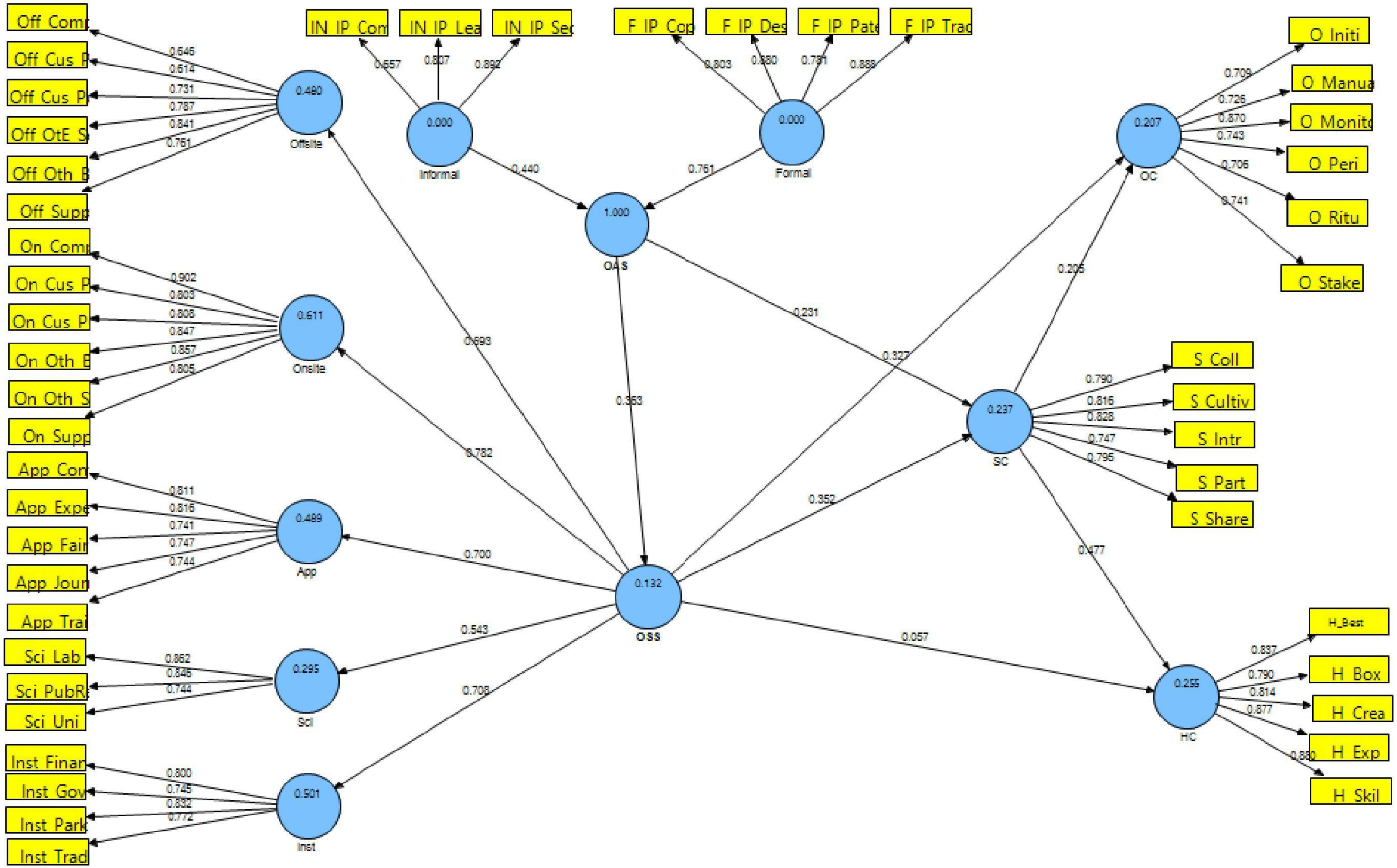


Fig. 3.6: Structural model results (Group differences: non-radical innovators sample – path diagram)

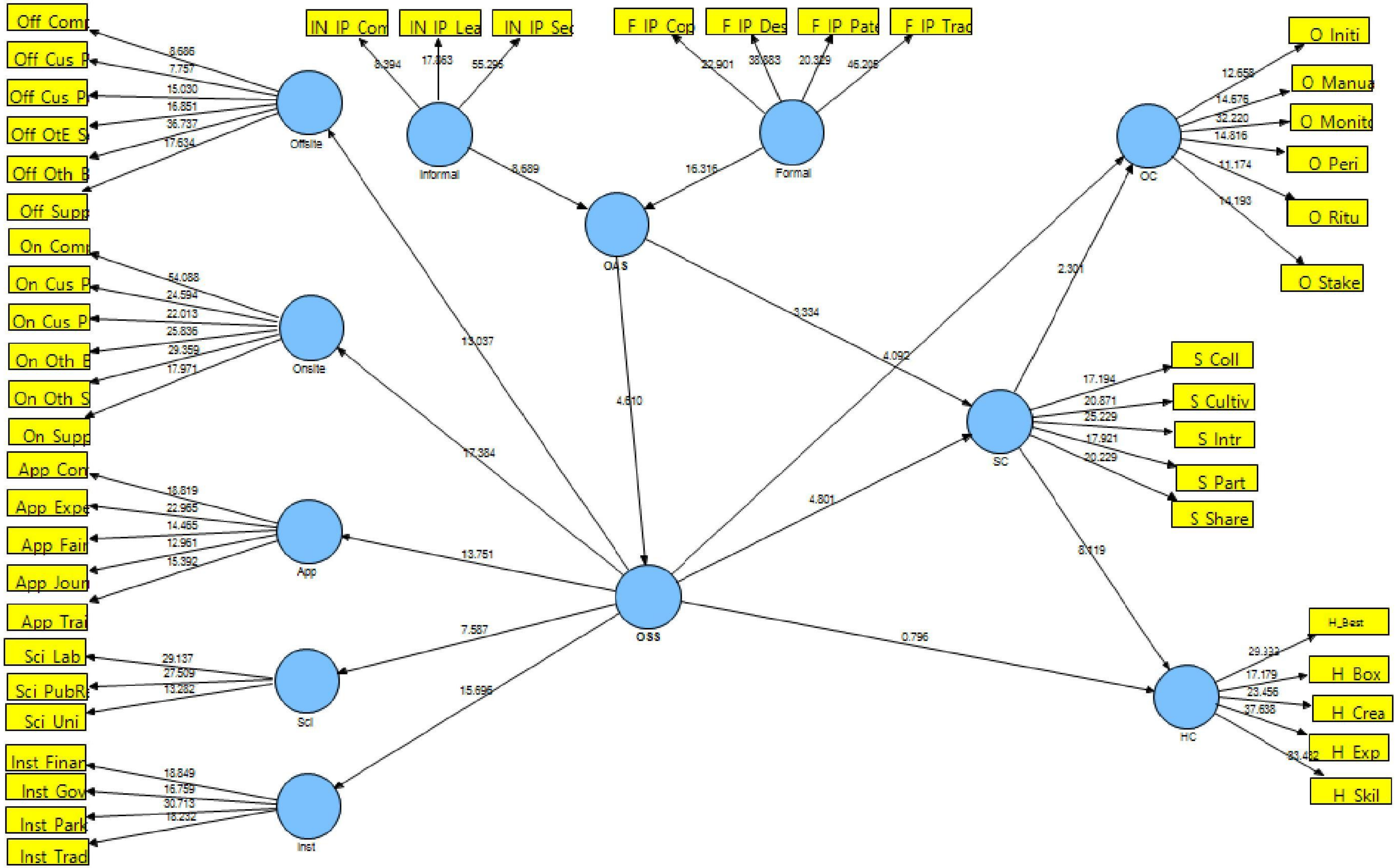


Fig. 3.7: Structural model results (Group differences: non-radical innovators sample –bootstrapping results - t-values)

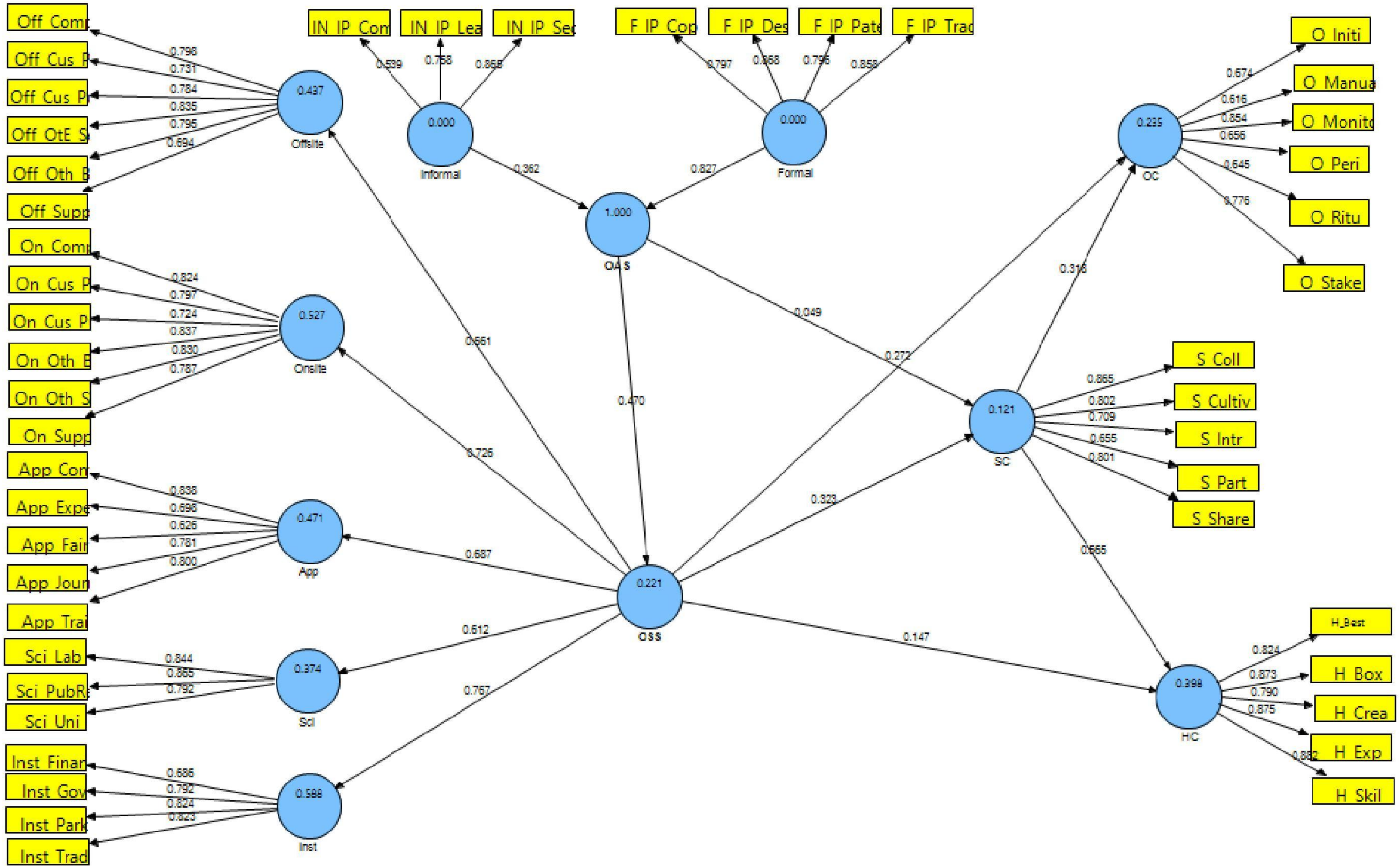


Fig. 3.8: Structural model results (Group differences: radical innovators sample – path diagram)

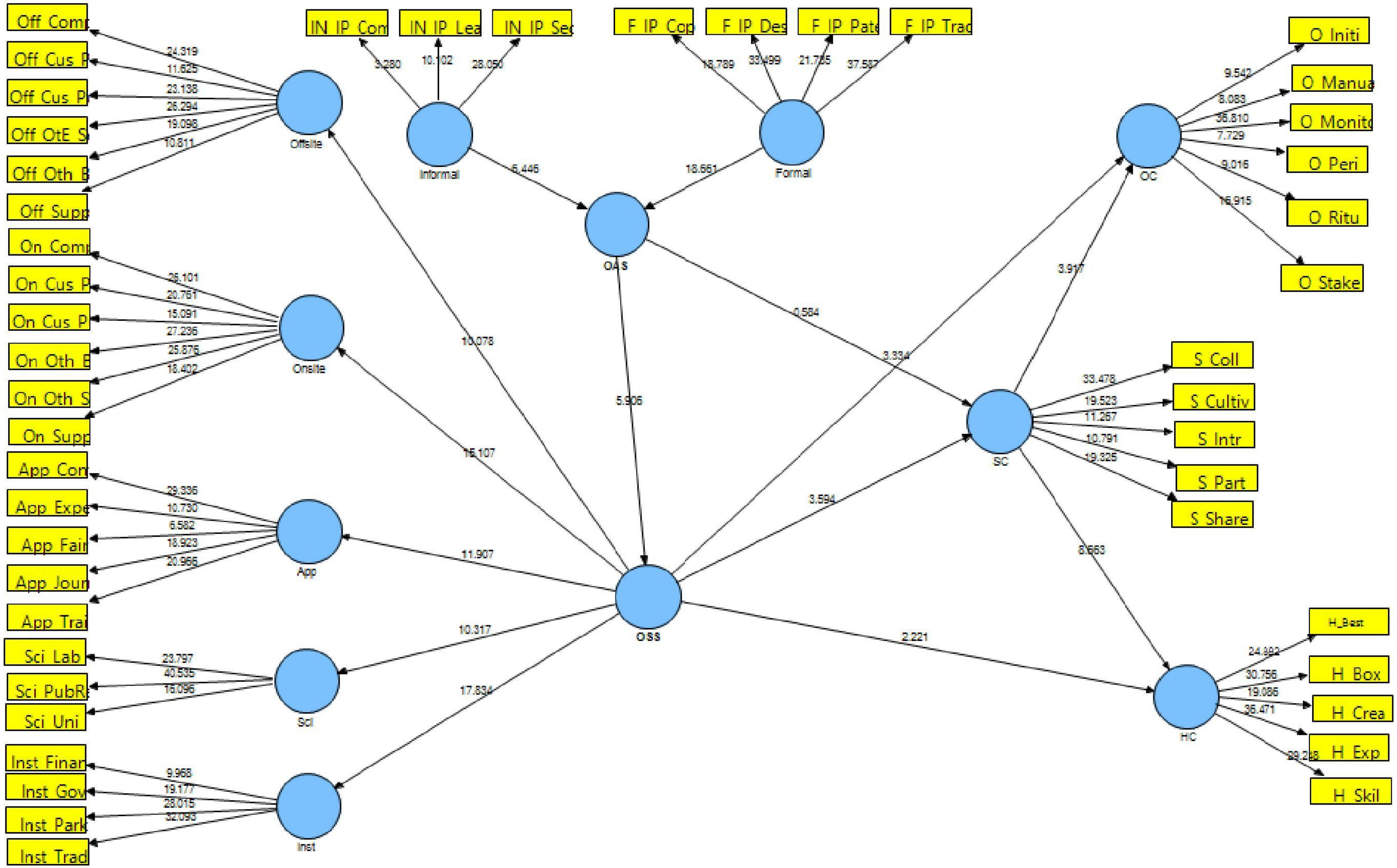


Fig. 3.9: Structural model results (Group differences: radical innovators sample –bootstrapping results - t-values)

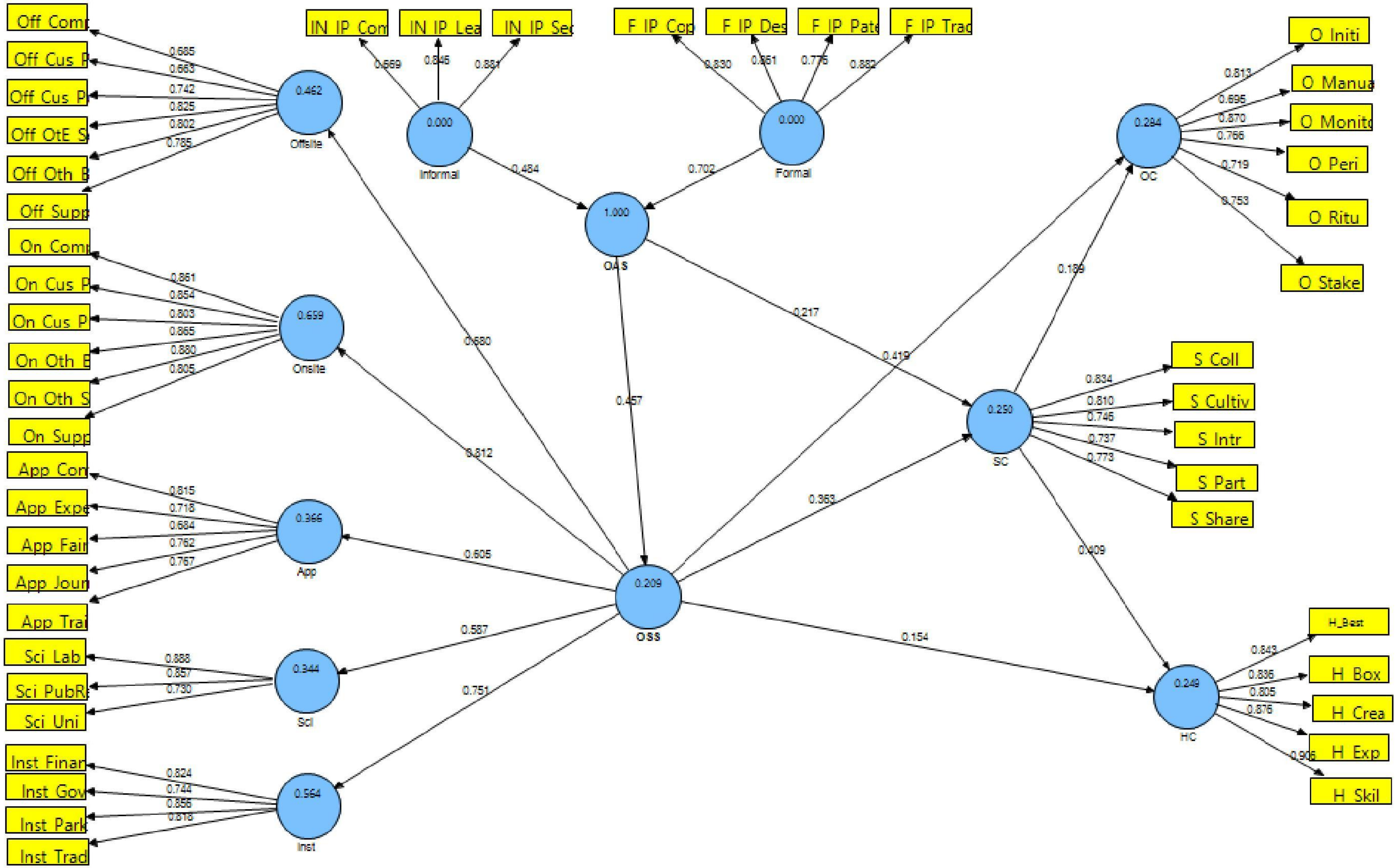


Fig. 3.10: Structural model results (Group differences: low efficacy of internal sources of know-how sample – path diagram)

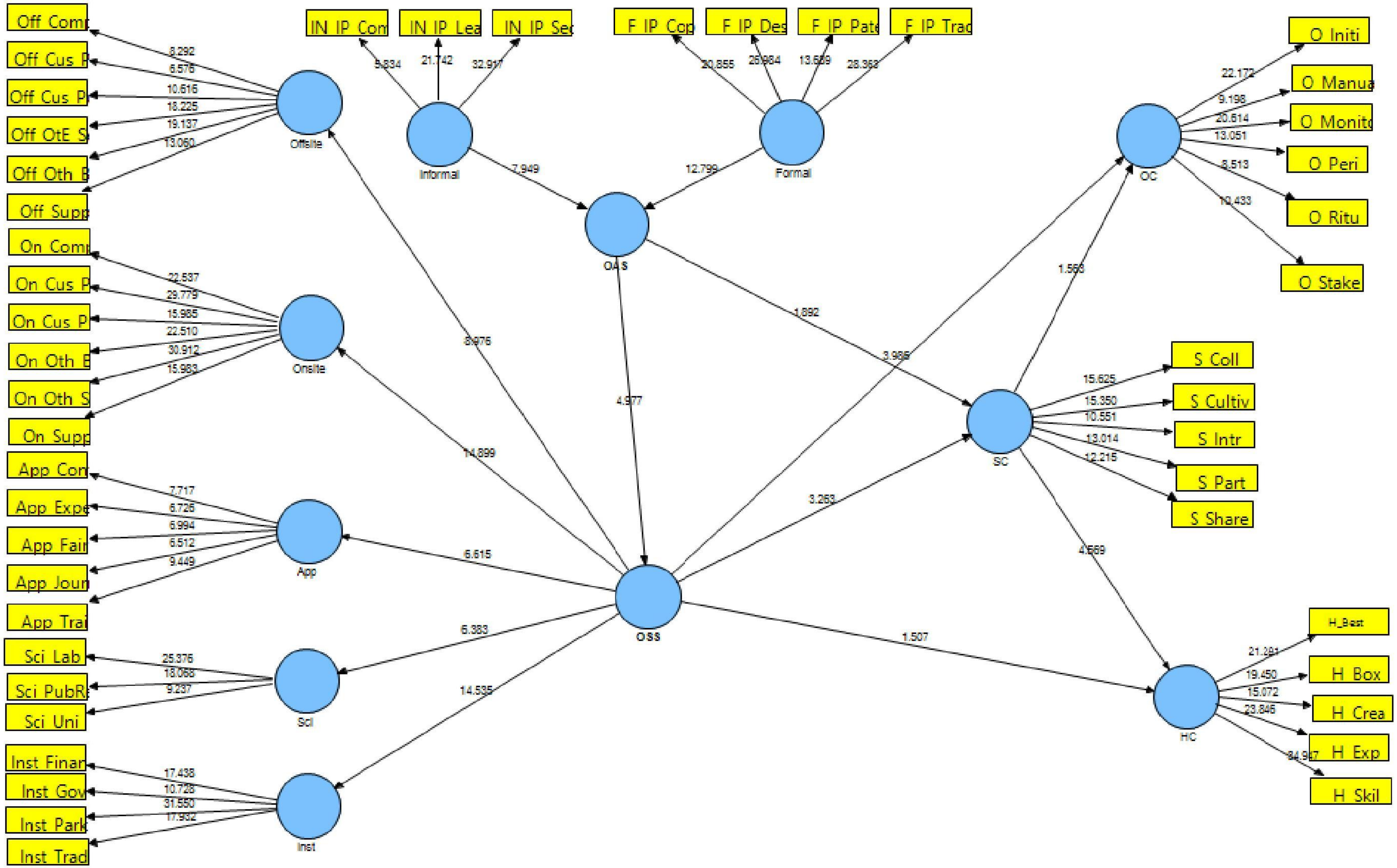


Fig. 3.11: Structural model results (Group differences: low efficacy of internal sources of know-how sample –bootstrapping results - t-values)

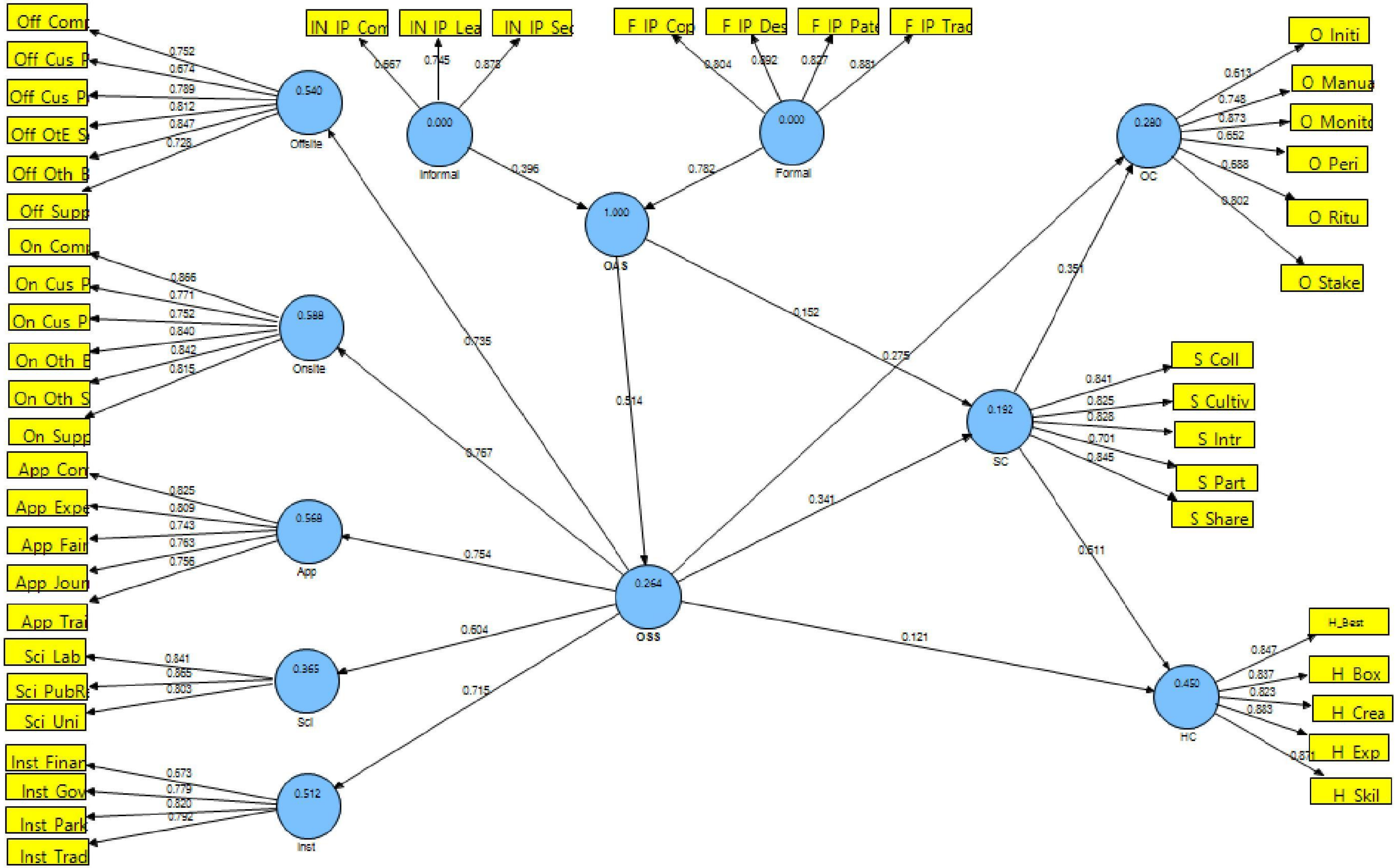


Fig. 3.12: Structural model results (Group differences: high efficacy of internal sources of know-how sample – path diagram)

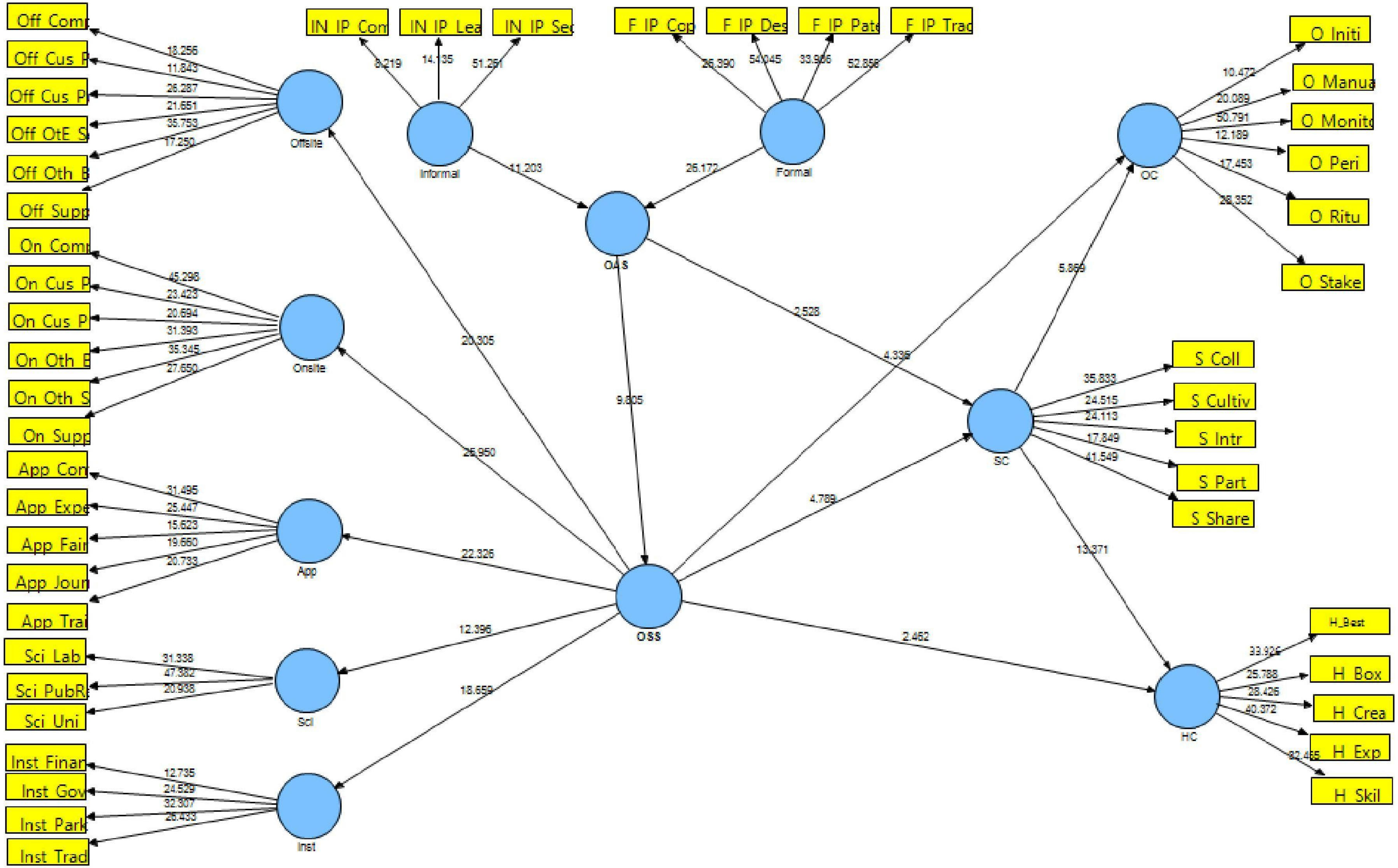


Fig. 3.13: Structural model results (Group differences: high efficacy of internal sources of know-how sample –bootstrapping results - t-values)

Chapter Four: Spatial Proximity and Appropriation of Coopetitive and Cooperative Innovation: The Firms' Response to the Environmental Dynamism

4.1. Introduction

In ever-increasing competitive markets, firms are seeking to create additional value, and thus improve their competitive advantage, through the systematic practice of acquisition and leveraging of external knowledge inputs to support new product and service development. The increasing importance of reliance on a diversified portfolio of knowledge sources has promoted further realisation of the merits of what is known as open innovation. Driven by the evident progress of the open innovation paradigm and articulated understanding of the emerging co-evolutional values and the co-specialisation discourse, considerable research has been devoted to understanding the antecedents and drivers of open innovation that can enable firms to openly interact with external actors and lead to greater chances of success of monitoring outgoing and incoming flows of knowledge. Nevertheless, in an economically and environmentally volatile market, knowledge assets security is an increasingly important consideration. Hence, understanding of how firms fashion their appropriation strategy to guard against unintended spillovers of knowledge has become progressively a tangible reality. In broadly based studies of the determinants of open innovation, there is suggestive evidence that firms' degree of openness and appropriability strategies are intertwined. Nonetheless, there is a complex relationship between appropriation and openness.

The emergence of the phenomenon of open innovation has been accompanied by an active debate concerning whether, and to what extent appropriation mechanisms help, or hinder open innovation (Zobel, Balsmeier & Chesbrough, 2016). Some studies have shown positive empirical regularities between the degree of openness and the use of appropriation mechanisms, and that a strong appropriation strategy is often beneficial for open innovation, and even necessary for signalling the firms` capabilities. On the other hand, scholars have argued that the higher the degree of openness, the more difficult it is to protect the innovation. Hence, the heightened emphasis on exclusivity that surrounds the intensive appropriation mechanisms can potentially hamper the firm`s abilities to engage in collaborative settings.

The question of whether or not appropriability mechanisms enable open innovation is particularly important when knowing that the geographic proximity of firms located in science and technology parks accelerate collaboration between them (Vásquez-Urriago, Barge-Gil & Modrego Rico, 2016). The results obtained in the chapter two showed that the firms located in science and technology parks, regardless of their sizes, tend to draw knowledge from a broad range of onsite and offsite sources. These findings confirmed the idea that innovation is turning more and more into a distributed and democratic phenomenon (von Hippel, 1988; Coombs, Harvey & Tether, 2003). In addition, the results obtained in the chapter three revealed that a firm`s overall appropriability strategy positively associated with its open search strategy, however, much less is known about the influence of formal and informal appropriation mechanisms, that rules resource exchanges in the collaborative settings, either on easing or constraining the firms' strategic manoeuvring.

Those studies that focus on the issues surrounding the role of appropriation in collaborations with various types of partners (Arora & Merges, 2004; Belderbos et al. ,2014; Veugelers & Cassiman, 2005), tend to overlook the context dependency aspects. While prior empirical research generates important insights regarding how general preferences related to appropriability strategies and openness are correlated (Laursen & Salter, 2014; Hagedoorn & Zobel, 2015), it is only partly known about what happens when open innovation enthusiast firms in a close proximity decide about their appropriability strategies. According to Balland (2012), the geographical proximity stimulates collaborative behaviour among co-located firms, more than those in far distance. Thus, without considering the potential context dependency of different appropriation mechanisms, conclusions derived from previous studies analysing either the effects of openness on appropriability strategy (Laursen & Salter, 2014) or the other way (Zobel, Lokshin, & Hagedoorn, 2017) may be biased. This substantiates the need for a thorough investigation into the effectiveness of different appropriation mechanisms.

In this context, it is important to examine how onsite firms' formal and informal appropriability mechanisms influences their subsequent openness towards the market-based actors (Laursen & Salter, 2014). This chapter addresses this gap by observing the roles of formal (legal) and informal (strategic) appropriability mechanisms in shaping firms' subsequent engagement with onsite and offsite market-based cooperative and coopetitive actors. Hence, a relevant question to be addressed is whether appropriability mechanisms enable firms to collaborate and, thereby, overcome joint innovation challenges. This fundamental question is of interest from both a policy as well as from a firm perspective. First, policy makers would like to accelerate innovative effort, in general, and encourage collaboration for addressing systemic challenges. Second, firms operating in science and technology park context are often encouraged to engage in, and maybe even depend on, collaborative efforts for achieving radical innovations. Hence, from a firm perspective, it is important to know whether appropriability mechanisms, which involves a resource-intensive process, enables or inhibits such collaborative efforts.

Besides, previous research show that turbulent conditions are always followed by a degree of raised causal ambiguity which hinders knowledge acquisition and its transfer. This effect could make existing knowledge, products and services obsolete and increase the risk of organisational inertia. Thus, firms will need to invest more on exploratory learning to sustain their superior performance. It is also worth noting that, there is strong evidence that geographical proximity favours knowledge spillovers. This argumentation points out another intriguing aspect of openness paradox, that is, the intensity of competition in a hostile environment exerts even more pressure on the firm`s appropriation strategy, also a greater necessity for firm open behaviour. Thus, further research is needed to investigate under which environmental circumstances are the different appropriation strategies more suitable, and how their distinct benefits overcome associated costs of knowledge spillovers in different types of open search and collaborative settings.

Although theoretically it could be expected that environmental dynamism to influence open search strategy associated with all forms of knowledge sources, the focus is specifically on market-driven sources in this study. The decision to focus primarily on market-driven open search strategies in this study was further reinforced by the nature of the firms that populated the sample, in which the density of firms with cognitive proximity tend to be more serious than disparities based on any other identity characteristics; as a result, likelihood of cooperation for innovation between firms and knowledge providers tends to be particularly higher in this context (Vásquez-Urriago, Barge-Gil & Modrego Rico, 2016). For early researchers, close collaborative settings represent an alternative mechanism to counter free-riding problems and opportunistic behaviours (Williamson, 1985). However, a group of geographically agglomerated market-based partners (and competitors) resemble a particular type of `diversity for conflict`, since its visibility makes it a highly likely trigger of conflict of interests. Therefore, there is a significant need to continue to explore the conditions under which the decisions about market-driven open search strategies become associated with appropriation mechanisms. This makes it a particularly interesting and suitable empirical setting to examine the following research questions:

How does the appropriability strategy of micro and small-and-medium sized enterprises influence their subsequent rational goal performance and market-driven open search relationships? What are the effects of different appropriation mechanisms on the firms' market-driven search strategies, when taking into account the location of partners?

The next question is, how does environmental dynamism influence firms` market-driven open search strategies, when taking into account the location of partners? Building upon this notion, this study examines how environmental dynamism affects the relationships between appropriation mechanisms and open search strategy?

Thus, the goal of this chapter is to examine the costs and benefits of different appropriation mechanisms by investigating how perceived environmental dynamism affects the co-located firms` formal and informal appropriation choices and the adaptation of various market-driven open search strategies. This chapter explores how the choices made by firms about their appropriation strategy, specifically in dynamic environments, affect their choices to be open to different external market-based onsite and offsite actors.

4.2. Theoretical Background

In the last several years, innovation paradigm has shifted from a focus on the closed models to more open models (Lee, Park & Bae, 2017). The focus on open models reflects the recognition that for organisations to avoid problems associated with the `competency traps`(Levitt & March, 1988), `lock-out effects`(Schilling, 1998), `lock-in effects`(Camagni, 1991) and `core-rigidity` (Leonard-Barton, 1992), they need to proactively establish scanning mechanisms to purposefully identify internal and external knowledge sources and paths to market (Daft & Weick, 1984; Cohen & Levinthal, 1990), in order to share uncertainties (Elenkov, 1997), diversify risks, promote learning and eventually accelerate innovation (Keupp & Gassmann, 2009; Fu, 2012; Chesbrough & Bogers, 2014). The key to moving from a closed innovation model to more open ones is to alter the appropriation context within which organisational strategies for innovation entrenched, and societal platforms for interaction with heterogeneous actors shaped. In this context, a systematic use of appropriation mechanisms ensures that firms can capture rents form, and efficiently protect innovation, while implementing their open search and sourcing strategies (Laursen & Salter, 2014; Zobel, Lokshin, & Hagedoorn, 2017).

The issue of potential associations between the appropriation strategy and open innovation has been approached broadly from two different perspectives: for the first group of the researchers, a firm`s appropriation strategy is the starting point from which any future open innovation strategy must evolve (Cohen, Nelson & Walsh, 2000). In contrast, the second group of researchers indicate that it is the firm's open innovation strategy that shapes its preferences for appropriation mechanisms (Somaya, 2012; James, Leiblein, & Lu, 2013). However, recently a third stream of research has emerged that suggests there is no unidirectional influence between open innovation and appropriation strategies (Henttonen, Hurmelinna-Laukkanen & Ritala, 2016).

Nevertheless, when it comes to investigating the role of appropriability strategy in decision making for opening up a firm`s borders to cooperative and coopetitive relations, the extant literature converges around two conflicting points of view. While, relying upon collaboration with external agents provides efficient mechanisms for accessing new knowledge (Stefan & Bengtsson, 2017), enabling streams of knowledge to flow across organisational boundaries (Chesbrough & Bogers, 2014) and exploiting `novel combinations`-in the Schumpeterian term (Schumpeter, 1934)-, it can also weaken the rent capturing power of firms from their knowledge (Arora, Athreye & Huang, 2016). The challenge posed by the opening up to external collaborators to innovate, reveals the stark paradox faced by many firms which has been dubbed as ` paradox of openness` by Laursen and Salter (2014). The paradox of openness leaves firms with a question which needs to be addressed if they want to adopt an ambidextrous strategy amid at broadening their relationships with other firms to develop innovation, and using appropriation mechanisms to capture the expected returns from their innovation. The interplay between appropriation mechanisms and openness is complex and the tension between these two amplifies the trade-off between appropriability and openness (Stefan & Bengtsson, 2016). For example, under such circumstances any collaborative efforts might be at risk, if the engaged parties fear that their knowledge is unprotected. A major challenge resulted from the desire of opening up the organisational boundaries relates to the fact that firms have to protect their innovation against unintended and involuntary spillovers to external actors. This exclusivity could in turn make them less attractive to potential partners (Arora, Athreye & Huang, 2016).

In this context, the role of formal appropriation mechanisms has been specifically disputed (Chesbrough, 2003b; Chesbrough, 2006; West & Gallagher, 2006; Chesbrough & Bogers, 2014). Whereas a small number of empirical studies has found positive associations between how open a firm can be and the strengths of its formal appropriability strategy (Laursen & Salter, 2014), other researchers have widely highlighted the potential risks of relying on strong formal appropriability strategies for collaboration with external partners (Baldwin & von Hippel, 2011). The implementation of protective strategies solely based on formal appropriation mechanisms may lead to a myopia of protectiveness (Dahlander & Gann, 2010). as Arundel (2001) and Laursen & Salter (2014) argue the use of formal appropriation mechanisms secures the ownership of intellectual property and signals quality of the owner, however it could presage a larger threat for collaboration acting as a sign of overprotectiveness (Arora, Athreye & Huang, 2016).

Nevertheless, as time goes by and both formally and informally protected innovations become out of date, firms eventually will need to invest on its exploratory learning to broaden existing knowledge (Jansen, Van Den Bosch & Volberda, 2006; Droge, Calantone & Harmancioglu, 2008). Therefore, some scholars have argued that the outcomes of appropriation mechanisms may be very sensitive to contextual factors. The stream of research that has explored how decisions about openness and appropriation mechanisms tend to be varied in nature, highlights the roles played by factors such as size, age, sector as well as location of partners.

Faced by the challenge of resource scarcity, accelerated knowledge spillovers and collaboration opportunities with neighbouring firms in close proximities allow smaller firms to benefit from agglomeration economies to a much greater extent than larger firms. Numerous studies demonstrate that the resource interdependence and complementarities among co-located firms in science and technology parks could accelerate collaborations, and stimulate cognitive proximity, social proximity and organisational proximity (Westhead, 1997; Siegel, Westhead & Wright, 2003; Corsaro et al., 2012; Díez-Vial & Montoro-Sánchez, 2016; Gkypali et al., 2016; Vásquez-Urriago, Barge-Gil & Modrego Rico, 2016) and minimise knowledge distance (Boschma, 2005). On one hand, these factors foster learning among the co-located firms, on the other hand they can also lead to an upsurge in unintended knowledge spillovers and opportunism, and eventually persuade the firms to adopt a rather strong appropriation strategy. Such effects could widen the scope of the paradox of openness and intensify lock-out effects (Schilling, 1998) for firms located in science and technology parks. Whether the significant of legally protected stocks in onsite firms enables or impedes co-creation and co-innovation thus exemplifies the research question.

On the other hand, turbulent markets are characterised by uncertainty and unpredictability (Dess & Beard, 1984; Duncan, 1972) which drive firms to invest more on exploratory learning (Daft & Weick, 1984; Dutton, Fahey & Narayanan, 1983). In the meantime, dynamism in the environment increases causal ambiguity and protects knowledge from being imitated by rivals. In addition, it makes harder for firms to transfer and acquire knowledge. This may help firms to achieve superior innovation in short term (Dess & Beard, 1984; Jaworski & Kohli, 1993).

In the long run, however, it may lead to organisational inertia by limiting the access to outside knowledge (Leonard-Barton, 1992) and making existing products and services obsolete (Eisenhardt & Martin, 2000; Teece, 2007). This review points out a gap in understanding how the use of various appropriation mechanisms in collaboration with different actors varies when considering the influence of environmental dynamism. Given the differentiation in the innovation literature between the costs and benefits of formal and informal appropriation mechanisms, the question emerges as to what extent perceived dynamism in the environment impact the formal and informal appropriability strategies of the co-located firms. As per explained in chapter two, both offsite and onsite market-based collaborative and coopetitive actors are identified as having the capacity for -positively- influencing the open system performance in tenant firms, and as important players in shaping open innovation portfolios, making them important units of analysis. Nevertheless, empirical evidence is lacking on how partners' geographical location affects the appropriability-openness paradox. In addition, there is scarce empirical work in the literature on linking the distinct types of appropriation mechanism to specific types of partners depending on location.

Seen in this light, a possible wisdom is that to manage both the problems and potential benefits associated with the paradox of openness in spatial proximity, onsite firms may need to prioritise and link the distinct types of appropriation mechanism to specific types of partners depending on their locations. Despite the growing awareness of the potential costs and benefits of openness in the literature, empirical evidence is lacking on how location affects the appropriability-openness relationship. Moreover, the question of which market-driven open search strategy is more suitable depending on the environmental features is still unresolved. As discussed earlier, the perceived degree of turbulence in a market could affect the firms` decisions about the appropriation choices. These conflicting arguments as well as inconclusive empirical results suggest that the role of appropriation mechanisms in shaping firms` open search strategy remains highly debated, requiring further research in this domain. Given this, it becomes a relevant question whether the association between appropriability mechanisms and open innovation is of a uniform nature, or whether it differs across relationships that vary in terms of spatial proximity of, and cognitive proximity between the partners.

4.3. Hypotheses

4.3.1. Market-driven Open Search Strategy and Performance

Nearly a decade after the Chesbrough`s seminal book on open innovation, Chesbrough & Bogers (2014) arrive at a rich description of the different approaches to shaping open innovation strategy adopted by organisations. From a strategic point of view, open innovation is “a distributed innovation process based on purposively managed knowledge flows across organisational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organisation’s business mode” (Chesbrough & Bogers, 2014:3). Hence, an organisational strategy centred on promoting the openness priorities the simultaneousness of both `creation and re-combination` and `absorption and integration` of inward and outward knowledge flows.

The key to the succession of open innovation strategy, through which a firm could sustain its superior performance, is access to reliable sources of external knowledge, know-how and ideas. In this process, the element of complementarity between a firm`s internal knowledge base and external sources of heterogeneous knowledge could be a driving force for the development of new capabilities and yielding better innovation outputs (Cassiman & Veugelers, 2006). However, this will need careful monitoring of potential sourcing opportunities, and investments need to be sufficiently made to build new linkages with the supply chain actors and other knowledge agents, and to respond to emerging organisational needs. Among all potential external partners, a firm`s supply chain sources of knowledge are known as the immediate sources of market knowledge (von Hippel, 1986; Hienerth, 2006; Laursen & Salter, 2006). It is also evidenced in the literature the importance of learning from supply chain partners to improve the innovation and performance, especially in smaller firms (Propris, 2002; Freel & Harrison, 2006; Tomlinson & Fai, 2013; Brunswicker & Vanhaverbeke, 2015). For many firms, their clients and customers are the main, and probably, the most frequently accessed points for gaining knowledge about the market in general, and experience feedback processes, in particular (von Hippel, 2005). Similarly, a firm`s suppliers could be seen as the main sources of technical knowledge about its market and functions (Kaufman, Wood & Theyel, 2000). Competitors are also known to be major players for the exchange of complementary knowledge and capabilities (Han, Porterfield & Li, 2012).

However, there is no general agreement among researchers as to what extent the interactions with supply chain partners and competitors imply benefits for different firms, and how the frequency of interaction affects decisions on continuity issues and priorities. On one hand, Laursen & Salter (2006) show that firms are more frequently engaged in dyadic relationships with suppliers than any other supply chain agents, on the other hand Enkel, Gassmann & Chesbrough (2009) indicate that clients are the most frequently visited sources of market knowledge. Similarly, even though Han, Porterfield & Li (2012) highlight the benefits of coopetitve relationships, Lavie (2006) indicates that the likelihood of opportunistic behaviour is much stronger in coopetitive settings than for cooperation with other supply chain actors. In line with a branch of the extant literature (von Hippel, 1986; Bengtsson & Kock, 2000; Ragatz, Handfield & Petersen, 2002) that emphasises the role of supply chain actors in sustaining superior performance, the findings in the chapter two confirmed the overall positive performance effects of incorporating value chain knowledge for the firms located in science and technology parks. Nonetheless, empirical evidence is still lacking on whether the location of a potential value chain partner in cooperative and coopetitive relations matters, and how spatial proximity of partners may influence the focal firm`s control structure and external focus.

Prior research shows that when spatial proximity is taken into account in pursuing collaborative activities with potential supply chain partners, how close one node is to the others could be seen as a strong predictor of economic success (Chiaroni, Chiesa & Frattini, 2011). These studies indicate that the intensity of co-innovation with distant partners is [negatively] influenced by the `effort cost` associated with `knowledge distance` (Praest Knudsen & Bøtker Mortensen, 2011). For instance, Sammarra & Biggiero (2008) conclude that the locality of suppliers could yield shorter lead times. On the other side of the spectrum, the appreciation of the heterogeneity of knowledge and its globally distributed patterns among distant partners (Moodysson, 2008) stresses the centrality of complementary knowledge that can stimulate innovation (Arvanitis & Bolli, 2013; Berchicci, 2013). Yet, another school of thought is advocate of a more balanced approach towards both the proximately-located and distant partners (Patel et al., 2014).

Besides these conflicting views on the role of proximity in supply chain collaboration for innovation, it is ultimately the organisational performance that act as a good measure of the success or failure of firms in achieving their expected goals from engaging in open innovation activities with the nearby or distant supply chain partner. The organisational goals are heterogeneous by nature (Quinn & Rohrbaugh, 1983), and the success in achieving rational goals of performance requires a higher level of efficiency and productivity in shaping beneficial network relations and leveraging knowledge exploitation opportunities. Thus, as discussed in the earlier chapters, the rational goal criteria provide a better set of indicators to compare a firm`s outputs relative to its competitors, market and established benchmarks (Hernández-Espallardo, Sánchez-Pérez & Segovia-López, 2011). The above insights supported the following hypotheses:

Hypothesis 1. The higher the intensity of a firm's onsite market-driven open search strategy, the more likely it becomes for the firm to achieve the expected rational goal outcomes.

Hypothesis 2. The higher the intensity of a firm's offsite market-driven open search strategy, the more likely it becomes for the firm to achieve the expected rational goal outcomes.

4.3.2. Formal and Informal Appropriation Mechanisms, Market-driven Open Search Strategy and Performance

Also critical to the success of leveraging economic opportunities through open search activities is a firm`s ability to appropriate value from its innovation. Appropriability is defined as “a firm’s ability to protect the advantages of (and benefit from) new products or processes” (Escribano,Fosfuri & Tribó, 2009: 98). The ability to appropriate value represents a key capability for building process that could sustain competitive advantage in a firm (Samson & Roden, 2012). However, in order to succeed in leveraging economic impacts from open innovation activities, a higher degree of disclosure is required. Openness necessitates a trade-off between the benefits of discovery and costs of divergence (Almirall & Casadesus-Masanell, 2010). Discovery could lead to a lower level of control over knowledge assets, or unintentional knowledge spillovers and imitation. This effect could also lessen the effectiveness of formal protection mechanisms.

While there is some evidence in the literature that learning from, and engagement with supply chain partners can have a positive effect on the smaller firms' performance, If the expected levels of rents from the supply chain collaborations are not attainable and perceived risks of exposure to the unintended knowledge spillovers are higher than potential benefits, they may choose not to engage with potential partners (Klein, Crawford & Alchian, 1978; Katz & Shapiro, 1986). In other words, a firm`s appropriation strategy and its value co-creation decisions are tightly connected. Firms use various appropriation mechanism to monitor and capture the rents from knowledge flows which are entering or exiting the organisation, thus, their appropriability strategies determine the success or failure of open search activities. Prior research shows that both the issues related to `lack of knowledge` and `lack of control` are among the mostly cited risks associated with openness (Enkel, Gassmann & Chesbrough, 2009). This creates a paradox because the mechanisms that are known to be essential for value appropriation may act as barriers to openness. The impact is higher for the smaller firms compared to their larger rivals. On one hand, smaller firm are more likely to benefit from openness, as their in-house R&D capacity is limited (van de Vrande et al., 2009). For smaller firms, open search activities play a key role in overcoming the liability of smallness (Gassmann, Enkel & Chesbrough, 2010). On the other hand, smaller firms are more vulnerable to intellectual property right infringement, as they lack the required resources and expertise to formally protect their intellectual property (Leiponen & Byma, 2009). It could hamper the ability of smaller firms to appropriate the rent from their key knowledge assets. This is also known as the fear of intellectual property degradation which is known to be a key barrier to openness in smaller firms, as evidenced in the literature on how concerns over confidentiality alters firms` innovation modes (Oakey, 2013).

On the other hand, various modes of intellectual property protection have their own benefits and costs. On the benefit side, generally formal appropriation mechanisms "give innovating firms time-limited rights to exploit their discoveries, inventions, and new designs. These formal appropriation mechanisms create incentives for firms to re-invest in innovations, new technologies, and to diffuse new products based on innovations that are protected by law" (Zobel, Lokshin & Hagedoorn, 2017: 44). However, resource constraints limit the ability of smaller firms to use formal protection mechanisms. As it is generally believed that a firm's size impacts the decision to use formal or informal appropriation mechanisms (Thomä and Bizer, 2013). Prior studies reveal that smaller firms normally tend to use the informal modes of intellectual property protection, such as secrecy, complexity and lead time advantage (Freel & Robson, 2016). Nevertheless, in contrast to most formal mechanisms, informal mechanisms "are not accompanied by an enforcement mechanism" (Neuhäusler, 2012:682), thus, not protected by law. Despite the fact that in the literature a general complementarity between different modes of intellectual property protection is assumed, some forms of protection mechanisms are inevitably mutually exclusive due to their legal origins (Hurmelinna-Laukkanen & Puumalainen, 2007). On the cost side, inconsistency in the strength of the protection offered by various mechanisms is known to be among the key factors affecting the firms` ability to appropriate the rent from their resources and achieve rational goals. Hence, it is necessary to first distinguish between various types of protection mechanism and investigate the impact of each of these mechanisms on rational goal performance in smaller firms, individually. Thus, the following relationships were hypothesised:

Hypothesis 3. The higher the intensity of use of formal appropriation mechanisms by a firm engaged in open search activities, the more likely it becomes for the firm to achieve the expected rational goal outcomes.

Hypothesis 4. The higher the intensity of use of informal appropriation mechanisms by a firm engaged in open search activities, the more likely it becomes for the firm to achieve the expected rational goal outcomes.

A firm`s ability to appropriate the rent from its innovation influences its willingness to engage in open innovation activities. There is a general agreement in the literature that the use of both formal and informal appropriation mechanisms is associated with the degree of openness in firms (West & Gallagher, 2006). For instance, the number of registered patents is believed to positively correlate with the intensity of joint research and development activities in firms (Brouwer & Kleinknecht, 1999), and signals the focal firm`s readiness to engage in collaborative settings. However, prior studies have also reported that the relationship between the intensity of a firm`s appropriability strategy, in general, and its openness has an axis symmetry and follows a concave curve (Laursen & Salter, 2014). One possible implication of that difference may lay in the application and shares of different protection mechanisms in the firm`s appropriability strategy. As explained by Chesbrough (2003a), the excessive use of strong formal protection types could hamper firms' attempts to build relationships and increase network ties. Cassiman & Veugelers (2002) distinguish between expected and realised values of each appropriation mechanism in collaborative settings. While it seems that the effective use of informal mechanisms of protection fosters collaborations with external partners, an overemphasised focus on the use of formal mechanisms does not necessarily increase the rate of engagement in collaborative settings. In contrast, Zobel, Balsmeier & Chesbrough (2016) find a positive association between the intensity of use of patents, as a formal mechanism for protecting intellectual property, and the number of a firm`s partners. The results are being justified on the basis of Teece (1986)'s notion of the tight intellectual property regimes that favours partnering strategies. In this scenario, the use of formal appropriation mechanisms increases the attractiveness and visibility of focal firm, and act as a reliable basis for solving potential conflicts over the ownership of joint intellectual property rights. This led to the following hypothesise:

Hypothesis 5. The use of formal appropriation mechanisms positively associates with an intense strategic focus on onsite market-driven open search activities.

Hypothesis 6. The use of formal appropriation mechanisms positively associates with an intense strategic focus on offsite market-driven open search activities.

As explained earlier, smaller firms use the informal mechanisms of intellectual property protection more frequently than the formal types of protection, as they face far greater challenges in accessing resources. Prior studies reveal that firms prefer informal protection mechanisms over formal ones when shaping their appropriation strategy for the horizontal collaborative settings (Leiponen & Byma, 2009). While reliance on the informal mechanisms may offer less security than the use of formal mechanisms, it could the focal firm's strategic manoeuvring. When firms are engaged in inbound open innovation activities, the risks of unintended knowledge spillovers are much less than the outbound activities. As a limited level of revealing is required in inbound open innovation activities, potential external agents will have less incentives for opportunistic behaviours. Thus, this could indicate further opportunity to appropriate a larger share of value from the open search activities, and a higher level of strategic focus on open search activities. This led to the following hypothesise:

Hypothesis 7. The use of informal appropriation mechanisms positively associates with an intense strategic focus on onsite market-driven open search activities.

Hypothesis 8. The use of informal appropriation mechanisms positively associates with an intense strategic focus on offsite market-driven open search activities.

4.3.3. Environmental Dynamism, Appropriation Mechanisms, Market-driven Open Strategy

A firm`s environment plays the key role in shaping its innovation processes and activities (Levinthal & March, 1993). Environmental dynamism is defined as the degree of perceived unpredictable change(s) in the environment (Dess & Beard, 1984), and characterised by uncertainty in market relationships and resource allocation in the short-run, rapid technology changes (Jaworski & Kohli, 1993; Mu & Di Benedetto, 2011). These normally result in an increases level of managerial uncertainty (Duncan, 1972), and further exploratory learning to meet new requirements (Daft & Weick, 1984). Changing economic, technological, social and political forces that govern turbulent markets, make it difficult for firms to adapt to new market demands and predict their rivals` next moves (Green, Covin & Slevin, 2008). For instance, technological turbulence could lead to shorter product lifecycles, and an increased need for external sources of know-how and further joint research and development activities (Li & Calantone, 1998). Firms use external sources of knowledge and ideas to compensate for their technological inferiority. In industries with rapid rates of technological change, environmental dynamism provides high levels of challenge for smaller firms, as they normally could not have the required and full knowledge to bring advanced products by themselves (Teece, 1986). Environmental dynamism “acts as a major push-and-pull force for adapting and innovating products, processes and routines” (Maes & Sels, 2014: 143). Under such circumstances, access to external knowledge is particularly beneficial, and a firm`s open search strategy acts as a means to respond to the changing environment (Cassiman & Veugelers, 2006), by improving innovation and accelerating the time-to-market for new products (Chesbrough, 2007).

Competitive conditions, which are direct results of the environmental dynamism, force firms to develop new capabilities to survive the changing environment, that could lead to further innovations and breakthroughs (Kimberly & Evanisko, 1981; Fuentelsaz, Gomez & Polo, 2003). A firm`s strategic flexibility plays the key role in shaping its ability “to precipitate intentional changes and adapt to environmental changes through continuous changes in current strategic actions, asset deployment, and investment strategies” (Nadkarni & Narayanan, 2007:245). Exploratory learning could help a firm to acquire strategic flexibility in order to tackle the challenges, such as lock-out effects (Schilling, 1998) and competency traps (Levitt & March, 1988) imposed by unpredicted turbulence in the market (Droge, Calantone & Harmancioglu, 2008). Hyper competition in the turbulent environment would make current markets and products obsolete (Droge, Calantone & Harmancioglu, 2008). As smaller firms` internal capacity for research and development is limited, it necessitates addressing some of the difficulties experienced by these firms through the exploratory learning mechanisms (Cassiman & Veugelers, 2006). The primary sources of information that can help a firm in a successful market analysis are its supply chain partners. As competition increases, it becomes more important than ever for firms to manage their supply chains. Clients and customers can provide firms with required market information which allows them to understand new demands and technological needs, and adjust their products and services in order to shape their current and new customers’ needs (Porter, 1980). In addition, other supply chain partners, such as suppliers, could help them to shape a joint strategy against their rivals to deal with uncertainty in the market, as competition is rather between supply chains than individual firms (Podolny,1994). Hence, the following relations were hypothesised:

Hypothesis 9. Environmental dynamism positively associates with an intense strategic focus on onsite market-driven open search activities.

Hypothesis 10. Environmental dynamism positively associates with an intense strategic focus on offsite market-driven open search activities.

Trust plays a key role in social life for organisations, as always there are potential risks in cooperation with the external agents, in particular in co-innovation (Chesbrough, 2007). In general, open innovation activities pose a threat to the firms already competing in the market and could increase the opportunities for opportunism. When firms decide to engage in the provision of collaborative innovation activities, they will normally need to adopt a strategy based on the practice of selective disclosure (Henkel, 2006; Alexy & George, 2013; Henkel, Schöberl& Alexy, 2014). The practice of selective disclosure by the focal firm encourages its partners to engage in the joint problem-solving activities (Alexy, George & Salter, 2013), as overprotectiveness may result in organisational inertia (Leonard-Barton, 1992). Nonetheless, this could increase their vulnerability to opportunistic behaviours.

On the other hand, while a turbulent environment could heighten the causal ambiguity (Song et al., 2005; Alvarez & Busenitz, 2007; Helfat et al., 2007), but it also could hamper a firm`s ability to transfer and acquire knowledge (Levin & Cross, 2004). Hence, as the environment changes more rapidly, entry barriers are becoming lower and firms may prefer closed approach to innovation (Drechsler & Natter, 2012). Such a negative atmosphere could not be conducive to the flow of knowledge between the partners, as the chance of imitation by competitors increases and the cost of coordination may seem to be large relative to the expected value of co-innovation Cassiman & Veugelers, 2006). Thus, the role of appropriation mechanisms importance in turbulent markets has been the centre of attention in recent years (Song et al., 2005; Droge, Calantone & Harmancioglu, 2008). Prior studies have shown that the effectiveness of appropriation mechanisms depends on the level of dynamism in a firm`s environment. As different environments require different strategies for exploratory and exploitative learning, they also impose different challenges to the role and scope of various intellectual property mechanisms in a firm`s appropriation strategy (Hung & Chou, 2013).

Prior research shows that formal appropriation mechanisms, in particular patenting, could hamper a firm`s ability to engage in collaborations with external partners (Laursen & Salter, 2014). Similarly, there is a general agreement in the literature that the excessive use of formal appropriation mechanisms could impede the firms` abilities to gain benefits from co-innovation (Jensen & Webster, 2009). This becomes more salient when causal ambiguity is present which requires a higher level of internal communications between partners and selective disclosure (Foss, Laursen & Pedersen, 2011). Hence, firms may tend to rely on the informal mechanisms of protecting intellectual property (Pisano, 2006; Chesbrough & Appleyard, 2007). In addition, smaller firms face more financial constraints compared to their larger rivals. As Love & Roper (2015) argue, due to the cost of formal appropriation mechanisms, smaller firms may be disadvantage if formal appropriability strategies are targeted. Hence, the following relations were hypothesised:

Hypothesis 11. Environmental dynamism positively moderates the impact of use of informal appropriation mechanisms on a firm`s strategic focus on onsite market-driven open search activities.

Hypothesis 12. Environmental dynamism positively moderates the impact of use of informal appropriation mechanisms on a firm`s strategic focus on offsite market-driven open search activities.

Hypothesis 13. Environmental dynamism negatively moderates the impact of use of formal appropriation mechanisms on a firm`s strategic focus on onsite market-driven open search activities.

Hypothesis 14. Environmental dynamism negatively moderates the impact of use of formal appropriation mechanisms on a firm`s strategic focus on offsite market-driven open search activities.

Fig. 4.1 illustrates all hypothesised relationships between research variables.

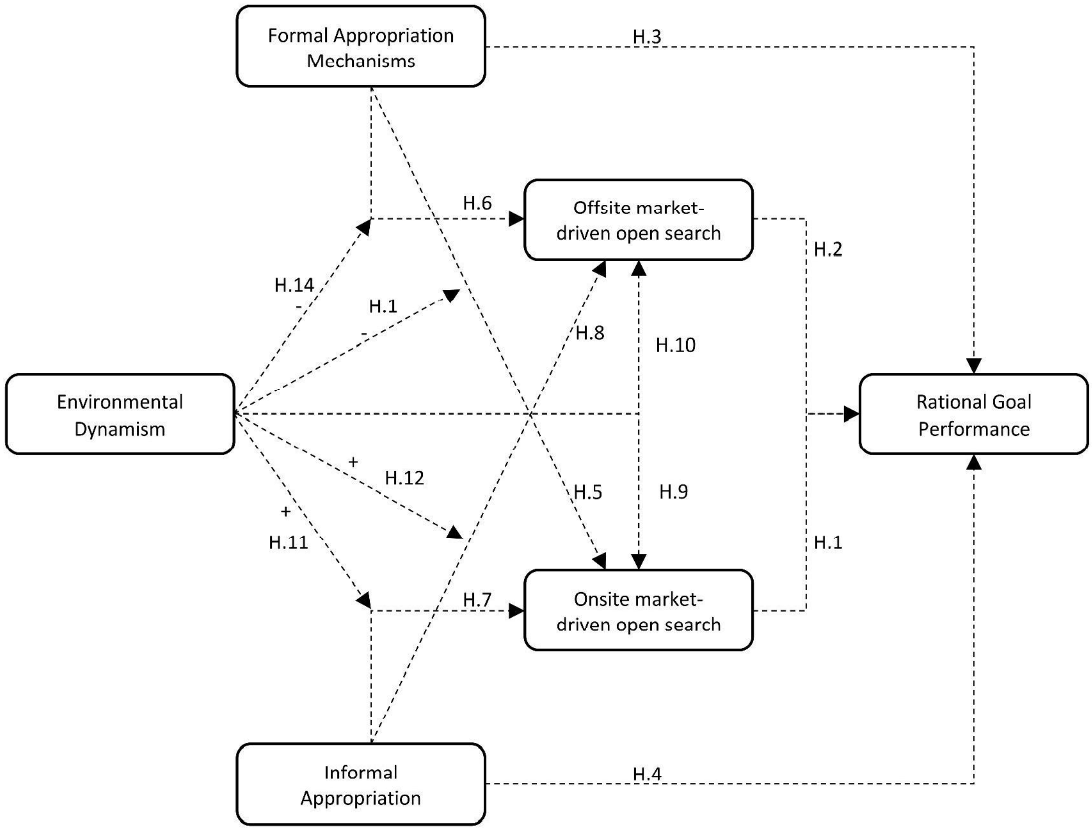


Fig. 4.1: Research model

4.4. Methods

4.4.1. Sample and Data Collection

To test hypotheses for this study, the population of firms located in science and technology parks in the United Kingdom were sampled. The dataset underlying this analysis is drawn from the UKSTP Survey which was first launched in 2015 and its purpose is to provide a means to measuring the levels and types of innovation activities among companies located in science and technology parks in the United Kingdom. In this study, the UKSTPC database[8] was used as the sampling frame. A stratified (by region) sample was drawn from tenant firms listed in the UKSTPC database. The survey targeted the highest-ranking officials in micro, small and medium size enterprises. The data were collected between 1 June to 20 October 2015 by means of a self-administered internet-based survey,

[8] The UKSTPC database is a company database listing over 6000 companies located in Science Parks, Technology Parks, Research Parks, Innovation Parks, Incubators, Innovation Centres and Accelerators around the United Kingdom. The UKSTPC database was developed between December 2014 to May 2015, as part of the UKSTP research project, specifically for current study. The UKSTPC database provides a comprehensive list of firms ranging from micro to large enterprises in different science and technology parks in the United Kingdom.

hosted by surveymonkey.com and on the project`s official website[9]. After three follow up emails, 485 responses were received. In total, forty-three questionnaires were discarded from this initial sample because the respondents had submitted incomplete questionnaires or the submitted questionnaire had missing data; these exclusions left 342 usable questionnaires.

4.4.2. Variable Definition and Measurement

4.4.2.1. Independent and Dependent Variables

Rational goal performance: According to Quinn & Rohrbaugh (1983), the rational goal dimension represents an aspect of the organisational effectiveness which is associated with efficiency and productivity. In other words, the rational goal criteria reflect on the success of a firm in maximising outputs relative to its competitors, market and established benchmarks (Hernández-Espallardo, Sánchez-Pérez & Segovia-López, 2011). Firm market performance was assessed with items adapted from (Gupta & Govindarajan, 1984; Venkatraman & Ramanujam, 1986). Firms were asked to rate the degree of their firms` development over the last three years relative to their main competitors in terms of: sales growth, turnover growth, profitability and market share. The answers were measured on 7-point scales, with a rating of 1 indicating that the firm has performed much worse than its competitors, and a 7 indicating that it has performed much better than other competitors. An exploratory factor analysis was conducted on the responses to the 4 items of rational goal performance measures which yielded a single factor solution with eigenvalue greater than one (all items were loaded highly >50, accounting for 85.84 percent of the variance). The scale had a Cronbach's alpha of 0.945 which shows a good reliability (Table 4.1).

Table 4.1: Exploratory factor analysis: Rational goal performance

Items	***Loadings***
Market Share	0.89
Profitability	0.91
Sales	0.95
Turnover Growth	0.95
% of Variance	85.84
Cronbach's alpha	0.95

[9] www.ukstpsurvey.org

Intensity of offsite market-driven open search strategy: The survey identifies six offsite market-driven sources for innovation. The search strategy of a company can be directed towards accessing any one or several of these offsite sources. The offsite market-driven sources are: offsite clients or customers from the private sector, offsite clients or customers from the public sector, offsite suppliers of equipment, materials, components, or software, offsite competitors, other offsite businesses in the focal firm`s sector that are not direct competitors, other offsite enterprises in other sectors. Using a 7-point Likert scale (1= `very unimportant` to 7= `very important`), firms were asked to report how important to their businesses` innovation and learning had been each of the above-mentioned sources between 2012 to 2015. An exploratory factor analysis on the items suggested that, all 6 items loaded (loadings >.50) on one factor with eigenvalue greater than one. Together, these factors accounted for 58.37 percent of the variance (Table 4.2). The Cronbach's alpha for the scale was .86.

Table 4.2: Exploratory factor analysis: Intensity of offsite market-driven open search strategy

Items	***Loadings***
Offsite Competitors	0.71
Offsite Clients or Customers from the Private Sector	0.67
Offsite Clients or Customers from the Public Sector	0.78
Other Offsite Enterprises in other Sectors	0.81
Other Offsite Businesses in Your Sector that are not Direct Competitors	0.82
Offsite Suppliers of Equipment, Materials, Components, or Software	0.78
% of Variance	58.37
Cronbach's alpha	0.856

Intensity of onsite market-driven open search strategy: The survey identified six types of market-driven source for innovation in science and technology parks. The search strategy of a tenant can be directed towards accessing any one or several of these onsite sources. The onsite market-driven sources are: onsite clients or customers from the private sector, onsite clients or customers from the public sector, onsite suppliers of equipment, materials, components, or software, onsite competitors, other onsite businesses in the focal firm`s sector that are not direct competitors, other onsite enterprises in other sectors. Firms were asked to indicate on a seven-point Likert-type scale the importance of six onsite market-driven sources for their firm's innovation activities during the last three years (2012–2015). A '1' meant that the firm did find the given source very unimportant important, while a '7' meant that it was a key source of market-driven knowledge for the focal firm. An exploratory factor analysis on the items suggested that, all 6 items loaded (loadings >.50) on one factor (eigenvalues>1) that accounted for 68.61 percent of the variance. Coefficient α for the scale was .91 (Table 4.3).

Table 4.3: Exploratory factor analysis: Intensity of onsite market-driven open search strategy

Items	*Loadings*
Onsite Competitors	0.86
Onsite Clients or Customers from the Private Sector	0.81
Onsite Clients or Customers from the Public Sector	0.78
Other Onsite Businesses in Your Sector that are not Direct Competitors	0.84
Other Onsite Enterprises in other Sectors	0.85
Onsite Suppliers of Equipment, Materials, Components, or Software	0.81
% of Variance	68.63
Cronbach's alpha	0.90

Formal Appropriation Mechanisms: refers to the exclusive privileges granted to owners of a variety of distinct new creations in terms of intangible assets (Zobel, Lokshin, & Hagedoorn, 2017). This scale was intended to capture a firm's perceived effectiveness of formal appropriation mechanisms to achieve its organisational objectives associated with its open search strategy. Formal appropriation mechanisms include: patents, trademarks, copyrights, and design rights. Firms were asked to indicate: how effective was each of the appropriation mechanisms for maintaining or increasing the competitiveness of their product and process innovations, on a 7-point Likert scale ranging from not at all (1) to very extremely important (7) to measure this construct. A principal factor analysis yielded a clear one-factor solution, accounted for 72.39 percent of the variance. All loadings were above the value of .50 suggested by Hair et al. (2014). The Cronbach`s alpha for the scale was 0.872 (Table 4.4). The measure of formal Appropriability Strategy has been widely used in the previous empirical research with regards to the firms' open innovation activities (Laursen & Salter, 2014; Freel & Robson, 2016; Zobel, Lokshin, & Hagedoorn, 2017, amongst others).

Table 4.4: Exploratory factor analysis: Formal appropriation mechanisms

Items	*Loadings*
Copyright	0.82
Design registration	0.88
Patents	0.82
Trademarks	0.88
% of Variance	72.39
Cronbach's alpha	0.87

Informal Appropriation Mechanisms: refers to the perceived effectiveness of informal appropriation mechanisms, such as lead time, complexity and secrecy product, as ways to guard innovations and achieve targeted organisational objectives associated with its open search strategy. The three-item reflective measure was intended to capture the extent to which a firm proactively engaged in using informal mechanisms to protect its intangible assets while scanning for partnering opportunities and knowledge acquisition. The managers of the surveyed firms were asked how effective the complexity of goods or services introduced by them, secrecy (including non-disclosure agreements) and lead time advantages had been for maintaining or increasing the competitiveness of product, process and service innovations in the previous three years. A 7-point, Likert-type scale ranging from not at all (1) to extremely important (7) was used to measure this construct. An exploratory factor analysis conducted in order to analyse the underlying dimensionality of the informal appropriation mechanism construct, using the three variables, yielded a one-factor solution explaining 62.71 percent of the total variance. All variables had loadings higher than 0.5. The scale had a Cronbach's Alpha of 0.701 (Table 4.5). The measure of Informal Appropriability Strategy has been widely used in the previous empirical research with regard to firms' open innovation activities (Laursen & Salter, 2014; Freel & Robson, 2016; Zobel, Lokshin, & Hagedoorn, 2017, amongst others).

Table 4.5: Exploratory factor analysis: Informal appropriation mechanisms

Items	***Loadings***
Complexity of goods or services introduced by your company	0.73
Lead time advantages	0.82
Secrecy (include non-disclosure agreements)	0.82
% of Variance	62.71
Cronbach's alpha	0.70

Environmental Dynamism (Moderator Valuable): reflects the perceived speed of change and instability of market, under which a firm uses it strategic reactiveness ability to gauge the implications of changes in its environment and minimise the downside risks inherent to their operations. Consistent with prior research (Green, Covin & Slevin, 2008), environmental dynamism was measured using five items adapted from adapted from Germain, Dröge & Daugherty (1994) and Jaworski & Kohli (1993). Firms were asked to report their agreement with these five statements (1=`strongly disagree` to 7= `strongly agree`) regarding their level of perceived dynamism in the market. In order to reduce the acquiescent bias and extreme response bias, a mixture of positive (questions 10.1 and 10.3 positively-keyed items) and negative (questions 10.2, 10.4, 10.5 contained negatively-keyed items) questions were used(Green, 2008). Example statements for environmental dynamism included `I Customer requirement and preferences are hard to forecast (positively-keyed item) ` and `Our industry is very stable with very little change resulting from major economic, technological, social, or political forces (negatively-keyed item) `. A principal factor analysis yielded a single factor structure, with all factor loadings were above the acceptance level of 0.50 (Hair et al., 2014). Cronbach alphas for the scale was .863, above the value of .70 suggested by Nunnally & Bernstein (1994), indicating an acceptable degree of reliability (Table 4.6).

Table 4.6: Exploratory factor analysis: Environmental dynamism

Items	*Loadings*
The set of competitors in my industry has remained relatively constant.	0.79
Customer requirement and preferences are hard to forecast.	0.81
Product/Service demand is hard to forecast.	0.83
Our industry is very stable with very little change resulting from major economic, technological, social, or political forces.	0.88
Actions of competitors are generally quite easy to predict.	0.71
% of Variance	64.74
Cronbach's alpha	0.86

4.4.2.2. Control Variables

The seminal work of Cassiman and Veugelers (2002) on appropriability strategy of firms engaged in dyadic relationships with external actors, and later the Chesbrough’s (2002) argument on open innovation have stimulated researchers to look at different ways in which innovating firms` proprietary, defensive and leveraging strategies may affect their open innovation activities. The relationship between the firms` openness and the appropriability strategy has been analysed from several different angles. Given that many studies of open innovation have found that a key source of difference between firms’ innovation performance is their firm-specific characteristics, a set of commonly used firm-specific control variables were included in the analysis.

Age: Drawing on the innovation literature, on the one hand younger firms tend to be more innovative (Huergo & Jaumandreu, 2004), on the other hand older firms possess more refined capabilities and resource that could facilitate the process of knowledge acquisition and exploitation (Sinkula, 1994; Huergo & Jaumandreu, 2004; Parida, Westerberg & Frishammar, 2012). Thus, the firm age, may interfere with the relationships being studied. Firm age was operationalised using the natural log of the number of years since establishment. The median age of the sample was 8.5 years.

Sector Effect: Prior research has indicated that the nature of the industries in which firms operate may influence their innovative capabilities (Dess, Ireland, and Hitt, 1990) and trigger them to develop their absorptive capacity. Moreover, higher levels of technological needs provide a powerful incentive to conduct intensive search and innovative activities (Castellacci & Zheng, 2010; Lee, Park & Bae, 2017). In turns, It may lead to difference in the rates of and the application of formal and informal appropriation mechanisms between high-technology firms and other rivals(Zobel, 2017). Thus, controlling for the sector effect variable could explain potential differences in efforts and resources invested in innovative activities. To control for sector effects, initially sample was divided in to 10 categories using the Eurostat classification of High-tech industry and knowledge-intensive industry (Eurostat, 2014) were generated at the two-digit industry level[10]. Then a dummy variable High-tech was constructed, where the variable received a value of 1 if the firm's main NACE code corresponded to a high-technology (manufacturing) or high-tech Knowledge intensive (services) sector. Otherwise, it had a value of 0 if the firm's main NACE code corresponded to other eight classes. Out of 52 manufacturing firms, 46.2% of firms were High-Technology, 32.7% Medium High-Technology, 9.6% of Medium Low-Technology, 11.5% Low-Technology. Similarly, out of 290 service firms, 49.7% were High-tech Knowledge intensive services, 12.1% Knowledge intensive services (Other), 27.2%Knowledge intensive market services, 3.8% Knowledge intensive financial services, 7.2% Less Knowledge Intensive services.

Radicalness: In order to address the needs of new customers, firms may introduce new products or services that involve radical changes in technology for the firm (Atuahene-Gima, Slater & Olson, 2005). The degree of radicalness of the firm's product and service reflects its learning capability and propensity for knowledge exploration and acquisition (McGrath, 2001) and also signals high

[10] Less Knowledge Intensive Services, Knowledge intensive services (Other), Knowledge intensive services (Market Services), Knowledge intensive services (Financial Services), Knowledge intensive services (High Technology), Low-Technology (Manufacturing), Medium Low-Technology (Manufacturing), Medium High-Technology (Manufacturing), High-Technology (Manufacturing) and other.

market and technological uncertainty and environmental dynamism (Koberg, Detienne & Heppard, 2003). Moreover, the nature of innovations, whether radical or incremental, is believed to be a strong predictor of appropriation mechanism (Hurmelinna-Laukkanen, Sainio & Jauhiainen, 2008). To account for the radicalness of the product or service introduced by firms, a dummy variable was introduced that took on the value of 1 if the firm had introduced a new product (covering both goods and services) to the market and received a value of 0 if the company had not introduced any new products to the market. The measure of radicalness has been widely used in the previous empirical research with regard to firms' open innovation activities (Laursen & Salter, 2006; Leiponen & Helfat, 2010, amongst others). About 48.5% of the firms in the sample indicated that their firms had introduced at least one new product or service innovation into the market.

Internationalisation: Previous research indicates that the relationship between openness and appropriability strategy of firms could take different forms depending on geographical context of market they operate in (Hagedoorn & Zobel, 2015). On the one hand, it is believed that firms are more prone to engage in open innovation if they operate in international markets (Gassmann, 2006). In a similar vein, Stefan & Bengtsson (2016) show that firms tend to protect their knowledge assets using formal appropriation mechanisms when collaborating with international partners. Nevertheless, such choices are often complex and costly (Trimble, 2015). In this study, a firm`s strategic focus on operating in international markets was captured using a dummy variable that took value of 1 if the firm had served foreign markets and 0 if the firm had only served the regional or national markets. In terms of market dispersion, 42.7% of the sample firm were only active in the national market, while 57.3% of them were actively engaged in selling products and services internationally.

4.4.2.3. Variables for Multi-Group Analyses

To explore the effects of firm size and the intensity of science-based search, this study followed a different approach based on the multi group analysis. In this study PLS based multi-group analysis was adopted to investigate the impact of two categorical variables on the influence of independent variables towards the dependent variable. The objective of performing multi-group analysis was to confirm that whether the paths between groups were significantly different or not. The presence of significant difference among the different groups (e.g. micro vs.

SMEs and low intensity vs. high intensity science-based search) suggests that each of these less explored factors may or may not have effect on the path strength and direction.

Size: It has long been acknowledged that there are marked differences in the scope and focus of the innovation strategies of smaller and larger firms. Work empirical in nature, such as that of van de Vrande et al. (2009); Lee et al. (2010); Parida, Westerberg & Frishammar (2012); Spithoven, Vanhaverbeke & Roijakkers (2013); Colombo, Croce & Murtinu (2014); Vahter, Love & Roper (2014) have shown that the size of enterprises influences the adoption of open innovation. However, micro enterprises have received scant attention in the open innovation literature. As typically conceived in the open innovation literature, the lack of recourses in micro enterprises to engage in innovation networks, difficulties in building absorptive capacity (Roper & Hewitt-Dundas, 2013), confined appropriability strategies (Spithoven, Vanhaverbeke & Roijakkers, 2013; Eppinger & Vladova, 2013; Laursen & Salter, 2014), lack of multidisciplinary competence bases (Parida, Westerberg & Frishammar, 2012), and having no or limited in-house R&D activities as well as identifiable innovation activities (van de Vrande et al., 2009) are said to be barriers to open innovation. In order to control for the potential effects of firm size, sample was divided into two groups (micro enterprises vs. SMEs) based on the total number of employees. Out of 342 firms, 65.8 percent were micro enterprises; 28.9 percent small enterprises; 5.3 percent medium size enterprises.

Intensity of science-driven open search strategy: Even though the affiliation with scientific and research organisations (e.g. commercial laboratories or R&D enterprises, public research organisations, universities or local academics) have been proven to be a prominent driver of innovativeness and source of knowledge spillover in firms located in science and technology parks, prior research provides ambiguous results on the effects of such collaborations on firms` proprietary, defensive, and leveraging strategies. From a careful reading of the literature on appropriation, two conflicting themes about the possible implications of cooperation with universities are emerged. The first theme that pays more attention to the firms' efforts to develop competitive advantage in collaboration with universities and other research institutes argues that due to the lack incentives and abilities to commercially exploit the co-owned knowledge the risk of universities. On the other hand, other researchers highlight an inherent risk that firms may face when cooperating with universities which is probability of imitation by another competitor working with the same university. To explore the intensity of firms` science-driven search, the importance of interactions with each of the three types of science-based partners: universities and local academics, commercial laboratories or R&D enterprises and universities or local academics, over the last three years (2012 to 2015) was measured on a 7-point Likert scale where 1 denoted `very unimportant` and 7 denoted `very important`. In order to observe the impact of the intensity of science-driven search on hypothesised relationships, a dichotomous variable (1 = low <3.92 and 2 = high > 3.92) was created based on the arithmetic mean (3.92) of the firms` overall scores on each of the three questions. Based on the mean value, firms were divided into two groups: firms with low intensity science-driven (42 percent of firms, n = 2.01) and firms with high intensity science-driven (58 percent of firms, n = 4.84) groups.

4.5. Data analysis and Results

4.5.1. Tests for Potential Biases

To ensure the representativeness of the sample, non-response bias testes were conducted using two groups of early and late responses (Armstrong & Terry, 1977). Details of the Mann–Whditney U tests are presented in Table 4.7. significant differences were found between the two groups.

Table 4.7: Non-response survey bias test: Mann–Whitney U tests

All firms (n=384)	Early respondents (n=178)		Late respondents (n=206)					
Variable	Mean	S.D.	Mean	S.D.	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Formal Appropriation mechanisms	2.91	1.72	2.87	1.72	14145.5	33451.5	-0.182	0.856
Informal Appropriation mechanisms	4.47	1.63	4.42	1.72	14234.5	33540.5	-0.081	0.935
Offsite market-driven open search strategy	4.61	1.24	4.65	1.08	14261	24992	-0.052	0.958
Onsite market-driven open search strategy	3.27	1.56	3.13	1.55	13550	32856	-0.842	0.4
Environmental Dynamism	4.31	1.27	4.50	1.21	13137	23868	-1.296	0.195
Rational Goal Performance	4.69	1.38	4.78	1.41	13411.5	24142.5	-0.995	0.32

As explained in the earlier chapters, data collected using surveys may also suffer from the common method variance (CMV) or bias (CMB). To test ex post for the presence of common method bias, the Harmon's one-factor test (Podsakoff et al., 2003) and the Common Latent Factor (CLF) method (Williams & Anderson, 1994) were adopted. The results of the unrotated principal component analyses showed that no single dominant factor accounted for the majority of the co-variance across all the items (explained variance by the single factor <50%), thus, common method bias was not likely to be a significant issue. (Table 4.8).

Table 4.8: Common method variance or bias test: Harman's one-factor test

		Extraction Sums of Squared Loadings	
Component	Total	% of Variance	Cumulative %
1	8.28	29.58	29.58

In addition, the presence of common method variance was also checked using the common latent factor method (Williams & Anderson, 1994). As presented in Table 4.9, the values obtained from subtracting the standardised weights of the model without CLF from the standardised weights of the model with CLF did not exceed the recommended threshold of 0.2, which was an indication of common-method variance absence (Malhotra, Kim & Patil, 2006).

Table 4.9: Common method variance or bias test: Common latent factor test

Variables	Standardised Regression Weights without CLF	Standardised Regression Weights with CLF	Difference
Other Onsite Enterprises in other Sectors	0.845	0.813	-0.032
Other Onsite Businesses in Your Sector that are not Direct Competitors	0.834	0.798	-0.036
Onsite Competitors	0.836	0.819	-0.017
Onsite Suppliers of Equipment, Materials, Components, or Software	0.772	0.753	-0.019
Onsite Clients or Customers from the Private Sector	0.746	0.775	0.029
Onsite Clients or Customers from the Public Sector	0.703	0.765	0.062
Offsite Suppliers of Equipment, Materials, Components, or Software	0.699	0.694	-0.005
Other Offsite Businesses in Your Sector that are not Direct Competitors	0.801	0.811	0.01
Offsite Competitors	0.655	0.652	-0.003
Offsite Clients or Customers from the Public Sector	0.694	0.698	0.004
Other Offsite Enterprises in other Sectors	0.791	0.802	0.011
Offsite Clients or Customers from the Private Sector	0.59	0.586	-0.004
Product/Service demand is hard to forecast.	0.812	0.812	0
Customer requirement and preferences are hard to forecast.	0.718	0.718	0
Our industry is very stable with very little change resulting from major economic, technological, social, or political forces.	0.876	0.876	0
The set of competitors in my industry has remained relatively constant	0.697	0.699	0.002
Actions of competitors are generally quite easy to predict.	0.62	0.621	0.001
Design registration	0.837	0.839	0.002
Patents	0.74	0.738	-0.002
Trademarks	0.85	0.849	-0.001
Copyright	0.757	0.762	0.005
Market Share	0.848	0.825	-0.023
Turnover Growth	0.945	0.92	-0.025
Profitability	0.872	0.853	-0.019
Complexity of goods or services introduced by your company	0.528	0.51	-0.018
Secrecy (include non-disclosure agreements)	0.782	0.782	0
Lead time advantages	0.687	0.68	-0.007
Sales	0.942	0.922	-0.02

4.5.2. Tests for Normality and Homoscedasticity

Prior to the evaluation of the research model, the critical assumptions of structural equation modelling techniques, including: patterns in terms of normality, homoscedasticity and multicollinearity, were examined. Using a series of Kolmogorov-Smirnov and Shapiro-Wilk (K-S) tests (Shapiro & Wilk, 1965), data was tested for normality. The findings, presented in Table 4.10 revealed that the assumption of normality was violated in all variables.

Table 4.10: Normality Test: Kolmogorov–Smirnov and Shapiro–Wilk tests

Construct	Kolmogorov-Smirnov Test			Shapiro-Wilk Test		
	Statistic	df.	sig.	Statistic	df.	sig.
Formal Appropriation mechanisms	0.15	342.00	0.00	0.90	342.00	0.00
Informal Appropriation mechanisms	0.13	342.00	0.00	0.93	342.00	0.00
Offsite market-driven open search strategy	0.10	342.00	0.00	0.96	342.00	0.00
Onsite market-driven open search strategy	0.13	342.00	0.00	0.94	342.00	0.00
Environmental Dynamism	0.05	342.00	0.05	0.99	342.00	0.01
Rational Goal Performance	0.12	342.00	0.00	0.96	342.00	0.00

However, as explained earlier, there is a general agreement in the literature that both the Kolmogorov-Smirnov and Shapiro-Wilk (K-S) tests are very sensitive to the size of sample (Pallant, 2013). Hence, all variables were subjected to a further set of skewness and kurtosis tests (Pallant, 2007). As shown in Table 4.11, all variables were found to be within the normal range of skewness and kurtosis (<±2.58) (Hair et al., 2009).

Table 4.11: Normality test: Skewness and Kurtosis values

Construct	**n**	**Mean**	**S.D.**	**Skewness**		**Kurtosis**	
				Statistic	***S.E.***	***Statistic***	***S.E.***
Formal Appropriation mechanisms	342	2.89	1.72	0.50	0.13	-0.86	0.26
Informal Appropriation mechanisms	342	4.44	1.68	-0.65	0.13	-0.54	0.26
Offsite market-driven open search strategy	342	4.63	1.15	-0.78	0.13	0.78	0.26
Onsite market-driven open search strategy	342	3.19	1.56	0.06	0.13	-0.98	0.26
Environmental Dynamism	342	4.42	1.24	-0.24	0.13	-0.32	0.26
Rational Goal Performance	342	4.74	1.39	-0.48	0.13	0.03	0.26

Mardia's coefficient was also estimated to check for possible violation of multivariate normality (Table 4.12). The critical ratio value (c.r.= 29.38) was found to be higher than the recommended threshold of 1.96 or less, indicating that the assumption of multivariate normality was not tenable.

Table 4.12: Multivariate Normality test: Mardia's test

Variable	skew	c.r.	kurtosis	c.r.
Sales	-0.53	-4.02	-0.08	-0.31
Lead time advantages	-0.31	-2.32	-1.35	-5.08
Secrecy (include non-disclosure agreements)	-0.45	-3.42	-1.27	-4.81
Complexity of goods or services introduced by your company	-0.86	-6.51	-0.49	-1.85
Profitability	-0.38	-2.83	-0.23	-0.86
Turnover Growth	-0.46	-3.48	-0.15	-0.56
Market Share	-0.38	-2.84	-0.17	-0.63
Copyright	0.45	3.42	-1.19	-4.50
Trademarks	0.44	3.30	-1.21	-4.55
Patents	0.58	4.41	-1.20	-4.53
Design registration	0.86	6.49	-0.54	-2.02
Actions of competitors are generally quite easy to predict.	0.28	2.15	-0.44	-1.66
The set of competitors in my industry has remained relatively constant	-0.02	-0.16	-0.76	-2.88
Our industry is very stable with very little change resulting from major economic, technological, social, or political forces.	-0.56	-4.20	-0.42	-1.58
Customer requirement and preferences are hard to forecast.	-0.08	-0.57	-1.10	-4.17
Product/Service demand is hard to forecast.	-0.58	-4.41	-0.49	-1.83
Offsite Clients or Customers from the Private Sector	-1.05	-7.93	1.29	4.86
Other Offsite Enterprises in other Sectors	-0.66	-5.00	0.06	0.22
Offsite Clients or Customers from the Public Sector	-0.71	-5.32	-0.15	-0.55
Offsite Competitors	-0.72	-5.43	-0.09	-0.35
Other Offsite Businesses in Your Sector that are not Direct Competitors	-0.77	-5.78	0.04	0.17
Offsite Suppliers of Equipment, Materials, Components, or Software	-0.74	-5.62	-0.38	-1.42
Onsite Clients or Customers from the Public Sector	0.30	2.25	-1.17	-4.40
Onsite Clients or Customers from the Private Sector	0.00	-0.02	-1.32	-4.98
Onsite Suppliers of Equipment, Materials, Components, or Software	0.19	1.44	-1.13	-4.26
Onsite Competitors	0.46	3.49	-0.90	-3.40
Other Onsite Businesses in Your Sector that are not Direct Competitors	0.17	1.27	-1.20	-4.52
Other Onsite Enterprises in other Sectors	0.15	1.10	-1.21	-4.57
Multivariate Kurtosis Value (Mardia's coefficient)				**112.81**
Critical Ratio Value				**25.45**

Furthermore, the Levene`s test of homogeneity of variances was used to evaluate homoscedasticity. Table 4.13 shows that all obtained values, except for informal appropriation mechanisms, were higher than the minimum significant level of 0.05 (Field, 2013).

Table 4.13: Homogeneity of variances test: Levene`s test

	Levene Statistic	df1	df2	Sig.
Formal Appropriation mechanisms	1.33	1	340	0.25
Informal Appropriation mechanisms	10.84	1	340	0.001
Offsite market-driven open search strategy	3.02	1	340	0.083
Onsite market-driven open search strategy	2.11	1	340	0.148
Rational Goal Performance	0.18	1	340	0.673
Environmental Dynamism	0.69	1	340	0.408

Finally, data were assessed for presence of multicollinearity (Table 4.14). All VIF values were found to be well below the threshold of 5, suggesting the absence of multicollinearity.

Table 4.14: Collinearity test

	Offsite Market-driven Search Strategy	Onsite Market-driven Search Strategy	Rational Goal Performance
	VIF	*VIF*	*VIF*
Environmental Dynamism	1.048	1.05	---
Formal Appropriation mechanisms	1.16	1.149	1.215
Informal Appropriation mechanisms	1.205	1.196	1.362
Offsite market-driven open search strategy	---	---	1.381
Onsite market-driven open search strategy	---	---	1.283

4.5.3. Statistical Method

In order to test the hypotheses presented in the earlier section, this study employed the partial least squares (PLS) technique. As explained earlier, the partial least squares technique is a regression-based technique which has been widely used in the field of management and business studies in recent years (West et al., 2016; Hung, 2017). The partial least squares technique is a nonparametric approach to the structural equation modelling that provides a flexible means to model latent constructs with multiple indicators, when the conventional assumptions of covariance-based are not tenable. The partial least squares technique was preferred over the co-variance-based techniques because: First, the incremental nature of current study necessitated the development of new structural paths. Second, the research model hypothesised multiple interaction effects (Mitchell, Mitchell & Smith, 2008; Sirén, Kohtamaki & Kuckertz, 2012). Finally, the assumptions of multivariate normality were violated (Chin, 1998).

4.5.3.1. Measurement Model

The results compiled in Table. 4.15, showed a satisfactory level of item-level internal consistency (Churchill, 1979; Chin, 1998; Hair et al., 2017a). Almost all indicators possessed significant factor loadings of greater than 0.7 or very close to the recommended threshold. Cronbach's coefficients (Cronbach, 1951) and composite reliability measures (Fornell & Larcker, 1981) were estimated to check the construct-level reliability of measurement mode. Cronbach's coefficients ranged between 0.70 and 0.94 (>0.7: Cronbach, 1951), and composite reliability measures were also greater than 0.7 (Nunnally & Bernstein, 1994), suggesting the construct-level reliability of measurement model.

Furthermore, as suggested by Nunnally & Bernstein (1994), the average variance extracted (AVE) was calculated for each construct to confirm the convergent validity of measurement model (Table 4.16). all AVEs were higher than the threshold value of 0.5 (Fornell & Larcker, 1981). The statistical results compiled in Table 4.16 suggested that none of the inter-construct correlations was greater than the associated square root of the AVE (Fornell & Larcker, 1981). In addition, as shown in Tabel 4.15, all cross-loadings were less than the inter-construct loadings (Chin, 1998), supporting both the construct-level and item-level discriminant validity of measurement model.

Table 4.15: Internal consistency, construct-level reliability and discriminant validity tests

	Formal Appropriation mechanisms	Informal Appropriation mechanisms	Environmental Dynamism	Offsite Market-driven Search Strategy	Onsite Market-driven Search Strategy	Rational Goal Performance	Cronbach's α	Composite Reliability (ρ_c)	AVE	Fornell-Larcker Criterion
Copyright	0.82	0.28	0.05	0.24	0.16	0.28				
Design registration	0.88	0.29	0.07	0.25	0.13	0.32	0.87	0.91	0.72	0.85
Patents	0.82	0.33	0.09	0.31	0.16	0.30				
Trademarks	0.88	0.36	0.10	0.30	0.13	0.31				
Complexity of goods or services introduced by your company	0.15	0.73	0.16	0.32	0.21	0.31				
Lead time advantages	0.28	0.82	0.23	0.32	0.35	0.29	0.70	0.83	0.63	0.79
Secrecy (include non-disclosure agreements)	0.45	0.82	0.11	0.30	0.29	0.30				
The set of competitors in my industry has remained relatively constant	0.07	0.13	0.79	0.26	0.24	0.08				
Customer requirement and preferences are hard to forecast.	0.09	0.22	0.81	0.29	0.19	0.12				
Product/Service demand is hard to forecast.	0.07	0.15	0.83	0.27	0.14	0.07	0.86	0.90	0.65	0.80
Our industry is very stable with very little change resulting from major economic, technological, social, or political forces.	0.12	0.22	0.88	0.32	0.23	0.09				
Actions of competitors are generally quite easy to predict.	0.01	0.13	0.71	0.22	0.15	0.08				
Offsite Competitors	0.20	0.26	0.24	0.71	0.28	0.21				
Offsite Clients or Customers from the Private Sector	0.15	0.22	0.20	0.67	0.24	0.28				
Offsite Clients or Customers from the Public Sector	0.25	0.34	0.28	0.78	0.29	0.32	0.86	0.89	0.58	0.76
Other Offsite Enterprises in other Sectors	0.25	0.30	0.30	0.81	0.39	0.29				
Other Offsite Businesses in Your Sector that are not Direct Competitors	0.29	0.31	0.27	0.82	0.38	0.29				
Offsite Suppliers of Equipment, Materials, Components, or Software	0.33	0.37	0.26	0.78	0.32	0.35				
Onsite Competitors	0.12	0.27	0.20	0.34	0.86	0.29				
Onsite Clients or Customers from the Private Sector	0.16	0.33	0.15	0.33	0.82	0.41				
Onsite Clients or Customers from the Public Sector	0.13	0.32	0.19	0.34	0.78	0.37	0.91	0.93	0.69	0.83
Other Onsite Businesses in Your Sector that are not Direct Competitors	0.12	0.28	0.24	0.34	0.84	0.26				
Other Onsite Enterprises in other Sectors	0.12	0.29	0.21	0.34	0.85	0.33				
Onsite Suppliers of Equipment, Materials, Components, or Software	0.20	0.30	0.19	0.37	0.81	0.38				
Market Share	0.34	0.37	0.12	0.34	0.33	0.89				
Profitability	0.30	0.33	0.09	0.37	0.38	0.91	0.94	0.96	0.86	0.93
Sales	0.35	0.35	0.13	0.35	0.44	0.95				
Turnover Growth	0.33	0.34	0.08	0.37	0.39	0.95				

Table 4.16: Descriptive statistics, simple correlations and convergent validity tests

	Mean	S.D.	AVE	1	2	3	4	5	6	7	8	9	10
1-Formal Appropriation mechanisms	2.89	1.72	0.72	---									
2-Informal Appropriation mechanisms	4.44	1.68	0.63	0.37	---								
3-Environmental Dynamism	4.42	1.24	0.65	0.09	0.21	---							
4-Offsite market-driven open search strategy	4.63	1.15	0.58	0.33	0.40	0.34	---						
5-Onsite market-driven open search strategy	3.19	1.55	0.69	0.17	0.36	0.24	0.42	---					
6-Rational Goal Performance	4.74	1.39	0.86	0.35	0.37	0.11	0.39	0.42	---				
7-Age$_{(Ln)}$	2.05	0.80	---	0.09	0.03	-0.03	0.06	-0.01	0.15	---			
8- Sector Effect	0.49	0.50	---	0.23	0.24	0.05	0.16	0.10	0.14	0.07	---		
9-Internationalisation	0.71	0.45	---	0.20	0.17	-0.03	0.04	-0.11	-0.01	0.12	0.16	---	
10-Radicalness	0.49	0.50	---	0.36	0.35	0.10	0.29	0.27	0.38	0.15	0.22	0.09	---

4.5.3.2. Structural Model

In this study, a set of criteria, including: R^2 (determination coefficients: Chin, 1998; Hair et al., 2014), f^2 (effect size criterion, as an indicator of changes in determination coefficients: Hair et al., 2017a), Q^2 (cross-validated redundancy measure), q^2 (Stone-Geisser`s criterion for predictive relevance, as an indicator of changes in cross-validated redundancy values: Geisser, 1975; Stone, 1974), GoF (criterion of goodness-of-fit: Tenenhaus et al., 2005), β (path coefficient) and t-value (significance level of the structural path coefficient) were estimated to evaluate the measurement and structural models, and significance of the hypothesised paths (Chin, 1998; Hair et al., 2014; Geisser, 1975; Stone, 1974).

4.5.3.3. Model Fit

As shown in Table 4.17, the estimated determination coefficients (R^2) for rational goal performance, offsite market-driven open search strategy and onsite open market-driven search strategy were 0.296, 0.262 and 0.161, respectively, suggesting a relatively moderate to weak explanatory power (Chin, 1998). On the other hand, Q^2 for all three dependent variables was greater than zero, confirming an acceptable level of predictive relevance. The examination of the goodness-of-fit (GoF) criterion also indicated strong level of robustness (GoF = 0.406) (Hair et al. 2017a). Introducing the control variables into the model slightly increased the model`s goodness-of-fit (0.453).

Table 4.17: Communalities, determination coefficients, cross-validated redundancy measures and goodness-of-fit criterion *(Base Model and model with controls)*

	Communality		***R^2 Value***		***Redundancy***		***Q^2 Value***	
	Model 1	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*
Formal Appropriation mechanisms	0.647	0.724	---	---	---	---	---	---
Informal Appropriation mechanisms	0.724	0.627	---	---	---	---	---	---
Environmental Dynamism	0.627	0.647	---	---	---	---	---	---
Offsite market-driven open search strategy	0.583	0.583	0.262	0.262	0.064	0.064	0.150	0.150
Onsite market-driven open search strategy	0.685	0.685	0.161	0.161	0.036	0.036	0.109	0.109
Rational Goal Performance	0.858	0.858	0.296	0.336	0.089	0.019	0.254	0.279
$Age_{(Ln)}$	---	1.00	---	---	---	---	---	---
Sector Effect	---	1.00	---	---	---	---	---	---
Internationalisation	---	1.00	---	---	---	---	---	---
Radicalness	---	1.00	---	---	---	---	---	---
GoF*	0.406	0.453						

4.5.3.4. Test of Hypotheses

A nonparametric bootstrapping analysis (5000 subsamples; 342 cases; individual sign change) was employed to estimate the standardised path coefficients and their statistical significance. In addition, the explanatory and predictive power (f^2, q^2) for each endogenous variable were estimated using the blindfolding procedure (omission distance G =7) (Götz, Liehr-Gobbers & Krafft, 2010).

4.5.3.4.1. Direct Path Analysis

As shown in Table 4.18, the statistical results indicated that both the intensity of a firm`s offsite market-driven open search strategy (β=0.15, t-value=2.46) and the intensity of its onsite market-driven open search strategy (β=0.27, t-value=5.01) were positively related to its rational goal performance, providing empirical evidence for Hypothesis.1 and Hypothesis.2. The explanatory and predictive power of both the intensity of offsite market-driven open search strategy ($f^2=0.023$, $q^2=0.019$) and the intensity of onsite market-driven open search strategy ($f^2=0.079$, $q^2=0.063$) on rational goal performance were found to relatively weak. Overall, these findings indicated that the higher the intensity of a firm's both onsite and offsite market-driven open search activities, the more likely it becomes for the firm to achieve the expected rational goal outcomes.

Hypotheses 3 and 4 were also supported, by demonstrating that formal appropriation mechanisms (β=0.21, t-value=4.16) and informal appropriation mechanisms (β=0.14, t-value=2.55) were positively related to rational goal performance. Both use of formal appropriation mechanisms ($f^2=0.050$, $q^2=0.041$) and informal appropriation mechanisms ($f^2=0.020$, $q^2=0.018$) showed a relatively weak explanatory and predictive power on rational goal performance. To summarise, these findings denoted that the higher the intensity of use of both formal and informal appropriation mechanisms by a firm engaged in open search activities, the more likely it becomes for the firm to achieve the expected rational goal outcomes.

Hypothesis 5 anticipated a positive association between the intensity of use of formal appropriation mechanisms and the intensity of onsite market-driven search activities. The results, however, revealed a statistically nonsignificant association between them (β=0.04, t-value=0.78). Hypothesis 5 thus was rejected. The explanatory and predictive power values were also very negligible ($f^2=0.002$, $q^2=0.001$). On the other hand, the hypothesised relationship between the intensity of use of formal appropriation mechanisms and the intensity of offsite market-driven search activities was statistically significant (β=0.21, t-value=3.94), providing empirical support for Hypothesis 6. The explanatory and predictive power of formal appropriation mechanisms on offsite market-driven search activites ($f^2=0.050$, $q^2=0.024$) were relatively weak.

The results also supported hypotheses 7 and 8 by demonstrating that the use of informal appropriation mechanisms positively associates with an intense strategic focus on both onsite market-driven (β=0.31, t-value=5.88) and offsite (β=0.26, t-value=5.45) market-driven open search activities. The use of informal appropriation mechanisms showed relatively weak explanatory and predictive power on both offsite market-driven ($f^2=0.079$, $q^2=0.039$) and onsite market-driven search activities ($f^2=0.097$, $q^2=0.061$).

Finally, hypotheses 9 and 10 proposed direct positive effects of environmental dynamism on the intensity of offsite market-driven (β=0.26, t-value=4.40) and onsite market-driven search activities (β=0.17, t-value=2.70), which both were supported. The explanatory and predictive power of environmental dynamism on offsite market-driven ($f^2=0.088$, $q^2=0.044$) and onsite market-driven search activities ($f^2=0.031$, $q^2=0.021$) were both relatively weak. The graphical representations of paths are presented in Fig. 3.10 and 3.11 (Appendix.4)

Finally, four control variables which were deemed to have potential effects on the firms` rational goal performance introduced into the base model. All hypotheses (direct paths) were simultaneously tested, while controlling for: firm age, sector effect, radicalness and internationalisation. As shown in Table 4.18, both age (β=0.11, t-value=2.56) and radicalness (β=0.16, t-value=3.30) significantly and positively were associated with rational goal performance. Two other control variables, sector effect (β=-0.01, t-value=0.19) and internationalisation (β=-0.07, t-value=1.46), exerted no significant impacts on rational goal performance.

Table 4.18: Structural model results *(base model)*

Hypothesis No.	*Path Direction*	*β*		*t-value*		*S.E.*		*Δ R^2*		*Δ Q^2*		*f^2*		*q^2*		*Supported/Not Supported*
		Model 1	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*	
H.1	Onsite -> RG_Prf	0.27***	0.24***	5.01	4.12	0.054	0.057	5.53	0.041	0.05	0.034	0.079	0.062	0.063	0.048	Supported
H.2	Offsite -> RG_Prf	0.15***	0.13**	2.46	2.16	0.061	0.060	1.62	0.012	0.01	0.010	0.023	0.018	0.019	0.013	Supported
H.3	Form_App -> RG_Prf	0.21***	0.17***	4.16	3.40	0.05	0.050	3.52	0.022	0.03	0.017	0.050	0.033	0.041	0.023	Supported
H.4	Inform_App -> RG_Prf	0.14***	0.13***	2.55	2.38	0.056	0.054	1.43	0.011	0.01	0.009	0.020	0.017	0.018	0.012	Supported
H.5	Form_App -> Onsite	0.04	0.04	0.78	0.77	0.054	0.054	0.15	0.002	0.00	0.001	0.002	0.002	0.001	0.001	Not supported
H.6	Form_App -> Offsite	0.21***	0.21***	3.94	3.91	0.052	0.053	3.67	0.037	0.02	0.020	0.050	0.050	0.024	0.024	Supported
H.7	Inform_App -> Onsite	0.31***	0.31***	5.88	5.90	0.053	0.053	8.11	0.081	0.05	0.054	0.097	0.097	0.061	0.061	Supported
H.8	Inform_App -> Offsite	0.26***	0.26***	5.45	5.40	0.045	0.049	5.80	0.058	0.03	0.033	0.079	0.079	0.039	0.039	Supported
H.9	Dy_Env -> Onsite	0.17***	0.17***	2.72	2.71	0.061	0.062	2.60	0.026	0.02	0.019	0.031	0.031	0.021	0.021	Supported
H.10	Dy_Env -> Offsite	0.26***	0.26***	4.39	4.37	0.06	0.060	6.52	0.065	0.04	0.039	0.088	0.088	0.044	0.045	Supported
Control	Age(Ln) -> RG_Prf		0.11***		2.56		0.045		0.013		0.005		0.019		0.007	Significant
Control	Sector Effect -> RG_Prf		-0.01		0.19		0.047		0.000		-0.006		0.000		-0.009	nonsignificant
Control	Internationalisation -> RG_Prf		-0.07		1.46		0.050		0.005		-0.001		0.007		-0.002	nonsignificant
Control	Radicalness -> RG_Prf		0.16***		3.30		0.049		0.020		0.012		0.030		0.016	Significant

Notes: *** $p<0.001$, ** $p<0.001$, * $p<0.05$;

4.5.3.4.2. Moderation Analysis

After examining the direct paths, the next step was to evaluate the significance of moderating effects (Hypotheses 11, 12, 13 and 14). As Henseler & Fassott (2010) argue, the estimation results of moderation analysis become feasible, only after obtaining the precise estimation of the latent constructs' scores within the base mode. After incorporating the moderator (product term) into the model, the path coefficients (β) and their significance (*t-value*), effect size (f^2) and predictive relevance (q^2) for all indirect paths were examined using bootstrapping (subsample: 5000, case:342) and blindfolding procedures (Table 4.19).

As shown in Table 4.19, the moderation model strengthened R^2 for both the offsite market-driven and onsite market-driven search activities from 0.262 (base model) to 0.345, and from 0.161 (base model) to 0.214, respectively. Similarly, it increased the model's Q^2 for both offsite market-driven and onsite market-driven search activities from 0.1495 (base model) to 0.200, and from 0.1085 (base model) to 0.143, respectively. In addition, by introducing the moderation effects into the base model it was revealed that the moderation model also possessed strong robustness (GoF=0.405).

Table 4.19: Communalities, determination coefficients, cross-validated redundancy measures and goodness-of-fit criterion *(Moderation model with controls)*

	Communality		***R^2 Value***		***Redundancy***		***Q^2 Value***	
	Model 1	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*
Formal Appropriation mechanisms	0.724	0.724	---	---	---	---	---	---
Informal Appropriation mechanisms	0.627	0.627	---	---	---	---	---	---
Environmental Dynamism	0.647	0.647	---	---	---	---	---	---
Offsite market-driven open search strategy	0.583	0.583	0.345	0.345	0.058	0.058	0.200	0.200
Onsite market-driven open search strategy	0.685	0.685	0.214	0.214	0.033	0.033	0.143	0.145
Rational Goal Performance	0.858	0.858	0.295	0.336	0.089	0.019	0.254	0.279
Informal Appropriation mechanisms * Environmental Dynamism (onsite)	0.357	0.357	---	---	---	---	---	---
Informal Appropriation mechanisms * Environmental Dynamism (offsite)	0.347	0.347	---	---	---	---	---	---
Formal Appropriation mechanisms * Environmental Dynamism (onsite)	0.352	0.352	---	---	---	---	---	---
Formal Appropriation mechanisms * Environmental Dynamism (offsite)	0.478	0.478	---	---	---	---	---	---
$Age_{(Ln)}$	---	1.00	---	---	---	---	---	---
Sector Effect	---	1.00	---	---	---	---	---	---
Internationalisation	---	1.00	---	---	---	---	---	---
Radicalness	---	1.00	---	---	---	---	---	---
GoF	0.45	**0.46**						

Pertaining to the postulated positive moderation effects of environmental dynamism on the relationship between the intensity of use of informal appropriation mechanisms on the firm`s strategic focus on onsite market-driven and offsite market-driven open search activities, the findings showed significant positive effect of the interaction term (informal appropriation mechanisms x environmental dynamism) on both onsite market-driven open search strategy (β=0.22, t-value=3.65), and offsite market-driven open search strategy (β=0.26, t-value=2.93). Hence, both Hypotheses 11 and 12 were supported (Table 4.19). Entering the interaction term into the model increased the R^2 for both onsite market-driven search and offsite market-driven search strategies by 4.4 and 5.4 percent, respectively. As prior studies ague, even a small lift in variance of 1 percent to 3 percent could be considered important (McClelland & Judd, 1993; Leischnig, Geigenmueller & Lohmann, 2014). Nevertheless, both explanatory and predictive power of interaction term on offsite market-driven ($f^2=0.055$, $q^2=0.032$) and onsite market-driven (f^2=0.083, q^2=0.040) search strategies were relatively weak. These findings also suggested that one standard deviation increase in the level of dynamism increased the impact of the use of informal appropriability strategy on the firm`s onsite market-driven open search strategy by 0.22, and on its offsite market-driven open search strategy by 0.26 percent.

Relying on the conclusions derived from the interpretation of interactions and regression coefficients could be sometimes misleading (Aiken & West, 1991). Hence, all statically significant interactions were also plotted and double-checked. The graphical representations of interactions between the variables are presented in 4.2 and Fig. 4.3. Fig. 4.2 revealed that, as predicted, the association between the use of informal appropriation mechanisms by the firm and its strategic focus on offsite market-driven open search activities was stronger when environmental dynamism was high, and became slightly weaker when environmental dynamism was low. In other words, it appears that the intensity of a firm`s offsite market-driven search activities only becomes elevated when it places more emphases on the use of informal appropriation mechanisms in presence of dynamism. In a similar vein, as Fig. 4.3 showed that the intensity of a firm`s onsite market-driven search activities only get higher when it places more emphases on the use of informal appropriation mechanisms in presence of dynamism. When the level of environmental dynamism is high, an effective appropriability strategy with a greater level of emphasis on the intensive use of informal mechanisms would enhance the firms` perceived usefulness of onsite market-driven open search activities, whereas it leads to a lower level of perceived effectiveness, in comparison, when environmental dynamism is low.

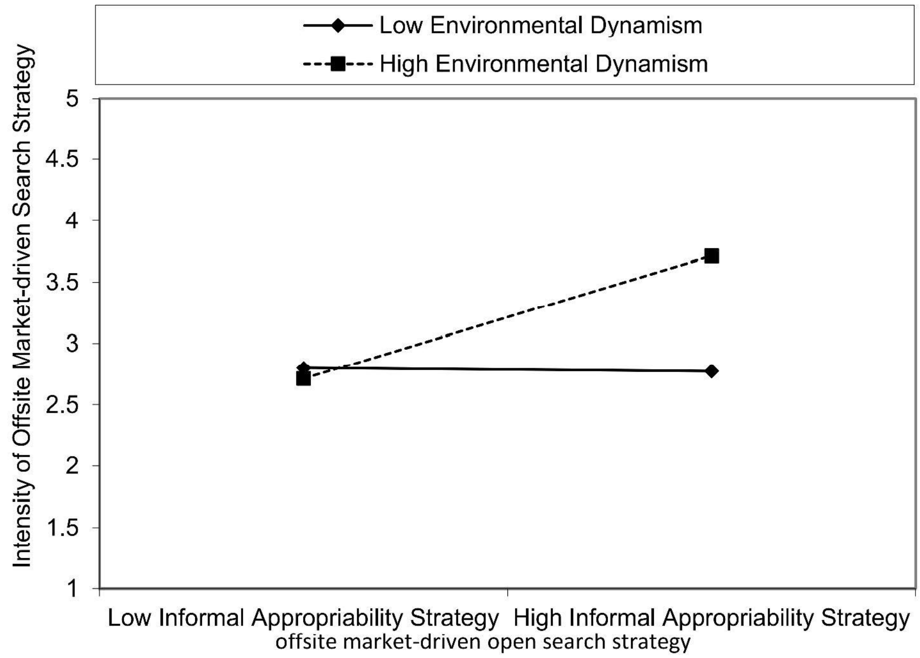


Fig. 4.2: Moderating effect of environmental dynamism on the relation between informal appropriation mechanisms and offsite market-driven open search strategy

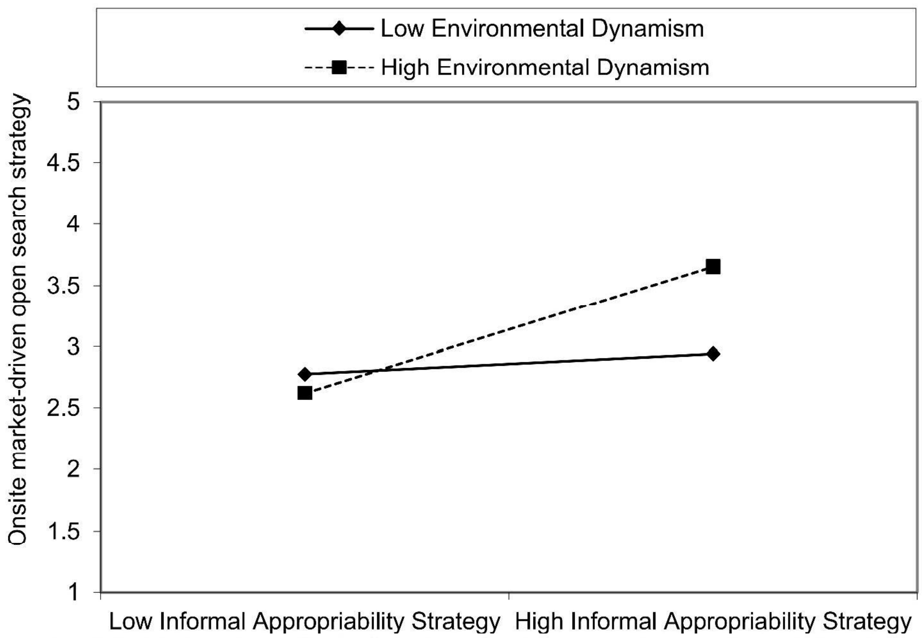


Fig. 4.3: Moderating effect of environmental dynamism on the relation between informal appropriation mechanisms and onsite market-driven open search strategy

The of findings of this study also supported Hypotheses 14, by demonstrating that the environmental dynamism negatively moderated the association between the use of formal appropriation mechanisms by a firm and its strategic focus on onsite market-driven open search activities (β=-0.27, t-value=4.49). The statistical results also showed that introducing the interaction term (formal appropriation mechanisms X environmental dynamism) into the model, R^2 for offsite market-driven open search strategy increased by 6.1%. Nevertheless, the interaction term exerted relatively weak explanatory and predictive power on offsite market-driven open search strategy (f^2=0.094, q^2=0.048). These findings also suggested that one standard deviation increase in environmental dynamism would weaken the impact of the use of formal appropriability strategy by the firm on the intensity of its offsite market-driven open search strategy by -0.272 percent. As presented in Fig. 4.4., it appears that the intensity of a firm`s offsite market-driven open search strategy becomes lower when it places more emphases on the use of formal appropriation mechanisms in presence of dynamism. In contrast, an appropriability strategy centred around the intensive use of formal mechanisms increases the perceived effectiveness of intensive offsite market-driven open search activities only when environmental dynamism is low.

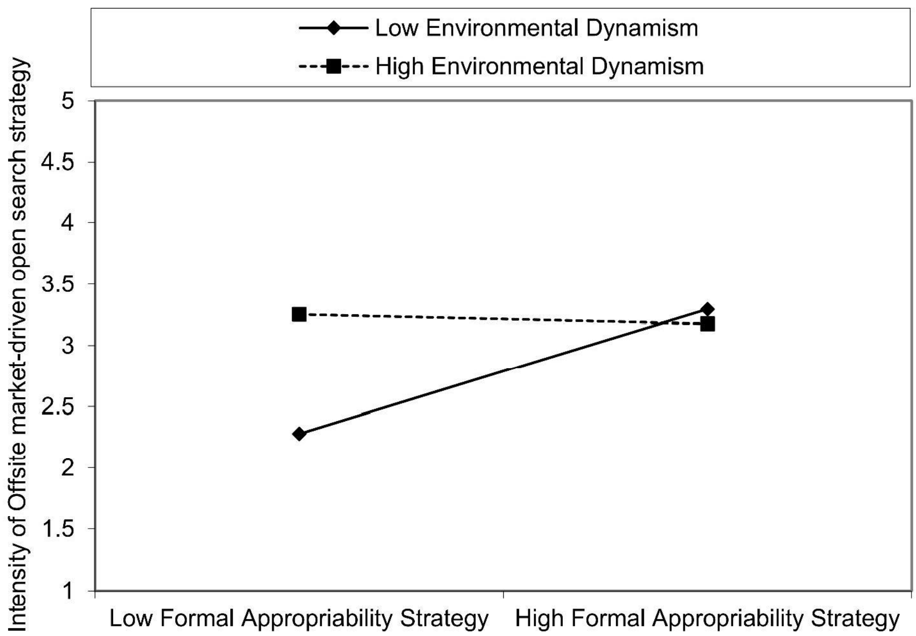


Fig. 4.4: Moderating effect of environmental dynamism on the relation between formal appropriation mechanisms and offsite market-driven open search strategy

The results provided no support for the anticipated negative moderating effect of environmental dynamism on the hypothesised relationship between the use of formal appropriation mechanisms by a firm and its strategic focus on onsite market-driven open search activities (Hypothesis 13). Nevertheless, the statistical results suggested a non-significant, yet negative effect (β=-0.16, t-value=1). While environmental dynamism did not seem to have any statistically significant effects on the relationship between the use of formal appropriation mechanisms and onsite market-driven open search strategy, a closer look at the interaction graph (Fig.4.5) revealed that when the level of environmental dynamism is high, an intensive use of formal appropriation mechanism would weaken the perceived effectiveness of an intensive onsite market-driven open search strategy; in contrast, it increases the perceived effectiveness of an intensive market-driven open search strategy when the level of environmental dynamism is lower. Nonetheless, for a firm that shapes its appropriability strategy based on an excessive use of formal protection mechanisms in presence of high dynamism, the level of perceived effectiveness of an intensive open search strategy centred around the reciprocal exchange of knowledge with co-located co-creation partners is almost the same, as of environment with lower levels of dynamism.

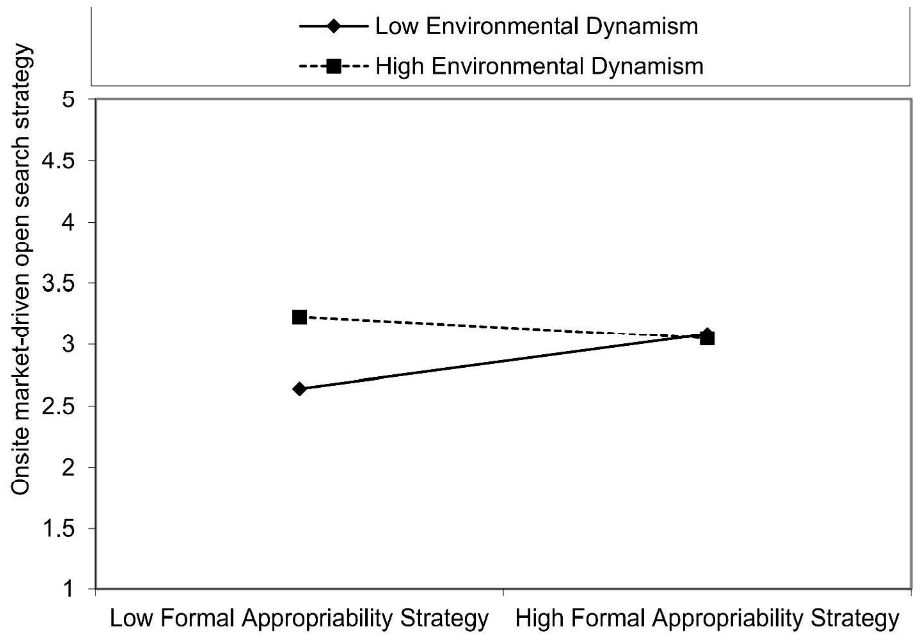


Fig. 4.5: Moderating effect of environmental dynamism on the relation between formal appropriation mechanisms and onsite market-driven open search strategy

All hypotheses were tested while controlling for firm age, sector effect, radicalness and internationalisation both before and after estimating the moderating effects of environmental dynamism. The results are presented in Table 4.20. Both control variables of age (β=0.11, t-value=2.54) and radicalness (β=0.16, t-value=3.26) were found to exert positive and significant effects on the firms' rational goal performance. In contrast, neither sector effect (β=-0.01, t-value=0.19), nor internationalisation (β=-0.07, t-value=1.44) exerted any significant effects on the rational goal performance. The graphical representations of paths are presented in Fig. 4.12 and 4.13 (Appendix.4).

Table 4.20: Structural relations and path significance of basic model (Moderation model and control variables)

Hypothesis No	*Path Direction*	*β* *Model 1*	*Model 2*	*t value* *Model 1*	*Model 2*	*Standard Error* *Model 1*	*Model 2*	*Δ R2* *Model 1*	*Δ R2* *Model 2*	*f^2* *Model 1*	*Model 2*	*q^2* *Model 1*	*Model 2*	*Supported/Not Supported*
Main effects														
H.1.	Onsite market-driven search -> Rational goal performance	0.27^{***}	0.24^{***}	5.07	4.11	0.053	0.058	0.055	0.041	0.078	0.062	0.063	0.048	Supported
H.2.	Offsite market-driven search -> Rational goal performance	0.15^{***}	0.13^{**}	2.43	2.14	0.061	0.060	0.016	0.012	0.023	0.018	0.018	0.013	Supported
H.3.	Formal appropriation mechanisms -> Rational goal performance	0.21^{***}	0.17^{***}	4.16	3.49	0.050	0.049	0.035	0.022	0.050	0.033	0.041	0.023	Supported
H.4.	Informal appropriation mechanisms -> Rational goal performance	0.14^{***}	0.13^{***}	2.53	2.40	0.056	0.054	0.015	0.011	0.021	0.017	0.018	0.012	Supported
H.5.	Formal appropriation mechanisms -> Onsite market-driven search	0.07	0.07	1.27	1.25	0.052	0.053	0.024	-0.122	0.031	-0.155	0.018	0.020	Not supported
H.6.	Formal appropriation mechanisms -> Offsite market-driven search	0.24^{***}	0.24^{***}	4.59	4.54	0.051	0.052	0.120	0.009	0.184	0.014	0.089	0.073	Supported
H.7.	Informal appropriation mechanisms -> Onsite market-driven search	0.30^{***}	0.30^{***}	5.80	5.89	0.051	0.051	0.121	0.121	0.154	0.154	0.092	0.098	Supported
H.8.	Informal appropriation mechanisms -> Offsite market-driven search	0.24^{***}	0.24^{***}	5.58	5.63	0.044	0.043	0.108	0.108	0.165	0.165	0.079	0.079	Supported
H.9.	Environmental dynamism -> Onsite market-driven search	0.14^{***}	0.21^{**}	2.35	2.33	0.059	0.060	0.080	0.080	0.101	0.101	0.063	0.064	Supported
H.10.	Environmental dynamism -> Offsite market-driven search	0.21^{***}	0.14^{***}	3.68	3.63	0.058	0.059	0.149	0.149	0.227	0.227	0.110	0.111	Supported
Moderator effect														
H.11.	Inform_App X Dy_Env -> Onsite market-driven search	0.22^{***}	0.22^{***}	3.65	3.77	0.059	0.058	0.044	0.044	0.055	0.056	0.032	0.038	Supported
H.12.	Inform_App X Dy_Env -> Offsite market-driven search	0.26^{***}	0.26^{***}	2.93	3.07	0.088	0.084	0.054	0.054	0.083	0.083	0.040	0.041	Supported
H.13.	Form_App X Dy_Env -> Onsite market-driven search	-0.16	-0.16	1.00	1.00	0.156	0.155	0.022	0.085	0.028	0.108	0.017	-0.055	Not supported
H.14.	Form_App X Dy_Env -> Offsite market-driven search	-0.27^{***}	-0.27^{***}	4.49	4.55	0.061	0.060	0.061	0.061	0.094	0.094	0.048	0.045	Supported
Control Variables														
C_1	Age(Ln)	---	0.11^{***}	---	2.54	---	0.045	---	0.012	---	0.019	---	0.007	Significant
C_2	Sector Effect	---	-0.01	---	0.19	---	0.047	---	0.000	---	0.000	---	-0.009	nonsignificant
C_3	Internationalisation	---	-0.07	---	1.44	---	0.051	---	0.005	---	0.007	---	-0.002	nonsignificant
C_4	Radicalness	---	0.16^{***}	---	3.26	---	0.050	---	0.020	---	0.030	---	0.016	Significant

Notes: *** p<0.001, ** p<0.001, * p<0.05;

4.5.3.5. Multi-group Analysis

The partial least squares-based multi-group analysis was used to explore the potential impact of firm size and intensity of science-driven open search strategy on the influence of independent variables towards the dependent variable. The sample was divided into two groups according to the variable of interest. A model was estimated for each subsample. Finally, by comparing path coefficients of similar hypothesised relationships across two subgroups, statistically significant differences were detected. signals the departure points between two groups of observations

4.5.3.1.1. Multi-group Analysis: Firm Size

To explore the potential effects of size, the sample was divided into two groups of `micro enterprises` and `small and medium size enterprises`. This study opted to follow the official definitions of SMEs and micro enterprises, provided by the European Commission (European Commission, 2015), OECD (OECD, 2005) and the UK's Companies Act 2006 (Legislation.gov.uk, 2006). 65.8 percent of firms in the sample were micro enterprises (less than 10 employees; n=225) and 34.2 percent SMEs (10 to 250 employees; n=117). Due to the dichotomous nature of the `size` variable, no further refinement or test of differences (F test) were deemed to be necessary.

To ensure the convergent validity (Fornell & Larcker, 1981) of measurement model across two groups, AVEs and square-root of each AVE were estimated. As shown in Table 4.21, all AVEs were above the threshold value of 0.5. Moreover, the square-root of each AVE exceeded the associated inter-construct correlation values, supporting the discriminant validity of measurement model across to groups. The estimated Cronbach`s coefficients and composite reliability measures were also greater than the recommended values of 0.7 (Cronbach, 1951) and 0.8 (Fornell & Larcker, 1981), respectively. This confirmed the internal consistency of measurement model across two groups.

Overall, the estimated determination coefficients (R2) were slightly higher for SMEs, compared to micro enterprises (Table 4.22). Both estimated determination coefficients and predictive relevance measures indicated relatively moderate explanatory and predictive power (Stone, 1974; Geisser, 1975; Chin, 1998). The examination of the goodness-of-fit (GoF) criterion for each group (micro enterprises: GoF=0.40, SMEs: GoF=0.40) also indicated strong robustness.

Table 4.21: Descriptive statistics, simple correlations and convergent validity tests (Group differences: micro enterprises vs. SMEs)

Micro enterprises *(n=225)* ***Constructs***	***Mean***	***S.D.***	***AVE***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
1- Environmental Dynamism	4.30	1.29	0.656	**0.810**									
2- Formal Appropriation mechanisms	2.69	1.64	0.716	0.043	**0.846**								
3- Inform_App * Dy_Env (Onsite)	---	---	0.392	-0.173	-0.002	**0.626**							
4- Inform_App * Dy_Env (Offsite)	---	---	0.427	-0.168	-0.008	0.965	**0.654**						
5- Informal Appropriation mechanisms	4.25	1.69	0.632	0.202	0.329	-0.123	-0.107	**0.795**					
6- Form_App * Dy_Env (Onsite)	---	---	0.385	0.086	-0.083	0.251	0.313	0.013	**0.621**				
7- Form_App * Dy_Env (Offsite)	---	---	0.375	0.107	-0.079	0.222	0.277	0.023	0.983	**0.613**			
8- Offsite market-driven open search strategy	4.53	1.18	0.576	0.319	0.250	-0.262	-0.256	0.381	0.153	0.185	**0.759**		
9- Onsite market-driven open search strategy	3.18	1.57	0.702	0.215	0.183	-0.162	-0.109	0.381	0.198	0.191	0.455	**0.838**	
10- Rational Goal Performance	4.69	1.41	0.867	0.063	0.315	-0.081	-0.057	0.393	-0.013	-0.010	0.377	0.462	**0.931**
SMEs *(n=117)* ***Constructs***	***Mean***	***S.D.***	***AVE***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
1- Environmental Dynamism	4.64	1.11	0.611	**0.782**									
2- Formal Appropriation mechanisms	3.27	1.80	0.725	0.138	**0.852**								
3- Inform_App * Dy_Env (Onsite)	---	---	0.486	0.042	0.018	**0.697**							
4- Inform_App * Dy_Env (Offsite)	---	---	0.525	-0.050	-0.015	0.913	**0.724**						
5- Informal Appropriation mechanisms	4.82	1.61	0.599	0.204	0.405	0.026	-0.028	**0.774**					
6- Form_App * Dy_Env (Onsite)	---	---	0.253	0.040	0.035	0.228	0.248	0.081	**0.502**				
7- Form_App * Dy_Env (Offsite)	---	---	0.231	0.127	0.103	0.239	0.233	0.094	0.903	**0.481**			
8- Offsite market-driven open search strategy	4.82	1.07	0.592	0.377	0.449	-0.143	-0.250	0.390	0.290	0.388	**0.769**		
9- Onsite market-driven open search strategy	3.20	1.54	0.656	0.308	0.162	0.154	0.049	0.346	0.328	0.283	0.346	**0.810**	
10- Rational Goal Performance	4.84	1.37	0.842	0.208	0.424	0.138	0.091	0.343	0.296	0.393	0.402	0.334	**0.918**

Table 4.22: Construct-level reliability, discriminant validity tests, communalities, determination coefficients, cross-validated redundancy measures and goodness-of-fit criterion (Group differences: micro enterprises vs. SMEs)

Micro enterprises *(n=225)*						
Constructs	***Composite Reliability (ρc)***	***Cronbach's α***	***Communality***	***Redundancy***	***R^2***	***Q^2***
Environmental Dynamism	0.905	0.868	0.656	---	---	---
Formal Appropriation mechanisms	0.910	0.867	0.716	---	---	---
Inform_App * Dy_Env (Onsite)	0.926	0.929	0.392	---	---	---
Inform_App * Dy_Env (Offsite)	0.937	0.929	0.427	---	---	---
Informal Appropriation mechanisms	0.837	0.707	0.632	---	---	---
Form_App * Dy_Env (Onsite)	0.902	0.890	0.385	---	---	---
Form_App * Dy_Env (Offsite)	0.898	0.890	0.375	---	---	---
Offsite market-driven open search strategy	0.890	0.852	0.576	0.048	0.313	0.172
Onsite market-driven open search strategy	0.934	0.915	0.702	0.024	0.230	0.161
Rational Goal Performance	0.963	0.949	0.867	0.068	0.311	0.272
GoF	**0.40**					
SMEs *(n=117)*						
Constructs	***Composite Reliability (ρc)***	***Cronbach's α***	***Communality***	***Redundancy***	***R^2***	***Q^2***
Environmental Dynamism	0.886	0.841	0.611	---	---	---
Formal Appropriation mechanisms	0.913	0.874	0.725	---	---	---
Inform_App * Dy_Env (Onsite)	0.950	0.954	0.486	---	---	---
Inform_App * Dy_Env (Offsite)	0.956	0.954	0.525	---	---	---
Informal Appropriation mechanisms	0.817	0.663	0.599	---	---	---
Form_App * Dy_Env (Onsite)	0.726	0.797	0.253	---	---	---
Form_App * Dy_Env (Offsite)	0.564	0.797	0.231	---	---	---
Offsite market-driven open search strategy	0.897	0.862	0.592	0.071	0.520	0.303
Onsite market-driven open search strategy	0.919	0.895	0.656	0.058	0.271	0.172
Rational Goal Performance	0.955	0.937	0.842	0.133	0.285	0.242
GoF	**0.45**					

Table 4.23 shows the estimated path coefficients across two groups. Overall, using the pair-wise parametric t-tests, no statistically significant differences between the structural relations across two groups were observed. In terms of the nature of relationships between the independent, moderating and dependent variables, however, some differences were noted. First, these findings revealed that the environmental dynamism did not exert any significant negative moderating influence on the impact of use of formal appropriation mechanisms by SMEs on their strategic focus on offsite market-driven open search activities (β=0.38, t-value=1.42). Hence, Hypothesis 12 was rejected for SMEs. Similarly, the anticipated association between the intensity of use of informal appropriation mechanisms by SMEs engaged in open search activities and their rational goal performance found to be non-significant (β=0.10, t-value=0.84). The graphical representations of paths are presented in Fig. 4.14 and 4.15 (Appendix.4).

The interaction plot, Fig.4.6, showed that in presence of high dynamism when a micro firm shapes its appropriability strategy based on an excessive use of formal protection mechanisms, the level of perceived effectiveness of an intensive market-driven open search strategy centred around the reciprocal exchange of knowledge with co-located co-creation partners becomes lower. However, contradicting results were found for SMEs. The remaining graphs are presented in Fig.4.7.

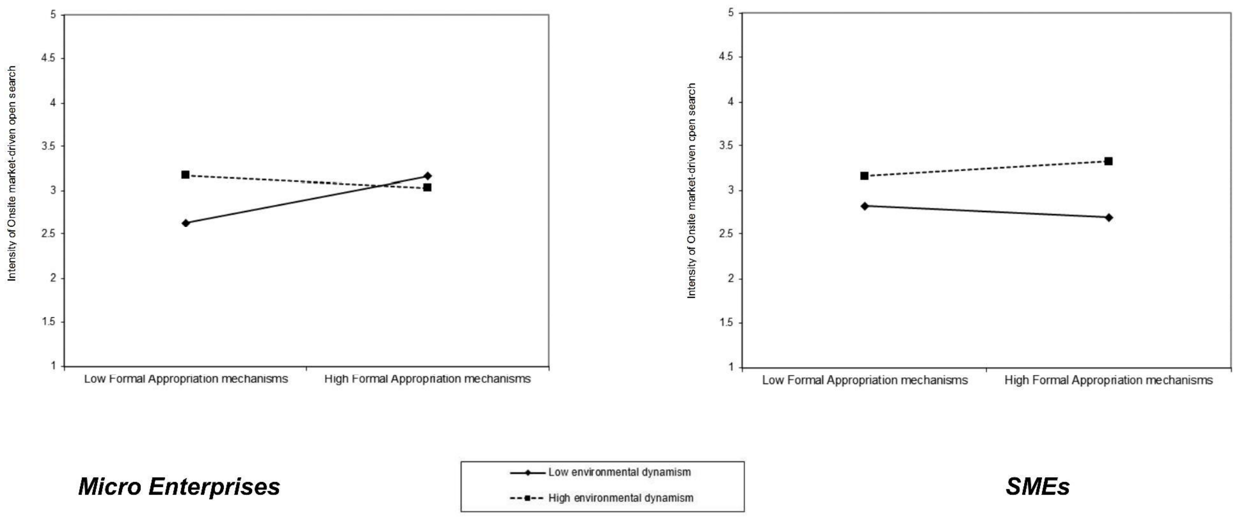


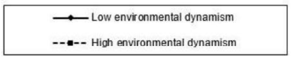
Fig. 4.6: Moderating effect of environmental dynamism on the relation between formal appropriation mechanisms and onsite market-driven open search strategy across micro enterprise and SME group

Table 4.23: Structural model results (Group differences: micro enterprises vs. SMEs)

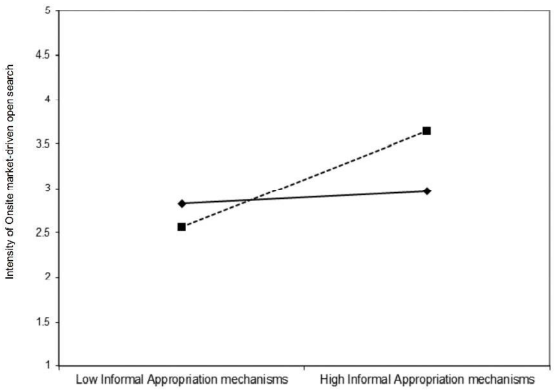
Hypothesis No	*Path Direction*	*Combined dataset (n=342)*		*Micro Enterprises (n=226)*		*SMEs (n=117)*		*Test of difference*		*Results*
		β	*t value*	*β*	*t value*	*β*	*t value*	*t value*	*p-value (2-tailed)*	
Main effects										
H.1.	Onsite market-driven search -> Rational goal performance	0.27^{***}	5.17	0.31^{***}	4.49	0.20^{**}	2.13	0.92	0.36	No significant difference
H.2.	Offsite market-driven search -> Rational goal performance	0.15^{***}	2.40	0.13^{*}	1.69	0.17^{*}	1.79	0.32	0.75	No significant difference
H.3.	Formal appropriation mechanisms -> Rational goal performance	0.21^{***}	4.25	0.17^{***}	2.92	0.28^{***}	3.11	0.97	0.33	No significant difference
H.4.	Informal appropriation mechanisms -> Rational goal performance	0.14^{***}	2.40	0.17^{***}	2.43	0.10	0.84	0.60	0.55	No significant difference
H.5.	Formal appropriation mechanisms -> Onsite market-driven search	0.07	1.33	0.10	1.50	0.01	0.12	0.61	0.54	No significant difference
H.6.	Formal appropriation mechanisms -> Offsite market-driven search	0.24^{***}	4.38	0.18^{***}	2.51	0.30^{***}	4.85	1.01	0.31	No significant difference
H.7.	Informal appropriation mechanisms -> Onsite market-driven search	0.30^{***}	5.92	0.31^{***}	5.06	0.27^{***}	3.06	0.61	0.54	No significant difference
H.8.	Informal appropriation mechanisms -> Offsite market-driven search	0.24^{***}	5.41	0.25^{***}	4.68	0.18^{***}	2.58	0.82	0.41	No significant difference
H.9.	Environmental dynamism -> Onsite market-driven search	0.14^{***}	2.41	0.10	1.39	0.24^{***}	2.45	1.00	0.32	No significant difference
H.10.	Environmental dynamism -> Offsite market-driven search	0.21^{***}	3.93	0.19^{***}	2.53	0.23^{***}	2.46	0.14	0.89	No significant difference
Moderator effect										
H.11.	Inform_App X Dy_Env -> Onsite market-driven search	0.22^{***}	3.57	0.24^{***}	3.29	0.28^{***}	2.05	0.35	0.73	No significant difference
H.12.	Inform_App X Dy_Env -> Offsite market-driven search	0.26^{***}	3.33	0.25^{***}	2.30	0.38	1.42	0.12	0.90	No significant difference
H.13.	Form_App X Dy_Env -> Onsite market-driven search	-0.16	0.99	-0.17	1.32	0.07	0.36	0.88	0.38	No significant difference
H.14.	Form_App X Dy_Env -> Offsite market-driven search	-0.27^{***}	4.71	-0.26^{***}	3.23	-0.32^{***}	2.90	0.13	0.89	No significant difference

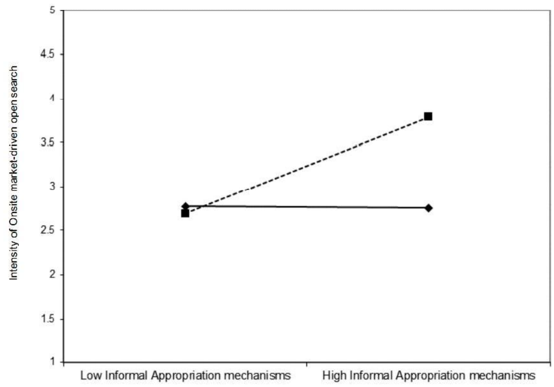
Notes: *** p<0.001, ** p<0.001, * p<0.05;

Micro Enterprises ***SMEs***

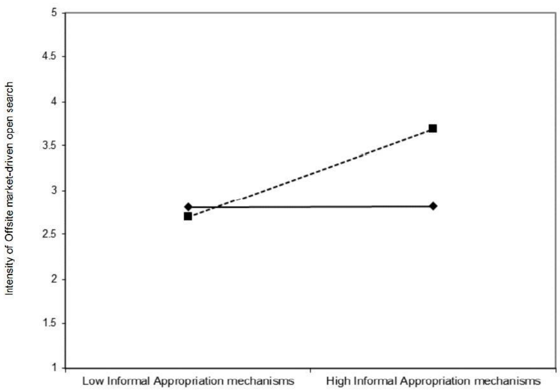


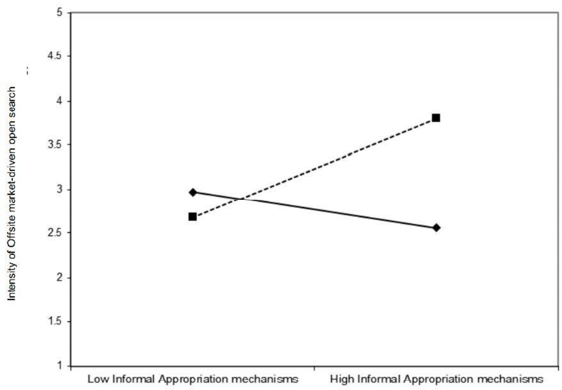
Moderating effect of environmental dynamism on the relation between informal appropriation mechanisms and onsite market-driven open search strategy



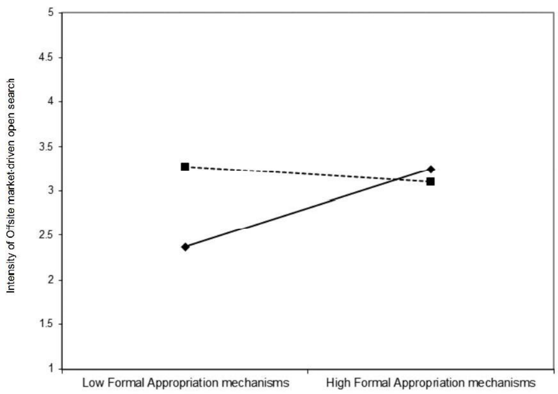


Moderating effect of environmental dynamism on the relation between informal appropriation mechanisms and offsite market-driven open search strategy





Moderating effect of environmental dynamism on the relation between formal appropriation mechanisms and offsite market-driven open search strategy



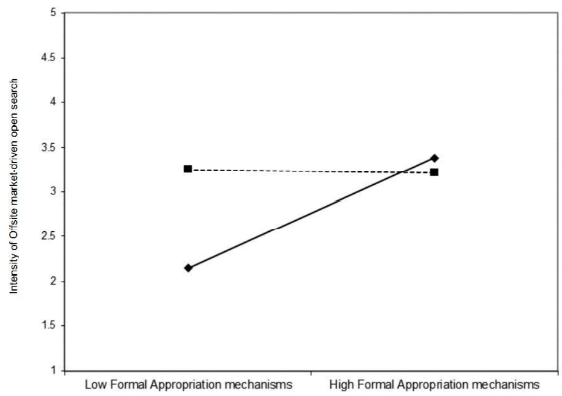


Fig. 4.7: Multigroup analysis: Interactions among formal and informal appropriation strategies, environmental dynamism, and onsite and offsite market-driven search strategies (Service vs. Manufacturing)

4.5.3.1.2. Multi-group Analysis: intensity of science-driven open search strategy

The science-driven open search activities are known to be key in launching innovation (Belderbos et al., 2004; Liefner et al., 2006). However, there is not much evidence about the extent to which on a firm`s strategic focus on science-driven open search activities would impact its other open search activities, proprietary, defensive and leveraging strategies. To explore the potential impacts of science-driven open search activities on the anticipated associations, the sample was divided into subsamples. On the questionnaire, respondents were asked to evaluate the importance of three science and research-based knowledge sources for their innovation activities on a 7-point Likert. Using the mean value, the metric scale was transformed into a dichotomous scale. The overall mean of the aggregated construct was 3.45. The arithmetic mean of the given scores on three questions (weighted importance score) was used to divide the sample: firms with low intensity science-driven open search activities (n=143, mean= 2.35; S.E.: 0.89) and firms with high intensity science-driven open search activities (n=226, mean= 5.06; S.E.: 0.88). The F-test confirmed that two groups were significantly different from each other ($F=782.17$, $p<0.000$).

The statistical results compiled in Table 4.24 confirmed the convergent validity of measurement model across two groups. All estimated AVEs were above the threshold value of 0.5. The square-root of each estimated AVE also exceeded the associated inter-construct correlation values, supporting the discriminant validity of measurement model across to groups. Moreover, all estimated Cronbach`s coefficients and composite reliability measures were above the recommended thresholds of 0.7 (Cronbach, 1951) and 0.8 (Fornell & Larcker, 1981), respectively. Hence, the internal consistency of measurement model across two groups was supported.

The estimated determination coefficients (R^2) were slightly higher for the group with high intensity science-driven open search activities (Table 4.25). Nevertheless, estimated determination coefficients and predictive relevance measures indicated relatively moderate explanatory and predictive power for both groups (Stone, 1974; Geisser, 1975; Chin, 1998). In addition, the examination of the goodness-of-fit (GoF) criterion across both groups (low intensity: GoF=0.39 and hgh intensity: GoF=0.36) resulted in moderate level of robustness.

Table 4.24: Descriptive statistics, simple correlations and convergent validity tests (Group differences: high/low intensity of science-driven open search strategy)

Low intensity *(n=143; Mean= 2.35; S.E.: 0.89)* **Constructs**	***Mean***	***S.D.***	***AVE***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
1- Environmental Dynamism	4.30	1.21	0.655	**0.810**									
2- Formal Appropriation mechanisms	2.35	1.61	0.721	0.076	**0.849**								
3- Inform_App * Dy_Env (Onsite)	---	---	0.417	-0.286	-0.015	**0.645**							
4- Inform_App * Dy_Env (Offsite)	---	---	0.446	-0.305	-0.016	0.936	**0.668**						
5- Informal Appropriation mechanisms	3.87	1.77	0.632	0.190	0.230	-0.146	-0.147	**0.795**					
6- Form_App * Dy_Env (Onsite)	---	---	0.396	0.015	-0.133	0.263	0.262	0.091	**0.629**				
7- Form_App * Dy_Env (Offsite)	---	---	0.397	0.025	-0.135	0.249	0.246	0.094	0.995	**0.630**			
8- Offsite market-driven open search strategy	4.29	1.20	0.558	0.324	0.211	-0.280	-0.323	0.396	0.228	0.236	**0.747**		
9- Onsite market-driven open search strategy	2.52	1.47	0.696	0.254	-0.031	-0.174	-0.108	0.330	0.242	0.232	0.359	**0.835**	
10- Rational Goal Performance	4.20	1.42	0.870	0.162	0.255	-0.087	-0.087	0.293	0.002	-0.005	0.281	0.358	**0.932**
High intensity *(n=199; Mean= 5.06; S.E.: 0.88)* **Constructs**	***Mean***	***S.D.***	***AVE***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
1- Environmental Dynamism	4.51	1.26	0.638	**0.799**									
2- Formal Appropriation mechanisms	3.27	1.69	0.706	0.073	**0.840**								
3- Inform_App * Dy_Env (Onsite)	---	---	0.072	0.083	-0.006	**0.267**							
4- Inform_App * Dy_Env (Offsite)	---	---	0.441	-0.064	0.047	0.081	**0.664**						
5- Informal Appropriation mechanisms	4.85	1.49	0.565	0.212	0.384	0.041	-0.026	**0.752**					
6- Form_App * Dy_Env (Onsite)	---	---	0.276	0.088	0.020	0.199	0.281	-0.020	**0.526**				
7- Form_App * Dy_Env (Offsite)	---	---	0.245	0.141	0.035	0.295	0.255	0.029	0.938	**0.495**			
8- Offsite market-driven open search strategy	4.87	1.04	0.585	0.347	0.334	0.097	-0.205	0.324	0.143	0.213	**0.765**		
9- Onsite market-driven open search strategy	3.67	1.43	0.627	0.206	0.173	0.251	-0.017	0.298	0.262	0.261	0.364	**0.792**	
10- Rational Goal Performance	5.13	1.24	0.824	0.042	0.334	0.167	0.131	0.356	0.175	0.215	0.376	0.324	**0.907**

Table 4.25: Construct-level reliability, discriminant validity tests, communalities, determination coefficients, cross-validated redundancy measures and goodness-of-fit criterion (Group differences: high/low intensity of science-driven open search strategy)

Low intensity *(n=143; Mean= 2.35; S.E.: 0.89)* ***Constructs***	***Composite Reliability (ρc)***	***Cronbach's α***	***Communality***	***Redundancy***	R^2	Q^2
Environmental Dynamism	0.905	0.868	0.655	---	---	---
Formal Appropriation mechanisms	0.912	0.872	0.721	---	---	---
Inform_App * Dy_Env (Onsite)	0.933	0.935	0.417	---	---	---
Inform_App * Dy_Env (Offsite)	0.941	0.935	0.446	---	---	---
Informal Appropriation mechanisms	0.837	0.713	0.632	---	---	---
Form_App * Dy_Env (Onsite)	0.906	0.893	0.396	---	---	---
Form_App * Dy_Env (Offsite)	0.907	0.893	0.397	---	---	---
Offsite market-driven open search strategy	0.882	0.838	0.558	0.044	0.362	0.199
Onsite market-driven open search strategy	0.932	0.912	0.696	0.039	0.219	0.156
Rational Goal Performance	0.964	0.950	0.870	0.055	0.219	0.190
GoF	**0.39**					
High intensity *(n=199; Mean= 5.06; S.E.: 0.88)* ***Constructs***	***Composite Reliability (ρc)***	***Cronbach's α***	***Communality***	***Redundancy***	R^2	Q^2
Environmental Dynamism	0.898	0.859	0.638	---	---	---
Formal Appropriation mechanisms	0.905	0.860	0.706	---	---	---
Inform_App * Dy_Env (Onsite)	0.262	0.935	0.072	---	---	---
Inform_App * Dy_Env (Offsite)	0.940	0.935	0.441	---	---	---
Informal Appropriation mechanisms	0.792	0.637	0.565	---	---	---
Form_App * Dy_Env (Onsite)	0.848	0.815	0.276	---	---	---
Form_App * Dy_Env (Offsite)	0.811	0.815	0.245	---	---	---
Offsite market-driven open search strategy	0.894	0.858	0.585	0.064	0.325	0.188
Onsite market-driven open search strategy	0.910	0.881	0.627	0.022	0.212	0.126
Rational Goal Performance	0.949	0.928	0.824	0.070	0.250	0.211
GoF	**0.36**					

Table 4.26 shows the estimated path coefficients across two groups. Overall, using the pair-wise parametric t-tests, no statistically significant differences between the structural relations across two groups were observed. In terms of the nature of relationships between the independent, moderating and dependent variables, however, some differences were noted. The findings revealed that the anticipated association between the intensity of use of informal appropriation mechanisms by a firm and its rational goal performance was nor significant for the firms with low intensity of science-driven open search activities (β=0.11, t-value=1.30). Similarly, the hypothesised relationships between the use of informal appropriation mechanisms and the intensity of onsite market-driven open search activities was found to be insignificant for both groups (low intensity: β=-0.08, t-value=0.96; high intensity: β=0.07, t-value=1.33). The graphical representations of paths are presented in Fig. 4.16 and 4.17 (Appendix.4).

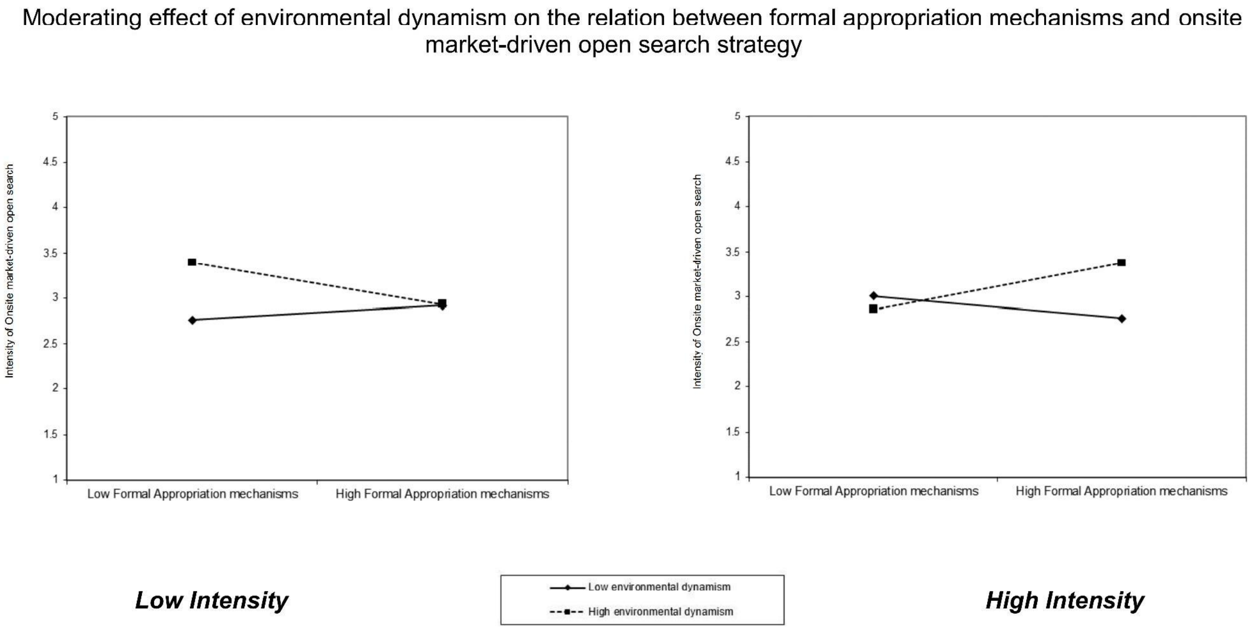


Fig. 4.8: Moderating effect of environmental dynamism on the relation between formal appropriation mechanisms and onsite market-driven open search strategy across low intensity and high intensity groups

The interaction plot, Fig.4.8, showed that in absence of dynamism when a firm with low intensity of science-driven open search activities shapes its appropriability strategy based on an excessive use of formal protection mechanisms, the level of perceived effectiveness of an intensive market-driven open search strategy centred around the reciprocal exchange of knowledge with co-located co-creation partners becomes elevated. However, contradicting results were found for the firms with low intensity of science-driven open search activities. The remaining graphs are presented in Fig.4.9.

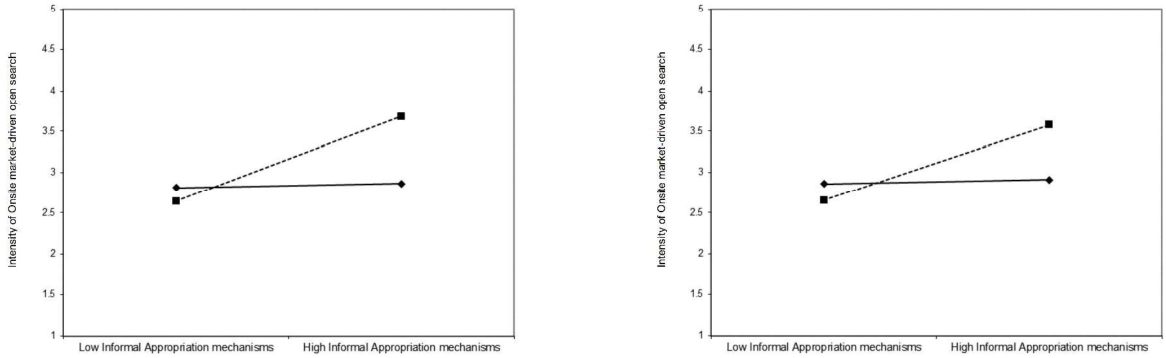
Table 4.26: Structural model results (Group differences: high/low intensity of science-driven open search strategy)

Hypothesis No	Path Direction	*Combined dataset (n=342)*		*Low intensity (n=143)*		*High intensity (n=199)*		*Test of difference*		Results
		β	*t value*	*β*	*t value*	*β*	*t value*	*t value*	*p-value (2-tailed)*	
Main effects										
H.1.	Onsite market-driven search -> Rational goal performance	0.27^{***}	5.17	0.30^{***}	3.40	0.17^{***}	5.17	1.24	0.21	No significant difference
H.2.	Offsite market-driven search -> Rational goal performance	0.15^{***}	2.40	0.08	0.87	0.20^{***}	2.40	0.96	0.34	No significant difference
H.3.	Formal appropriation mechanisms -> Rational goal performance	0.21^{***}	4.25	0.22^{***}	2.93	0.17^{***}	4.25	0.54	0.59	No significant difference
H.4.	Informal appropriation mechanisms -> Rational goal performance	0.14^{***}	2.40	0.11	1.30	0.18^{***}	2.40	0.60	0.55	No significant difference
H.5.	Formal appropriation mechanisms -> Onsite market-driven search	0.07	1.33	-0.08	0.96	0.07	1.33	1.39	0.17	No significant difference
H.6.	Formal appropriation mechanisms -> Offsite market-driven search	0.24^{***}	4.38	0.18^{***}	2.70	0.26^{***}	4.38	0.82	0.41	No significant difference
H.7.	Informal appropriation mechanisms -> Onsite market-driven search	0.30^{***}	5.92	0.27^{***}	3.22	0.24^{***}	5.92	0.11	0.91	No significant difference
H.8.	Informal appropriation mechanisms -> Offsite market-driven search	0.24^{***}	5.41	0.25^{***}	4.25	0.16^{***}	5.41	0.93	0.35	No significant difference
H.9.	Environmental dynamism -> Onsite market-driven search	0.14^{***}	2.41	0.16^{**}	1.96	0.11^{***}	2.41	0.32	0.75	No significant difference
H.10.	Environmental dynamism -> Offsite market-driven search	0.21^{***}	3.93	0.16^{*}	1.87	0.25^{***}	3.93	0.78	0.44	No significant difference
Moderator effect										
H.11.	Inform_App X Dy_Env -> Onsite market-driven search	0.22^{***}	3.57	0.25^{***}	2.39	0.22^{***}	3.57	0.42	0.67	No significant difference
H.12.	Inform_App X Dy_Env -> Offsite market-driven search	0.26^{***}	3.33	0.31^{***}	2.68	0.23^{***}	3.33	0.53	0.60	No significant difference
H.13.	Form_App X Dy_Env -> Onsite market-driven search	-0.16	0.99	-0.15	0.85	0.19	0.99	1.24	0.22	No significant difference
H.14.	Form_App X Dy_Env -> Offsite market-driven search	-0.27^{***}	4.71	-0.31^{***}	4.22	-0.26^{***}	4.71	0.47	0.64	No significant difference

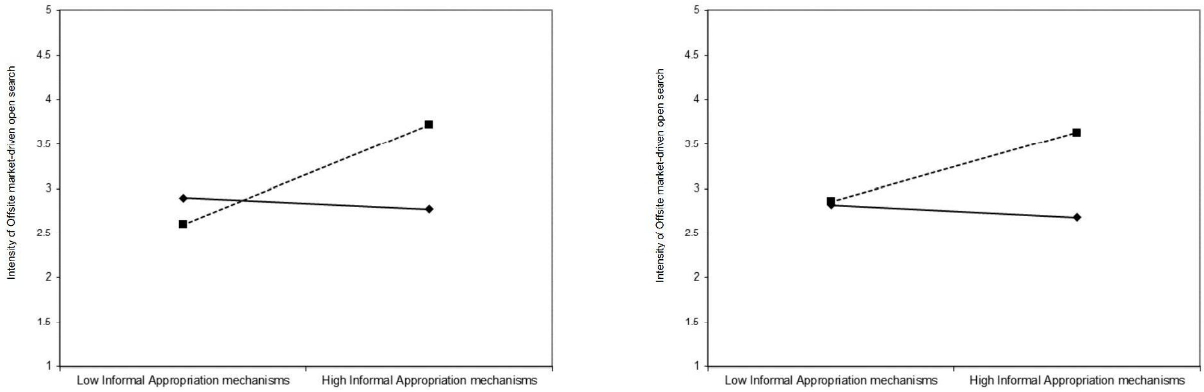
Low intensity science-driven search strategy

High intensity science-driven search strategy

Moderating effect of environmental dynamism on the relation between informal appropriation mechanisms and onsite market-driven open search strategy



Moderating effect of environmental dynamism on the relation between informal appropriation mechanisms and offsite market-driven open search strategy



Moderating effect of environmental dynamism on the relation between formal appropriation mechanisms and offsite market-driven open search strategy

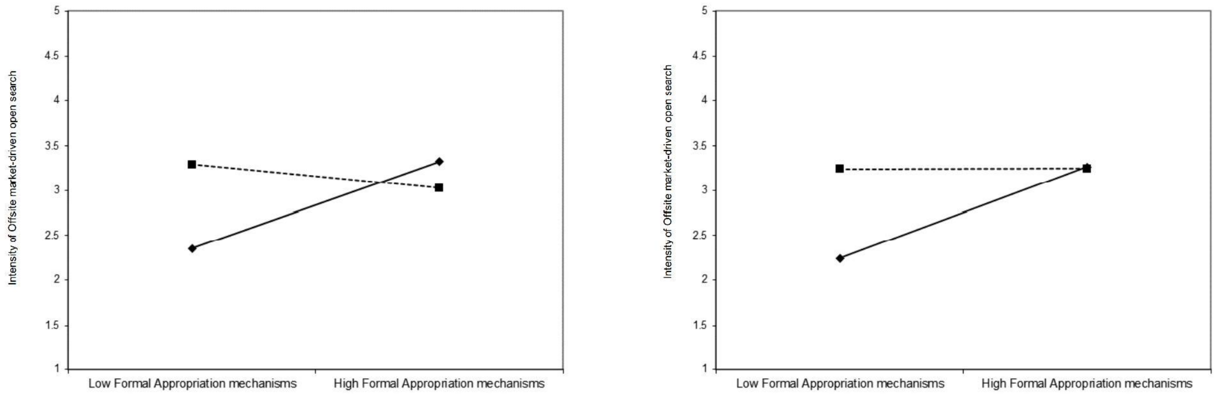


Fig. 4.9: Multigroup analysis: Interactions among formal and informal appropriation strategies, environmental dynamism, and onsite and offsite market-driven search strategies (low vs. high science-driven open search strategy)

4.6. Discussion and Conclusions

Using data collected from 342 firms located in science and technology parks in the United Kingdom, this study attempted to explore the effects of environmental dynamism, use of formal and informal appropriation mechanisms, on offsite and onsite market-driven open search activities, and rational goal performance. In keeping with expectations, both the intensity of onsite market-driven open search activities and the intensity of offsite market-driven search activities were significantly related to the firms` rational goal performance. Moreover, it was revealed that the higher the intensity of use of formal or informal appropriation mechanisms gets, the more likely it becomes for the firm to achieve the expected rational goal outcomes. In addition, the findings supported the anticipated positive associations between the use of informal appropriation mechanisms and the intensity of both onsite and offsite market-driven open search activities in firms. The use of formal appropriation mechanisms was also found to be positively associated with an intense strategic focus on offsite market-driven open search activities. Finally, the results showed that the environmental dynamism is positively associated with an intense strategic focus on both onsite and offsite market-driven open search activities in firms.

Besides, this study also empirically tested a set of hypotheses proposing opposite and positive contingent effects of use of formal and informal appropriation mechanisms on the intensity of onsite and offsite market-driven open search activities, depending on the perceived level of dynamism in the environment. These findings showed that the environmental dynamism positively moderates the impact of use of informal appropriation mechanisms on a firm`s strategic focus on both onsite and offsite market-driven open search activities. Furthermore, the environmental dynamism found to be a negative moderator of the impact of use of formal appropriation mechanisms on a firm`s strategic focus on offsite market-driven open search activities. Overall, these findings reported that, as predicted, when the level of environmental dynamism is high, an effective appropriability strategy with a greater level of emphasis on the intensive use of informal mechanisms would enhance the perceived level of effectiveness of an intensive onsite market-driven open search strategy, as well as offsite market-driven open search strategy. On the other hand, it appeared that the intensity of a firm`s offsite market-driven open search strategy becomes lower when it places more emphases on the use of formal appropriation mechanisms in presence of environmental dynamism. Nevertheless, it seemed that the environmental dynamism, despite the negative sign of the coefficient, does not exert any statistically significant effects on the anticipated relationship between the use of formal appropriation mechanisms and onsite market-driven open search strategy.

After obtaining the results for the hypothesised relationships between the variables, this study is able to address the three key questions posted at the introduction section about the appropriability strategy of firms located in science and technology parks. The first question was: `how does the appropriability strategy of micro and small-and-medium-sized enterprises influence their subsequent rational goal performance, as well as their offsite and onsite market-driven open search activities? `. Regarding the appropriability-openness paradox, the extant literature converges around two conflicting points of view (Arora, Athreye & Huang, 2016). The promoters of `organisational openness` highlight the role of openness as an efficient mechanism for accessing new knowledge and enabling streams of knowledge to flow across organisational boundaries (Allen, 1983; Chesbrough & Bogers, 2014; Laursen & Salter, 2014; Arora, Athreye & Huang, 2016; Stefan & Bengtsson, 2017). They are generally sceptical about the effectiveness of strong formal protection mechanisms in achieving the expected openness outcomes (Chesbrough, 2003b; 2006; West & Gallagher, 2006; von Hippel & Von Krogh, 2006; Baldwin & von Hippel, 2011). On the other hand, the promoters of spillover prevention mechanisms believe that the use of formal appropriation mechanisms can protect the firms` valuable knowledge and reduce the chances of unintended knowledge spillovers in reciprocal interactions with co-creation partners (Cassiman & Veugelers, 2002; Hagedoorn & Zobel, 2015). Nevertheless, there is no consistent evidence that whether the co-located firms, compared to their non-geographically proximate rivals, rely more on formal appropriation mechanisms or on informal appropriation mechanisms in their open search activities, this study found that the use of informal and formal appropriation mechanisms could have differing consequences depending on whether a firm`s strategic focus is directed towards its potential offsite or onsite market-based co-creation partners. Firms located in science and technology parks tend to invest in both offsite and onsite market driven-open search activities. In Chapter Two, it was revealed that the reciprocal open search activities with onsite market-based co-creation partners have no statistically significant impacts on the firms` open system performance. In this chapter, however, it was found that both offsite and onsite market-driven open search activities exert positive and significant influences on the rational goal performance.

The second part of the question considered was about the potential effects of different appropriation mechanisms on the intensity of firms' strategic focus on market-driven open search activities, when taking into account the location of market-based co-creation partners; specifically, the potential strengthening or weakening influence of different appropriation methods on cooperation and coopetition for innovation. Geographical proximity is known to be the key driver of cognitive proximity between co-located firms (Boschma, 2005). Prior studies show that cognitive and social proximities between the co-located firms would naturally promote interactions between them (Ben Letaifa & Rabeau, 2013). The higher degree of cognitive proximity increases both social and organisational proximities between the co-located firms, thus, decreases knowledge distance (Storper, 1999; Ben Letaifa & Rabeau, 2013). These positive effects would stimulate collaborations between the co-located firms, leading to formation of an atmosphere supportive of openness. The ecosystem of science and technology parks plays a key role in facilitating the knowledge spillovers among co-located firms (Vásquez-Urriago, Barge-Gil & Modrego Rico, 2016), by providing them with an access to further exploratory learning opportunities, which sets the foundations for their open search activities (Khavandkar & khavandkar, 2015). Nevertheless, the paradox of appropriability-openness relationship presents a challenge for shaping open search strategy in firms. On the one hand, distinct types of appropriation mechanisms offer varying levels of protection in different circumstances (Pavitt, 1984), on the other hand, the nodding relationship between a firm`s appropriability strategy and the intensity of its open search activities could limit its openness (Laursen and Salter, 2014).

It is evident from the results that an effective appropriability strategy with a greater level of emphasis on the intensive use of informal mechanisms could increase the perceived level of effectiveness of intensive onsite and offsite market-driven open search activities in firms. Moreover, the level of perceived effectiveness of an intensive open search strategy centred around the reciprocal exchange of knowledge with offsite market-driven co-creation partners also increases when the appropriability strategy is shaped based on an excessive use of formal protection mechanisms. Yet, the intensity of use of formal appropriation mechanisms does not seem to exert any meaningful influences on the open search activities centred around reciprocal exchanges with onsite market-based co-creation partners. These findings, once again, reflect the complexity of relationship between appropriability and openness, or how a firm tries to appropriate rents from its innovations, and how open it can be in its reciprocal open search activities with co-creation partners (Laursen & Salter, 2014; Arora, Athreye & Huang, 2016)

The second question was about the extent to which tenant firms have been able to adjust and balance their market-driven search strategies in response to dynamism in the environment, in particular taking into account the location of their co-creation market-based partners. Prior studies show that firms tend to increase the depth of their overall search strategies to combat the uncertainty brought by environmental dynamism (Dutton, Fahey & Narayanan, 1983; Daft & Weick, 1984; Cruz-González et al., 2015). Nevertheless, there was scant evidence in the literature about how environmental dynamism could influence the intensity of market-driven open search strategy, taking into account the location of potential partners. The results of this study showed that environmental dynamism positively associates with an intense strategic focus on both onsite and offsite market-driven open search activities. Faced with environmental dynamism, firms tend to emphasise more on intensive reciprocal open search activities with both onsite and offsite market-based partners, to offset uncertainty and unpredictability regarding new innovations by using outside ideas, and vice versa. These findings suggest that geographical proximity, specifically in case of homogenous clusters, helps to reduce potential institutional barriers between the co-located firms. As it is easier for the firms to screen and source complementary knowledge in science and technology parks, they are more likely to engage in open search activities. In other words, spatial and cognitive proximities between the co-located firms in science and technology parks influence the propensity of co-located firms in science and technology parks, to engage in open search activities. The patterns of search strategy among co-located firms indicate that there are no differences between the determinants of 'search intensity' of their reciprocal interactions with onsite and offsite market-based partners, when faced with environmental dynamism.

The third question considered was about whether environmental dynamism exerts any positive or negative influences on the anticipated associations between the use of formal and informal appropriation mechanisms by a firm and its strategic focus on onsite and offsite market-driven open search activities. First of all, the findings of this study showed that the higher the intensity of a firm's onsite and offsite market-driven open search strategy gets, the more likely it becomes for the firm to achieve the expected rational goal outcomes, which were consistent with the extant literature (Allen, 1983; Chesbrough & Bogers, 2014; Laursen & Salter, 2014; Arora, Athreye & Huang, 2016; Stefan & Bengtsson, 2017). Moreover, the results indicated that the use of informal appropriation mechanisms is positively associated with an intense strategic focus on both onsite market-driven and offsite market-driven open search activities in firms. However, only the positive association between the use of formal appropriation mechanisms by a firm and its intensified strategic focus on offsite market-driven open search activities found to be significant. Yet despite the anticipation of a positive association between the use of formal appropriation mechanisms and the intensity of onsite market-driven open search activities in firms, this association was not significant.

As evident from the literature, casual knowledge ambiguity increases in presence of environmental dynamism (Lippman & Rumelt, 1982; Reed & Defillippi, 1990). Casual knowledge ambiguity heightens rivals` scepticism about what to imitate and how to imitate (Alvarez & Busenitz, 2007). From the theoretical point of view, the more uncertain an environment gets, the easier it becomes to protect knowledge from opportunistic behaviours, which may help firms to achieve superior performance in the short-run (Dess & Beard, 1984; Jaworski & Kohli, 1993). On the other hand, the more uncertain an environment gets, it becomes harder for the firm to transfer and acquire external knowledge, which may lead to organisational inertia (Leonard-Barton, 1992). This paradox highlights the question posed at the beginning of the chapter.

The findings of this study confirmed that the relationships between the use of formal and informal appropriation mechanisms and the intensity of onsite and offsite market-driven open search activities are contingent on the level of environmental dynamism. However, the use of informal appropriation mechanisms seems to be more pro openness, than the formal appropriation mechanisms. As explained earlier, environmental dynamism was found to positively moderate the impact of use of informal appropriation mechanisms on a firm`s strategic focus on both offsite and onsite market-driven open search activities. In other words, when the level of environmental dynamism is high, an effective appropriability strategy with a greater level of emphasis on the intensive use of informal mechanisms would enhance the firms` perceived usefulness of both offsite and onsite market-driven open search activities, and vice versa. In contrast, the intensity of a firm`s offsite market-driven open search strategy becomes lower when it places more emphases on the use of formal appropriation mechanisms in presence of environmental dynamism. These findings showed that firms, faced with environmental dynamism, are less likely to invest in intensive reciprocal interactions with offsite market-based partners when they intensively use formal appropriation mechanisms to protect their intellectual property. While the magnitude of the anticipated relation was also negative (reversing) for the onsite market-driven open search activities, yet it was not statistically significant. The pattern was tested using two subsamples of the firms with an intensive strategic focus on science-driven interactions, and the firms with less intensive strategic focus on science-driven interactions. The results indicated that the firms with an intensive strategic focus on science-driven open search activities are more active in reciprocal interactions with onsite market-based partners rather than the other group. Nevertheless, the differences between them were not significant. As evident from the literature, the higher the intensity of science-driven interactions gets, it become more likely for the firms to register patents (Schwartz et al., 2012; Hohberger, Almeida & Parada, 2015). The knowledge generated through interactions with universities and other research organisations is codified, thus inherently leaky. The science-based actors, such as universities and research organisations, normally have multiple partners. If firms which are engaged in reciprocal interactions with science-based partners do not -jointly with their partners or individually- protect codified knowledge using the legal appropriation mechanisms, other partners of the same science-based actor may get access to it. Overall, it seems that the higher the intensity of use of informal appropriation mechanisms gets, the chances of reciprocal market-driven open search activities increase. Firms faced with environmental dynamism rely on informal appropriation mechanisms to attenuate the danger of `lock-in effects` (Camagni, 1991).

Nevertheless, as Brouwer and Kleinknecht (1996) argues firms tend to engage in open search activities only if they find themselves in `core rigidity` (Leonard-Barton, 1992). For smaller firms, open search activities play a key role in overcoming the liability of smallness (Gassmann, Enkel & Chesbrough, 2010). However, the results of this research showed that there were no statistically significant differences between SMEs and micro enterprises. The prevalence of market-driven open search activities and use of both informal and formal appropriation mechanisms among the tenant firms of all sizes, suggests that size does not matter. Taken together, these findings suggest that there are marked differences in the type of market-driven open search activities of firms located in science and technology parks, which appear to be linked to the intensity of use of different appropriation mechanisms.

Appendix.4

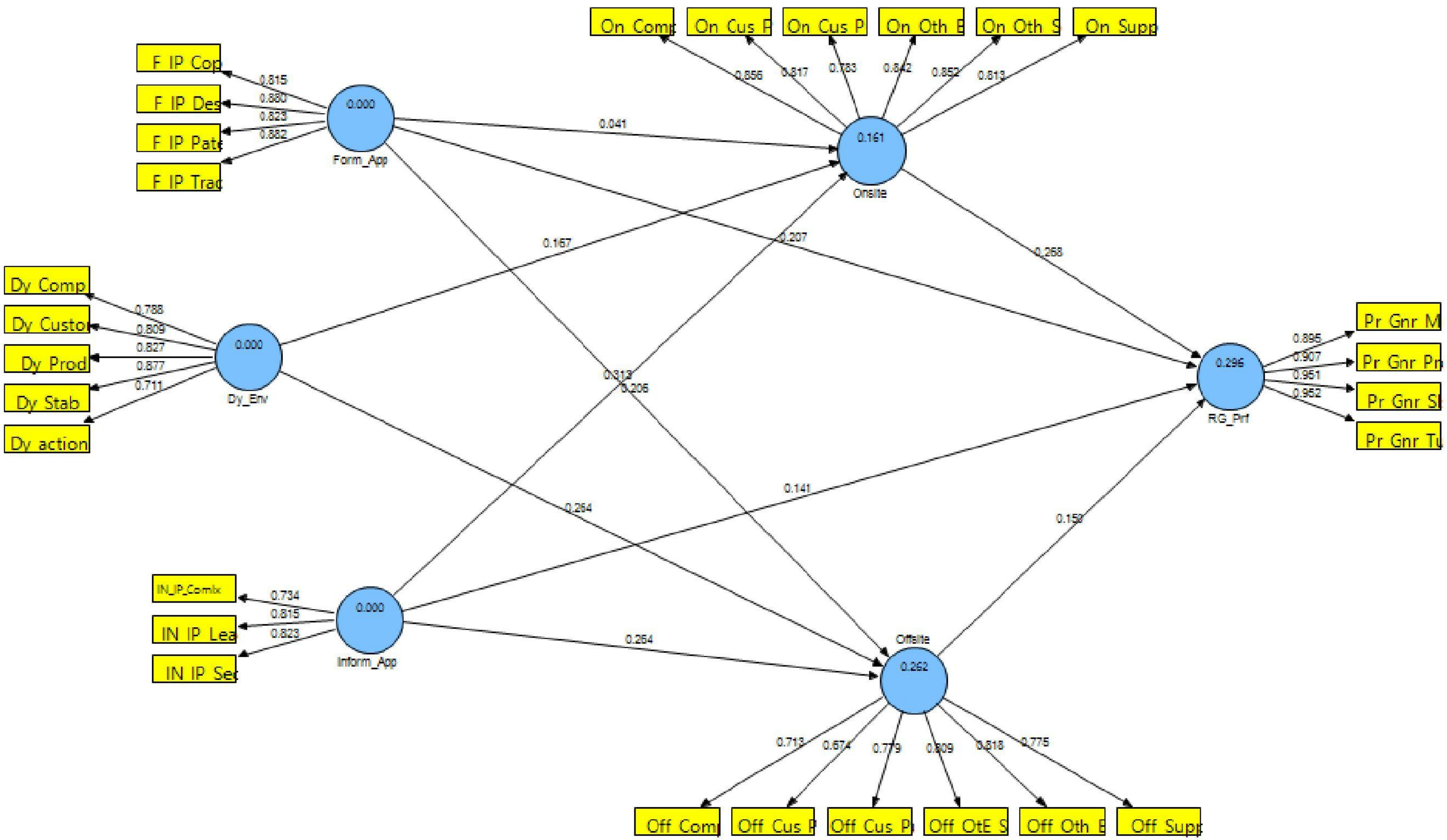


Fig. 4.10: Structural model results (base model: entire sample – path diagram)

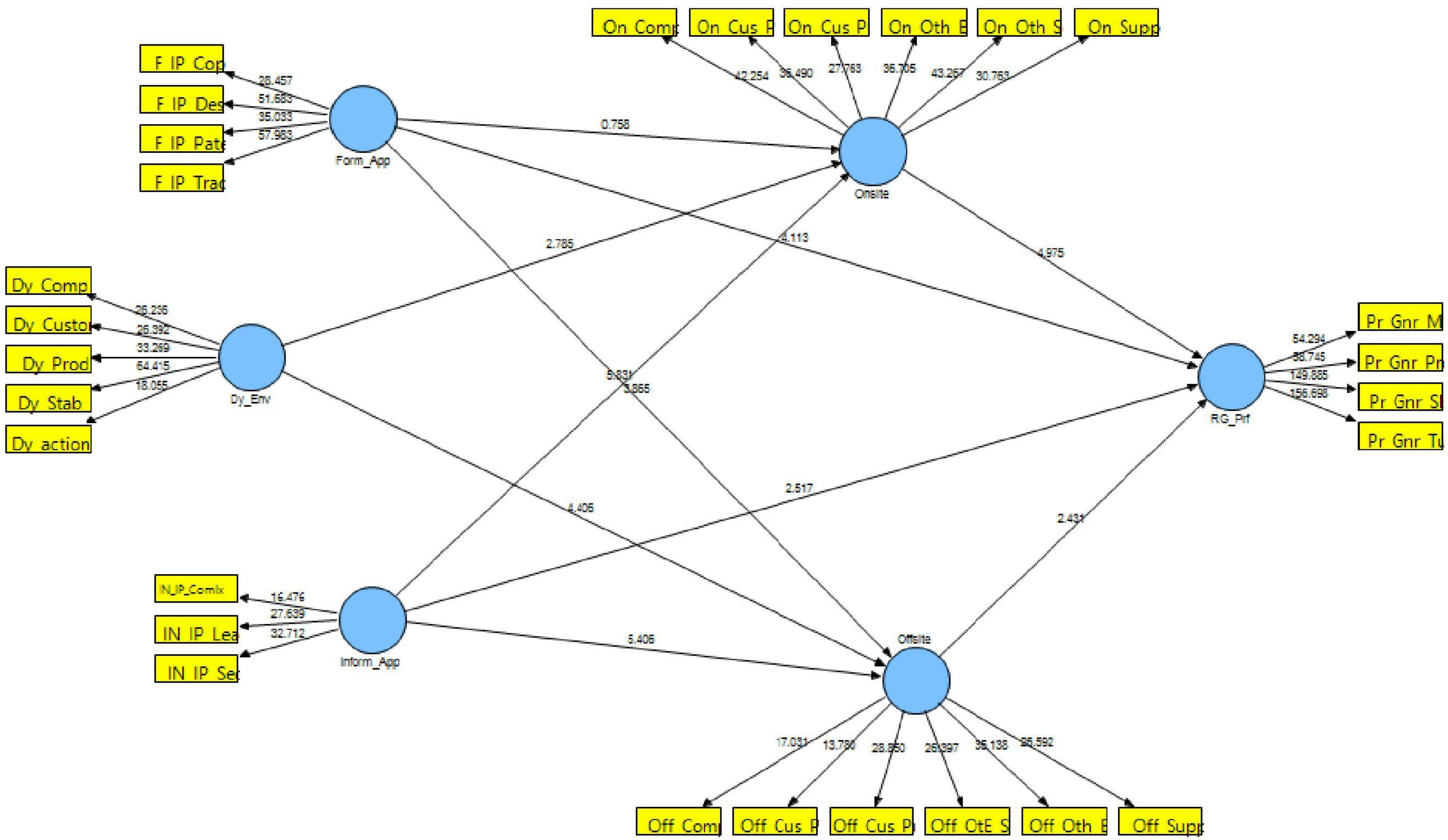


Fig. 4.11: Structural model results (base model: entire sample – bootstrapping results - t-values)

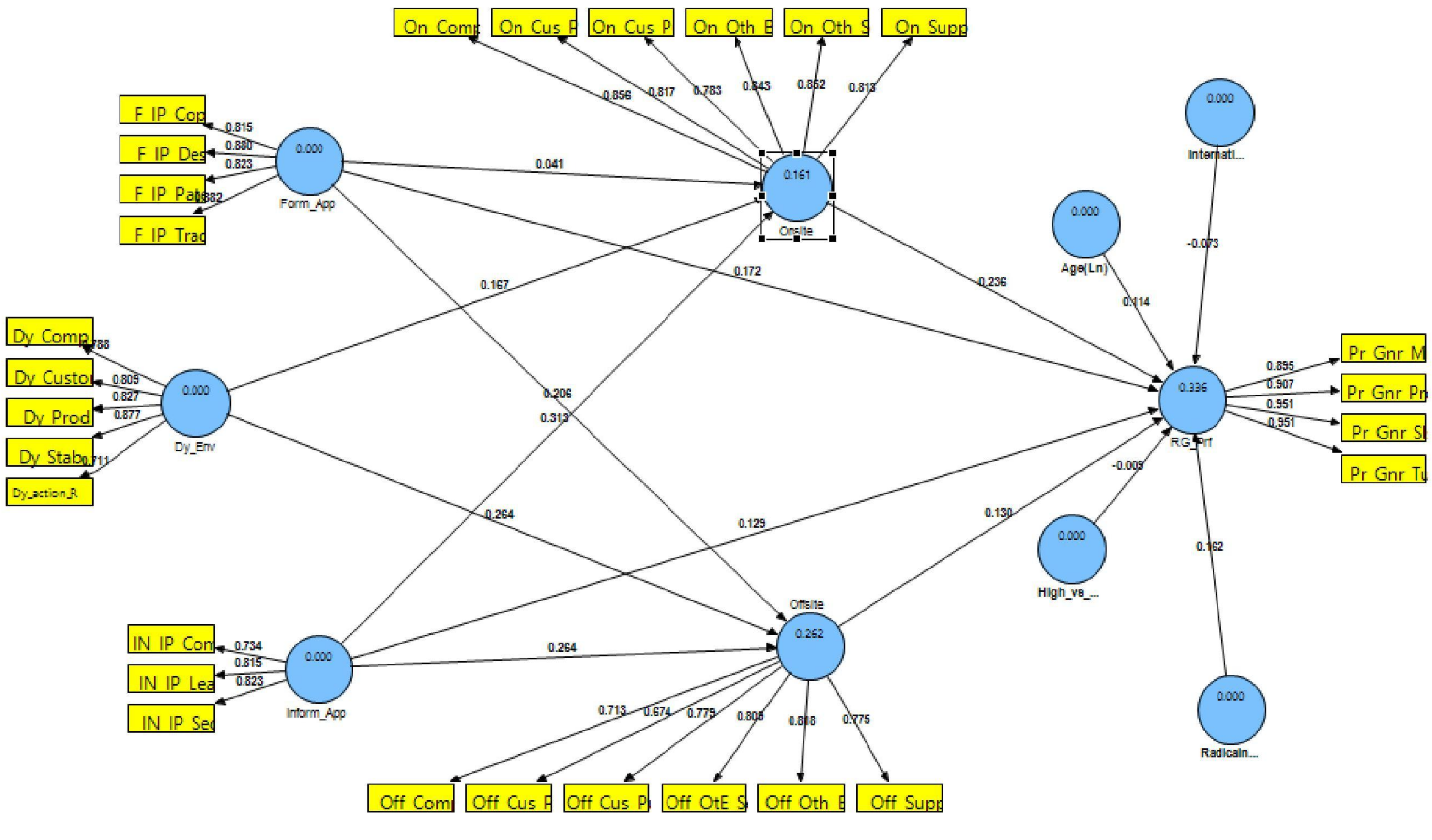


Fig. 4.12: Structural model results (base model with controls: entire sample – path diagram)

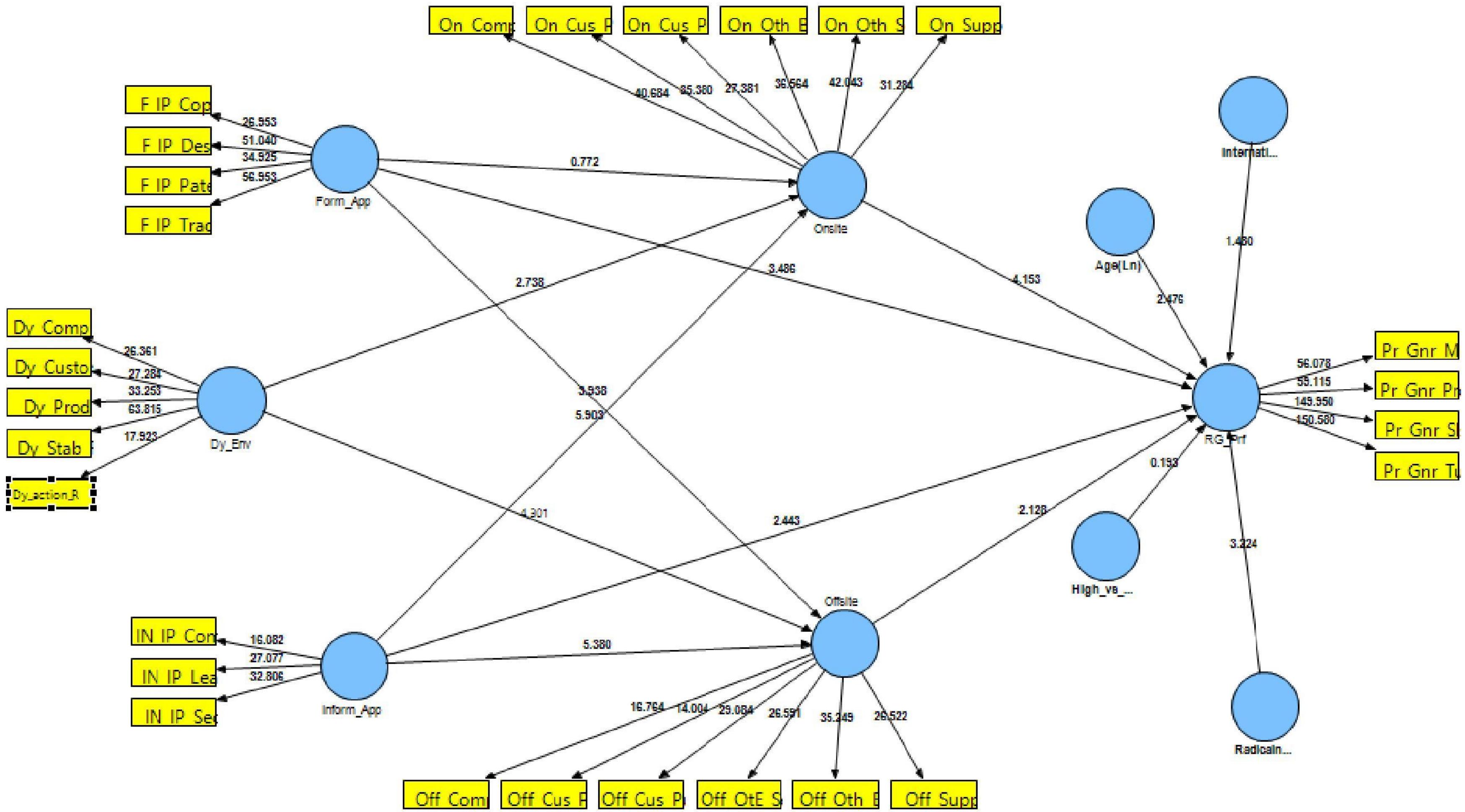


Fig. 4.13: Structural model results (base model with controls: entire sample – bootstrapping results - t-values)

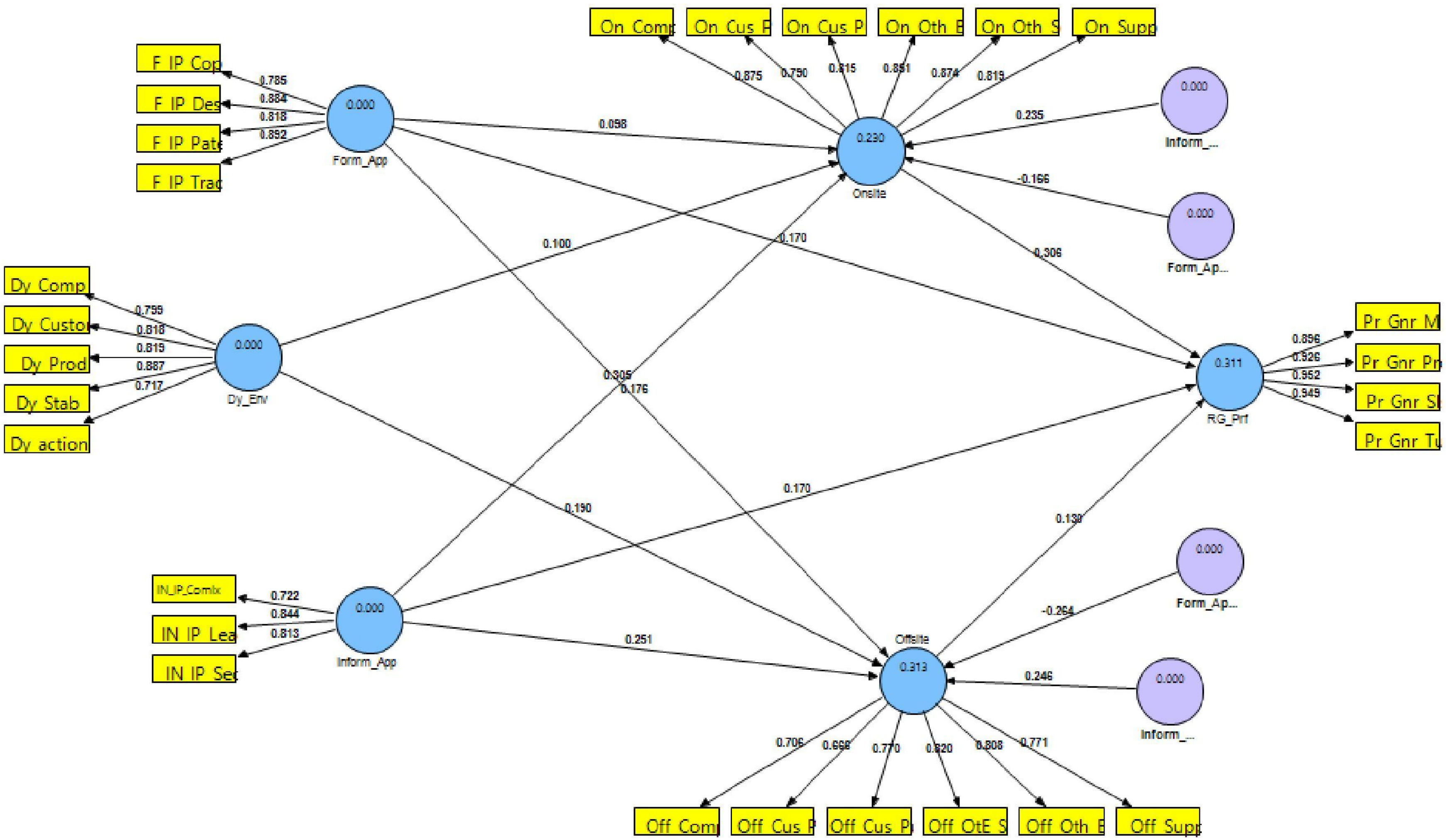


Fig. 4.14: Structural model results (Group differences: micro enterprises sample – path diagram)

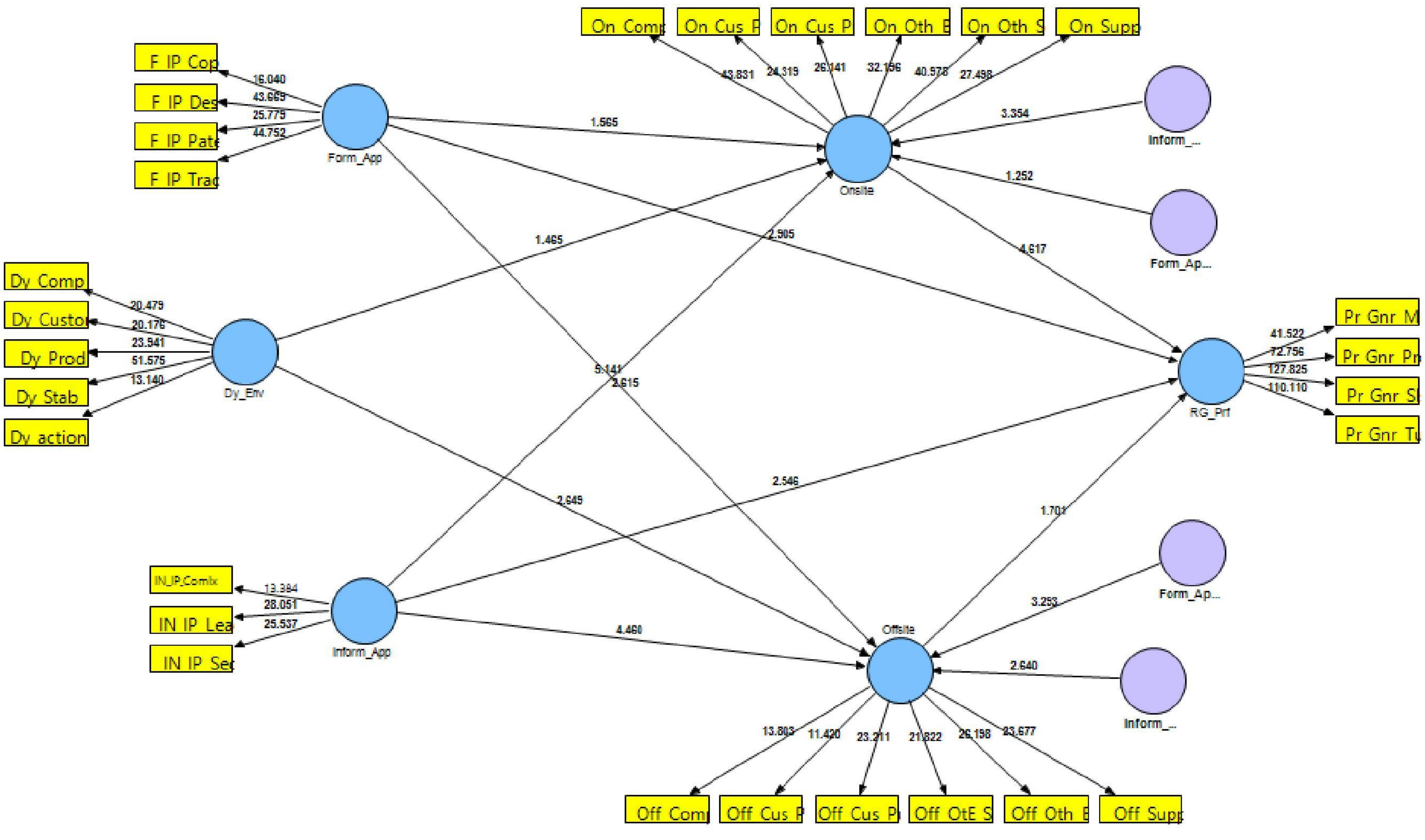


Fig. 4.15: Structural model results (Group differences: micro enterprises –bootstrapping results - t-values)

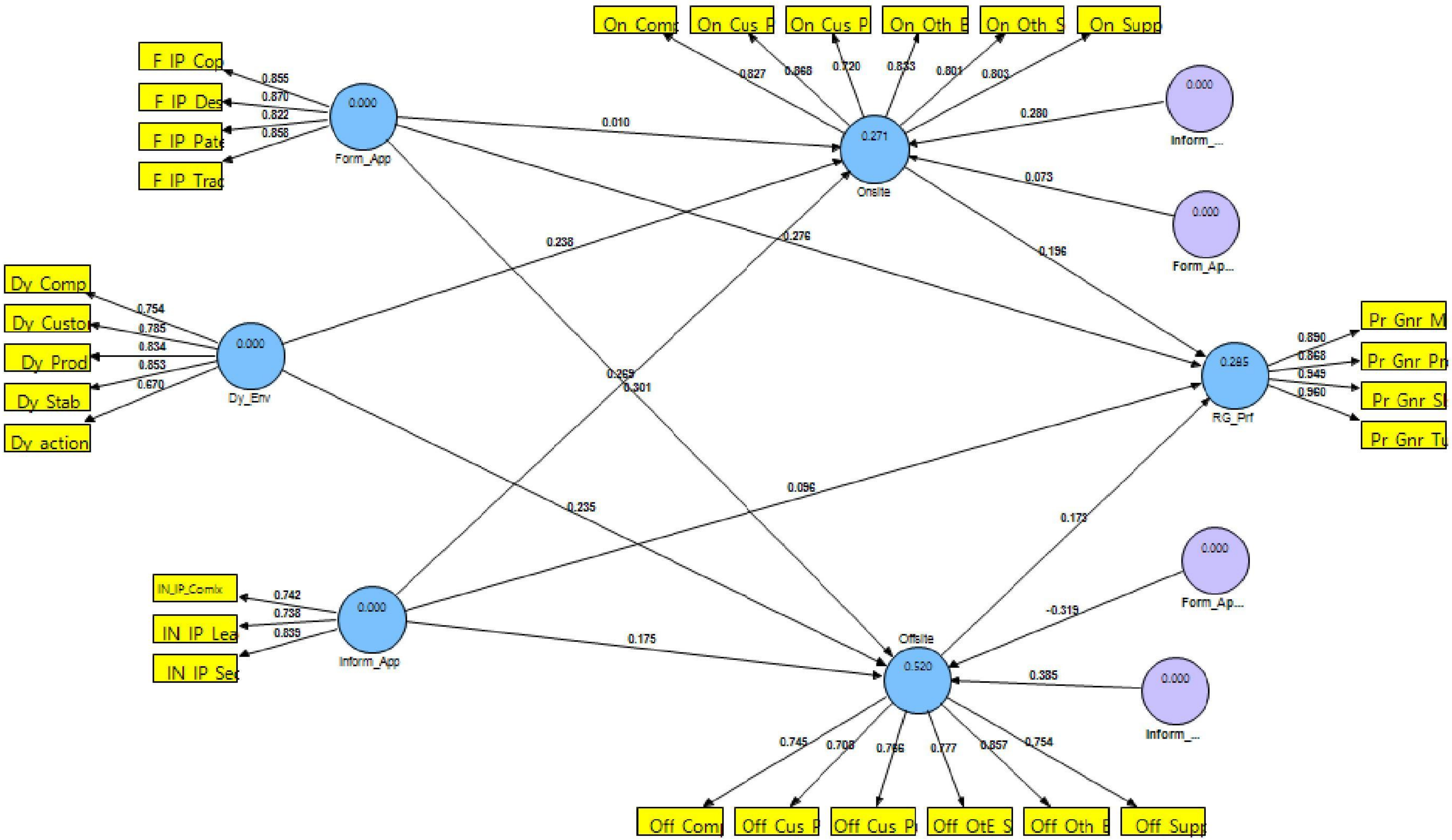


Fig. 4.16: Structural model results (Group differences: SMEs sample – path diagram)

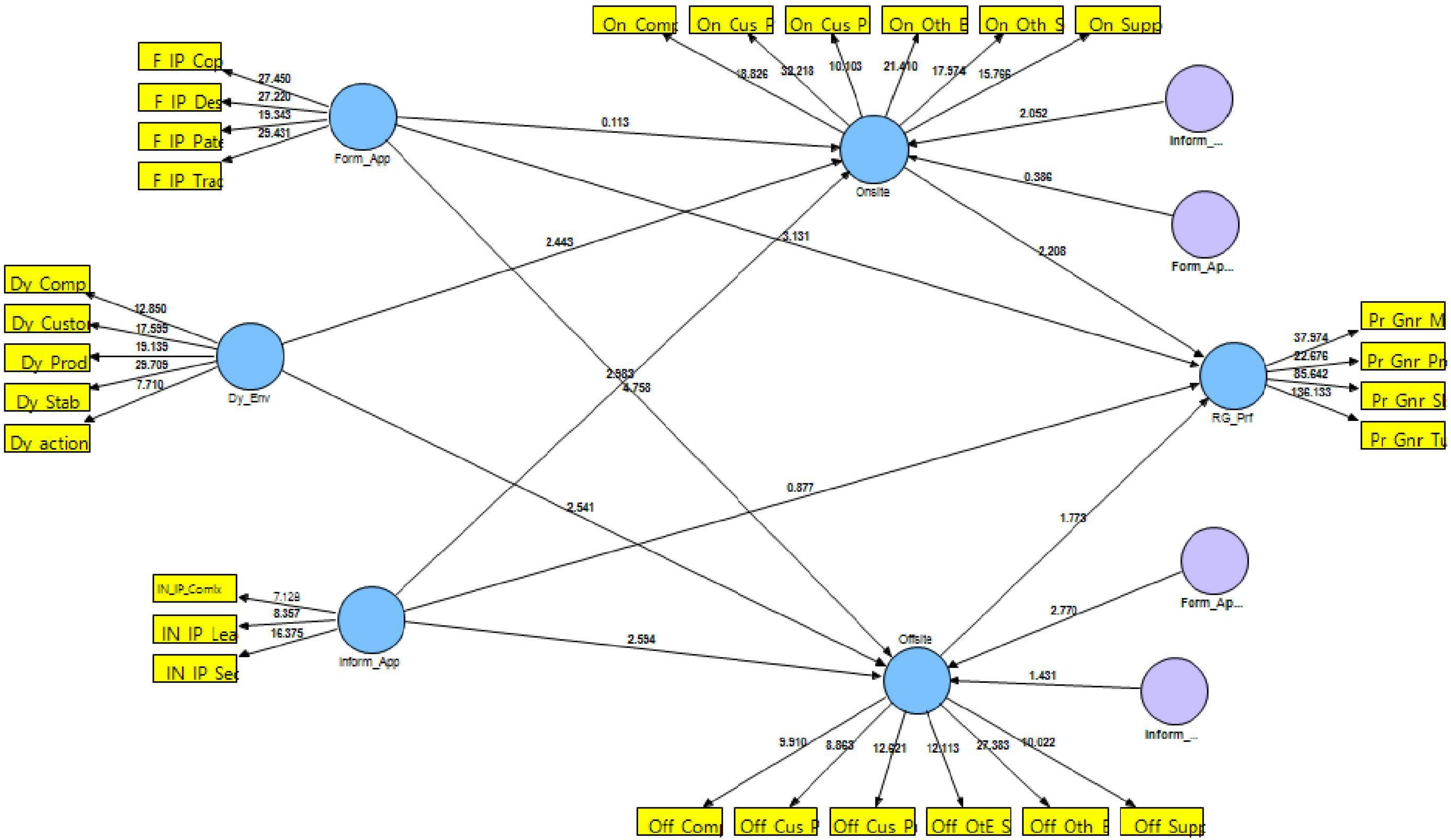


Fig. 4.17: Structural model results (Group differences: SMEs –bootstrapping results - t-values)

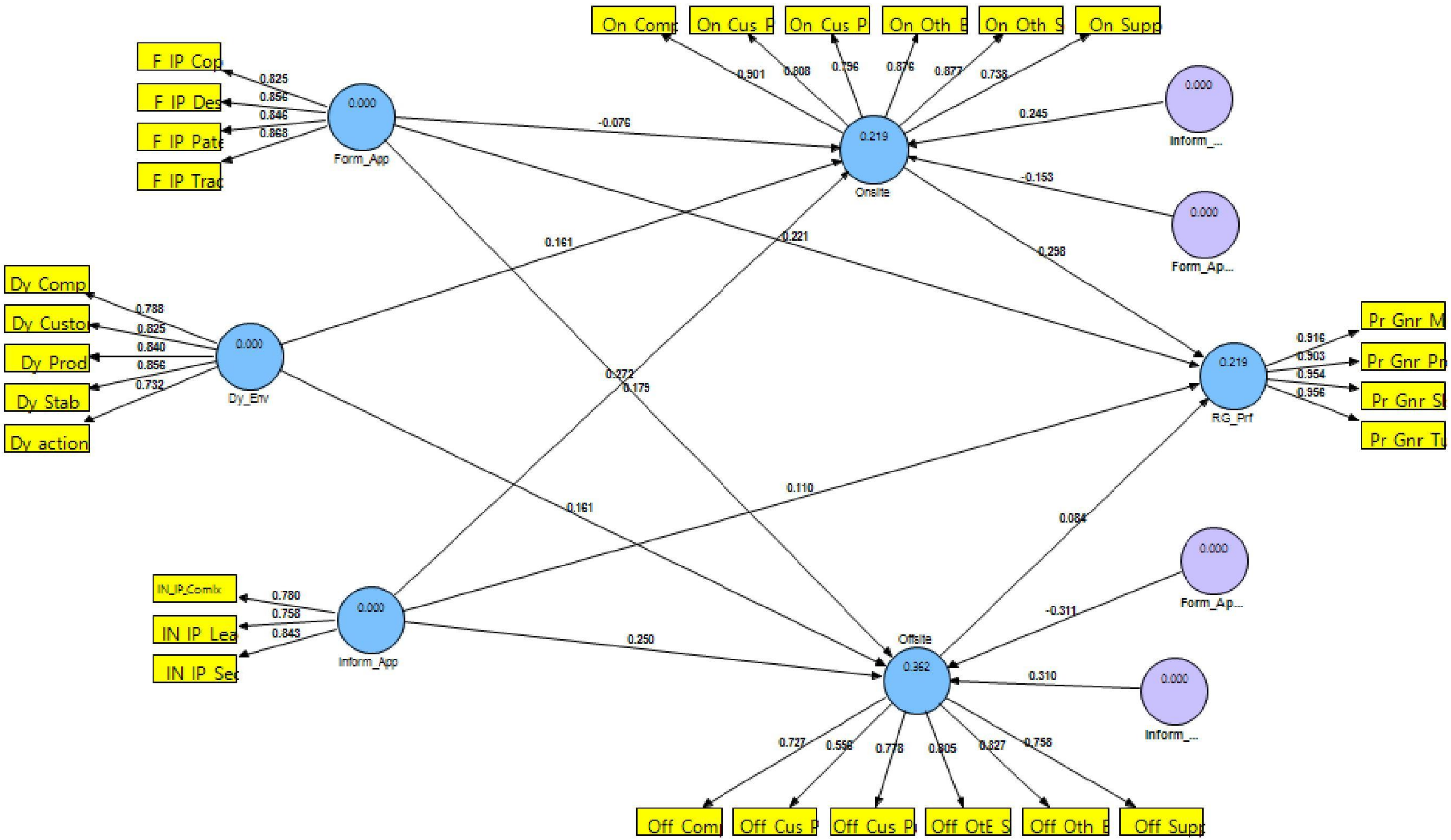


Fig. 4.18: Structural model results (Group differences: low intensity of science-driven open search strategy sample – path diagram)

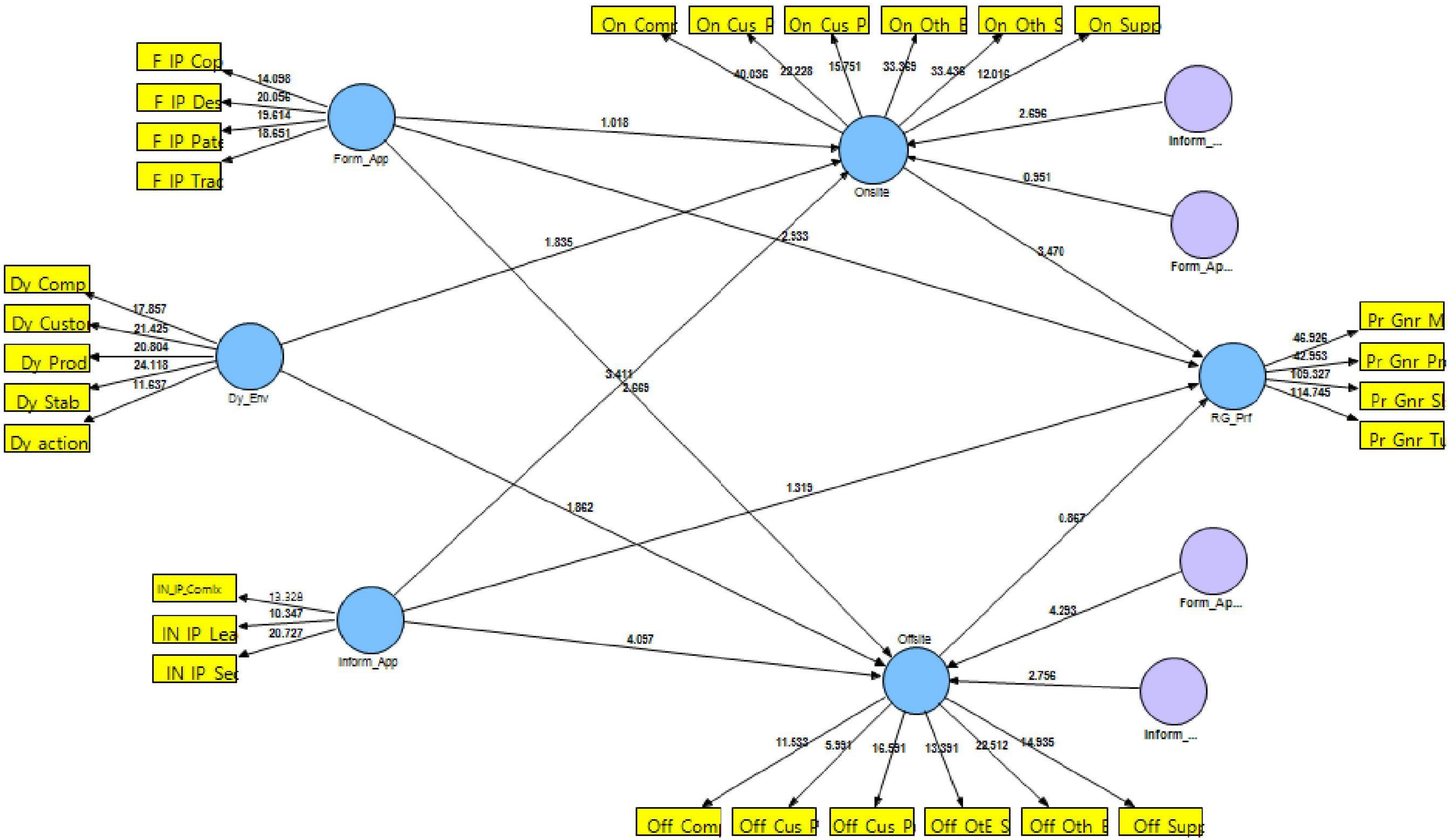


Fig. 4.19: Structural model results (Group differences: low intensity of science-driven open search strategy sample –bootstrapping results - t-values)

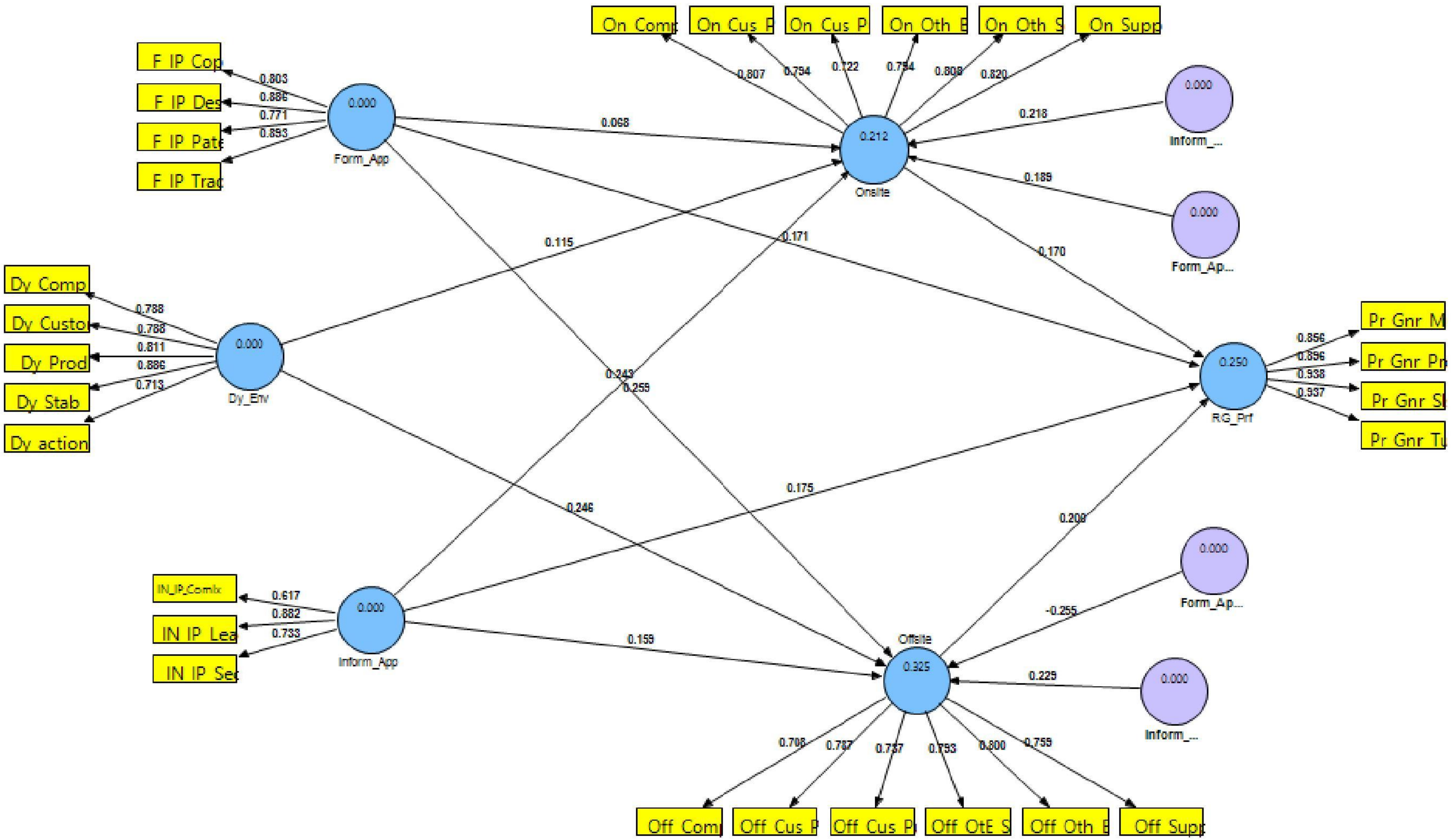


Fig. 4.20: Structural model results (Group differences: high intensity of science-driven open search strategy sample – path diagram)

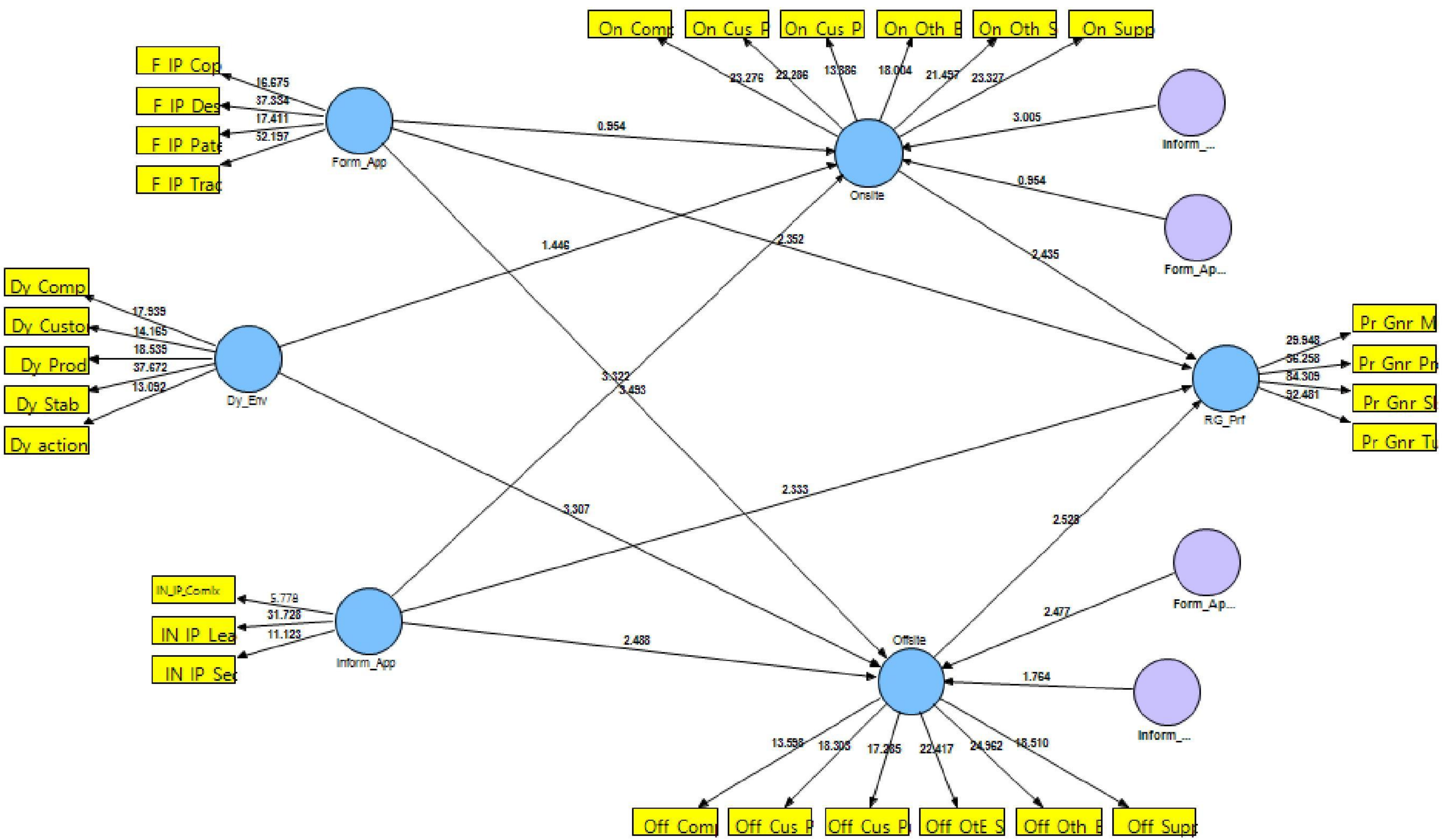


Fig. 4.21: Structural model results (Group differences: high intensity of science-driven open search strategy sample –bootstrapping results - t-values)

Chapter Five: Final Remarks

This research highlighted a new avenue for understanding the co-located firms' openness search activities. The first study (chapter two) suggested that the distinct types of open search activities hold different potentials for generating organisational efficiencies.

These findings extend previous research in three ways. The results directly supported recent arguments for greater attention to open innovation models and activities in smaller firms (Chesbrough, 2002; van de Vrande et al., 2009; Lee et al., 2010; Parida, Westerberg & Frishammar, 2012; Spithoven, Vanhaverbeke & Roijakkers, 2013; Colombo, Croce & Murtinu, 2014; Chesbrough & Bogers, 2014; Vahter, Love & Roper, 2014). As discussed, open innovation literature has traditionally focused on larger firms. There is a general agreement in the literature that large firms have superior access to resources and higher capacity to exploit external knowledge sources than their smaller rivals (Teece, 1986). For smaller firms, their liability of smallness presents several challenges (Freeman, Carroll & Hannan, 1983), and limits their ability to engage in open search activities is constrained (Hewitt-Dundas, 2006). These stylised facts implicitly portray small firms as relatively reactive players in innovation ecosystems, who need to be led by larger rivals. This view fails to recognise their innovation potential. Rather than portraying a firm`s open search strategy as a set of resource-intensive activities, missions and objectives, the findings of this study showed that smaller firms can actively stimulate their innovation performance by engaging in reciprocal interactions with external co-creation partners with different knowledge backgrounds, and by sourcing their missing knowledge from a wide variety of external resources. Furthermore, these findings supported the theoretical position that diversification of reciprocal interaction channels would increase the probability of achieving specified targets.

Second, this study added to the literature by testing a model that examined how distinct types of open search activities associate with various dimensions of performance. This study carried out in the second chapter found that offsite market-driven, science-driven and technical and application-driven open search strategies were associated with the firms` ability to exhibit superior levels of flexibility and adaptability. On the other hand, onsite and offsite market-driven, science-driven, technical and application-driven and institutional open search strategies exerted positive influences on their productivity. Future research should also assess whether distinct types of open search activities influence other aspects of organisational effectiveness. Although the results of this study highlighted that firms could achieve higher levels of adaptability and productivity by investing in their reciprocal open search activities, the observed effects may take on different patterns depending on the type of innovative activity involved.

Third, this study provided compelling evidence about the beneficial effects of agglomeration in science and technology park. The results of this study reconfirmed that geographical proximity in onsite firms` network relations matter. In the ecosystem of science and technology parks, geographical proximity shapes onsite firms` cognitive structure and perceptions of organisational, social and technical proximities in reciprocal interactions with co-creation partners, and positively influences their openness behaviour and performance. It would be very useful if future research investigates the roles of structural and management-level factors which make an ecosystem of science and technology park more likely to create inclusive climates for open innovation activities. Moreover, future researchers should distinguish between coopetitive and cooperative market driven search activities, which is another interesting area for further research.

The extant literature offers contrasting findings on the roles played by coopetition-based and cooperation-based interactions in shaping the value of smaller firms' growth options. Hence, exploring the potential impacts of reciprocal interactions with coopetition-based and cooperation-based partners on innovation performance seems to be relevant for decision making about homogeneous or heterogeneous clustering approaches in science and technology parks, as it would provide further insights on what benefits can be expected from each clustering approach.

The second study (chapter three) was motivated by a desire to understand the roles of open search and appropriability strategies in co-evolution of dynamic capabilities in co-located firms. The findings of this study supported the notion that potential short-term and long-term benefits of open search activities should be differentiated from each other, as they could imply different meanings. These findings introduced the key components of dynamic capabilities, as alternative receptive mechanisms which could explain the potential long-term effects of open search activities in firms. The results of this study revealed that the higher the intensity of a firm`s open search strategy gets, the more likely it becomes for the firm to accumulate social, organisational and human capital. Furthermore, it was confirmed that the intensity of appropriability strategy has a positive impact on the firm`s ability to extract positive incremental returns from social proximity. Finally, this study found that the higher the level of social capital accumulated by a firm engaged in open search activities gets, the more likely becomes for the firm to accumulate organisational and human capital.

Overall, the study carried out in the chapter three, contributes to the literatures on open innovation, appropriability strategy and dynamic capabilities in several ways. First, this study began to look into the black box enclosing the interface between open search strategy and dynamic capabilities, by providing evidence that the intensity of a firm`s open search strategy is significantly related to its accumulated stocks of social capital, human capital and organisational capital. The study also provided evidence that a firm`s appropriability strategy is positively contributed to the accumulation of social capital. Importantly, these findings suggested that the accumulated stocks of social capital by a firm engaged in open search activities would result in further accumulation of organisational capital and human capital. Hence, future research should look at the potential effects of distinct types of open search activities on the accumulation of dynamic capabilities.

As explained, this study found strong and direct effects for the anticipated associations between a firm`s open search strategy and social, organisational and human capital. Thus, it seems that social, organisational and human capital may potentially mediate the relationship between the intensity of a firm`s open search strategy and its performance. In other words, open search activities may exert their influences on the performance in different ways. Future research should continue to examine other components of dynamic capabilities as well as other antecedents of absorptive capacity, as they could provide further insights into the underlying mechanisms of why same levels of exposure to external knowledge may offer varying levels of benefits and results in different circumstances (Edvinsson & Sullivan, 1996; Youndt, Subramaniam & Snell, 2004; Subramaniam & Youndt, 2005; Escribano, Fosfuri & Tribó, 2009; Harison & Koski, 2010; Khavandkar et al., 2016).

The results of this study also indicated that there might be a mediating effect of social capital by which onsite firms could benefit more from their open search and appropriability strategies, and accumulate further human and organisational capital. This pattern could become clearer if future research examines the indirect effects of open search activities on the accumulation of human and organisational capital through social capital. The findings of this study supported the notion that a firm`s social capital is important for accumulation of human capital and organisational capital. On the one hand, the accumulated stocks of social capital increase the level of employees` understanding of how, what and when to acquire new knowledge, skills and capabilities in reciprocal interactions with co-creation partners. On the other hand, the accumulated stocks of social capital determine the success or failure of a firm`s endeavours in connecting external knowledge to its internal knowledge base. Hence, future research should examine the potential mediators for the anticipated associations between distinct types of open search activities and human and organisational and social capital- and between open search activities and firm performance – potentially mediated by social, human and organisational capital-. It would be of value to explore interactions between these components, threshold levels, and the possibility of their combined effects. Therefore, open innovation researchers should be careful to base their focus on the antecedents of a firm`s absorptive capacity and, thus, investigate the mediating roles of dynamic capabilities in studies focused on the relationships between open search strategy and performance.

Although this study goes further than other studies in examining potential effects of the open search activities, but there are several limitations to their generalisability. This study examined the relationship between the variables for a relatively idiosyncratic set of firms located in science and technology parks. There are different groups of geographically agglomerated firms in which the type of agglomeration strategy and the nature of agglomerated firms could produce different patterns. Hence, future research should examine the anticipated associations between the variables using different samples. This study also acknowledges that there are several limitations that may have led to the overestimation of effect sizes for the relationships between the variables. For instance, this study was built upon a survey in which measures of open search strategy and appropriability strategy and components of dynamic capabilities were collected concurrently. Therefore, future research should focus on collecting longitudinal data to test the predictive relationship between the independent and dependent variables, and later between them and performance measures. This study also used a single respondent report on all variables. This problem may be mitigated by the fact that the respondents who assessed their firms` situation had direct knowledge about how distinct aspects of their open search activities and use of appropriation mechanisms were managed and what levels of social, human, and organisational capital were achieved. Future research should test the robustness of this study`s findings by collecting data from multiple respondents.

The third study (chapter four) corroborated and extended contemporary theory and methods in the area of open innovation research. The findings illustrated that environmental context plays a key role in influencing whether a firm`s appropriability strategy leads to more market-driven open search activities - taking into account the location of partners-. The findings of this study revealed that whether the intensity of use of appropriation mechanisms triggers the market-driven open search activities through which a firm could sustain its superior performance depends not only on level of dynamism in the environment, but also on whether proximity is a meaningful predictor of open search objectives in a given geographical context. When the level of environmental dynamism is high, an appropriability strategy with a greater level of emphasis on the intensive use of formal mechanisms would signal potential offsite and onsite partners that reciprocal interactions with the focal firm may associate with having a disproportionately small share of economic value. In contrast, when the use of informal appropriation mechanisms is the main focus of the focal firms' proprietary, defensive and leveraging strategies, differences would be salient and potential market-based partners would be motivated to derogate organisational barriers in order to engage in reciprocal exchanges of knowledge with the firm. On the other hand, an appropriability strategy centred around the use of informal mechanisms increases the perceived level effectiveness of intensive offsite and onsite market-driven open search activities for the focal firm.

As explained, this study showed that environmental dynamism reverses the positive association between the use of formal appropriation mechanisms and the intensity of market-driven open search activities. Typically, formal appropriation mechanisms cause firms to feel safe and protected. For the firms faced with environment dynamism, however, formal appropriation mechanisms appear to damage their openness with respect to market-driven open search activities. An important aspect of environmental dynamism is that it increases causal ambiguity (Song et al., 2005; Helfat et al., 2007; Alvarez & Busenitz, 2007). On the other hand, an intensive use of formal appropriation mechanism could decrease the probability reciprocal exchange of knowledge between co-creation partners. Future research is necessary to empirically test whether only single type of formal appropriation mechanisms negatively impacts the perceived effectiveness of intensive open search activities of the firms faced with environmental dynamism, or such negative effects could be avoided under the right conditions. If this were found to be the case, it would contrast with the theoretical assumptions that the excessive use of all formal protection mechanisms negatively affects knowledge transfer between the co-creation partners (Simonin, 1999; Szulanski, Cappetta & Jensen, 2004; Levin & Cross, 2004).

Although environmental dynamism and appropriability strategy appeared to be the only meaningful drivers of difference in the perceived level of effectiveness of intensive market-driven open search activities in firms, it is important to keep in mind that both are exogenous factors. The institutional context and economic relationships define whether a particular protection mechanism makes any differences for the firm and its open search strategy. Moreover, these two factors are key to understanding how appropriation mechanisms interplay with other organisational characteristics. Hence, further research needs to be conducted, in both geographical regions and organisations in which different cultures (regimes) for appropriation or other demographic disparities are salient, to extend the results of the current study and also to disentangle the direct and moderating effects of environmental dynamism on the anticipated associations between the use of formal and informal appropriation mechanisms and distinct types of open search activities. Future research also should examine whether the nature of open search activities operationalised in dynamic environments differ qualitatively from those with less dynamic environments.

The findings of this study also highlighted a new avenue for understanding the smaller firms' openness behaviour. Like any other study, this study had its limitations. First, given the specific sample of micro and small and medium size enterprises located in science and technology parks in the United Kingdom, the generalisability of the findings might be limited to similarly sized firms. Nevertheless, given that the sample consisted primarily of micro enterprises and SMEs, which make up the majority of tenants in science and technology (UKSPA, 2011), and given that the sampled firms are from diverse industry backgrounds and regions in the United Kingdom, the generalisability of the results does not seem overly limited. Future studies should investigate how the hypothesised relationships work in different context. In this sense, it is desirable to further adapt the analysis to a sample of non-park firms and compare the results. Moreover, to improve the generalisability of the findings, future researchers should perform similar analyses on sample of equally distributed manufacturing and service firms.

Second, the results should be interpreted within the context of the study's limitations. Similar to the results obtained in chapters two and three, this study also relied on single informants. As MacKinnon et al. (2002) indicate the inflation of results based on the use of data collected from a single type of source (firms located in science and technology parks) is a limitation of this study. No doubt, objectively available measures (such as: stocks market indices) could appear to be the most reliable sources of information. However, given that the majority of firms in the sample were privately owned - not publicly listed- such data did not exist. Although the study took cautions to alleviate biases, it is still a limitation that this study faces (Starbuck, 2004).

Third, it is to be acknowledged that the specific operationalisations of the onsite and offsite market-driven open search strategy measures might have affected the observed relationships between the variables. While this study used an aggregated measure of both coopetition-based and cooperation-based reciprocal interactions, an alternative way could be to differentiate them. Hence, future researchers should investigate how distinct types of market-driven open search strategies (cooperative vs, coopetitive) as well as distinct organisational modes, such as licensing in/out, contribute to firms` performance and affect the relationship between formal and informal appropriation strategies and open search activities in the environments with different levels of dynamism.

This study constitutes a first attempt for investigating the different effects of appropriability strategy on open search strategy in presence of dynamism in the environment. This study relied on arguments from prior literature in order to suggest explanations based on the empirical results, however, it could be argued that the findings are pretty much silent about the pattern that takes place. In future studies, researchers should provide further insights on how other types of open search activities receive the effects of the hypothesised relationships in this study. Mediated or even moderated models consists of different dimensions of environmental dynamism (i.e. technological turbulence and market turbulence) could elaborate on the understanding of these complex relationships. Finally, it should be highlighted that this study only centred around one aspect of the open innovation activities, which was open search practices. Hence, future studies should also investigate how different open innovation practices could be affected by firms` appropriation decisions, whether environmental dynamism matters in shaping firms` open innovation and appropriation practices.

List of References

Afuah, A. 2000. How much do your co-opetitors' capabilities matter in the face of technological change? ***Strategic Management Journal***, 21(3): 397–404.

Agostini, L., & Nosella, A. 2017. A dual knowledge perspective on the determinants of SME patenting: Results of an empirical investigation. ***Management Decision***, *55*(6), 1226–1247.

Ahn, J. M., Mortara, L., & Minshall, T. 2013. The effects of open innovation on firm performance: A capacity approach. ***STI Policy Review***, 4(1): 79–93.

Aiken, L., & West, S. 1991. ***Multiple regression: Testing and interpreting interactions***. Newbury Park, CA: SAGE Publications Ltd.

Albahari, A., Catalano, G., & Landoni, P. 2013. Evaluation of national science park systems: A theoretical framework and its application to the italian and spanish systems. ***Technology Analysis & Strategic Management***, *25*(5), 599–614.

Alcácer, J., & Chung, W. 2007. Location Strategies and Knowledge Spillovers. ***Management Science***, *53*(5), 760–776.

Alexy, O., & George, G. 2013. Category divergence, straddling, and currency: Open innovation and the legitimation of illegitimate categories. ***Journal of Management Studies***, 50(2): 173–203.

Allen, R. 1983. Collective invention. ***Journal of Economic Behavior and Organization***, 4(1): 1–24.

Almirall, E., & Casadesus-Masanell, R. 2010. Open versus closed innovation: A model of discovery and divergence. ***The Academy of Management Review***, 35(1): 27–47.

Alvarez, S. A., & Busenitz, L. W. 2007. The entrepreneurship of resource-based theory. ***Entrepreneurship: Concepts, Theory and Perspective***, 207–227.

Amara, N., & Landry, R. 2005. Sources of information as determinants of novelty of innovation in manufacturing firms: Evidence from the 1999 statistics canada innovation survey. ***Technovation***, 25(3): 245–259.

Amara, N., Landry, R., & Traoré, N. 2008. Managing the protection of innovations in knowledge-intensive business services. ***Research Policy***, 37(9): 1530–1547.

Amirahmadi, H., & Saff, G. 1993. Science and technology parks: A critical assessment. ***Journal of Planning Literature***, 8(2): 107–123.

Ansari, S. M., Fiss, P. C., & Zajac, E. J. 2010. Made to fit: How practices vary as they diffuse. ***Academy of Management Review***, 35(1): 67–92.

Aramburu, N., & Sáenz, J. 2011. Structural capital, innovation capability, and size effect: An empirical study. ***Journal of Management and Organization***, 17(3): 307–325.

Arbussà, A., & Coenders, G. 2007. Innovation activities, use of appropriation instruments and absorptive capacity: Evidence from Spanish firms. ***Research Policy***, 36(10): 1545–1558.

Ardito, L., & Messeni Petruzzelli, A. 2017. Breadth of external knowledge sourcing and product innovation: The moderating role of strategic human resource practices. ***European Management Journal***, 35(2): 261–272.

Argyris, C., & Schon, D. A. 1978. ***Organizational learning: A theory of action perspective***. Reading, MA: Addision-Wesley.

Armstrong, J. S., & Overton, T. S. 1977. Estimating non-response bias in mail surveys. ***Journal of Marketing Research***, 14(3): 396–402.

Arora, A., & Merges, R. P. 2004. Specialized supply firms, property rights and firm boundaries. ***Industrial and Corporate Change***, 13(3): 451–475.

Arora, A., Athreye, S., & Huang, C. 2016. The paradox of openness revisited: Collaborative innovation and patenting by UK innovators. ***Research Policy***, 45(7): 1352–1361.

Arrow, K. 1962. Economic welfare and the allocation of resources of invention. In R. Nelson (Ed.), ***The Rate and Direction of Inventive Activity: Economic and Social Factors***: 609–625. Princeton, NJ: National Bureau of Economic Research. Princeton University Press.

Arthurs, J. D., & Busenitz, L. W. 2006. Dynamic capabilities and venture performance: The effects of venture capitalists. ***Journal of Business Venturing***, 21(2): 195–215.

Arundel, A. 2001. The relative effectiveness of patents and secrecy for appropriation. ***Research Policy***, 30(4): 611–624.

Arvanitis, S., & Bolli, T. 2013. A comparison of national and international innovation cooperation in five European countries. ***Review of Industrial Organization***, 43(3): 163–191.

Arvanitis, S., & Hollenstein, H. 1996. Industrial innovation in Switzerland: A model-based analysis with survey data. In A. Kleinknecht (Ed.), ***Determinants of Innovation the Message from New Indicators***. London: Macmillan Press.

Athaide, G. A., & Zhang, J. Q. 2011. The determinants of seller-buyer interactions during new product development in technology-based industrial markets. ***Journal of Product Innovation Management***, 28(s1): 146–158.

Atuahene-Gima, K., Slater, S. F., & Olson, E. M. 2005. The contingent value of responsive and proactive market orientations for new product program performance. ***Journal of Product Innovation Management***, 22(6): 464–482.

Bakouros, Y. L., Mardas, D. C., & Varsakelis, N. C. 2002. Science park, a high tech fantasy? An analysis of the science and technology parks of Greece. ***Technovation***, 22(2): 123–128.

Baldwin, C., & von Hippel, E. 2011. Modeling a paradigm shift: From producer innovation to user and open collaborative innovation. ***Organization Science***, 22(6): 1399–1417.

Balland, P.A. 2012. Proximity and the evolution of collaboration networks: Evidence from research and development projects within the Global Navigation Satellite System (GNSS) Industry. ***Regional Studies***, 46(6): 741–756.

Barney, J. B. 1986. Organizational culture: Can it be a source of sustained competitive advantage? ***The Academy of Management Review***, 11(3): 656–665.

Baum, J. A. C., Calabrese, T., & Silverman, B. S. 2000. Don't go it alone: alliance network composition and startups' performance in Canadian biotechnology. ***Strategic Management Journal***, *21*(3), 267–294.

Becker, W., & Dietz, J. 2004. R&D cooperation and innovation activities of firms—evidence for the German manufacturing industry. ***Research Policy***, 33(2): 209–223.

Belderbos, R., Carree, M., Diederen, B., Lokshin, B., & Veugelers, R. 2004. Heterogeneity in R&D cooperation strategies. ***International Journal of Industrial Organization***, 22(8): 1237–1263.

Belderbos, R., Cassiman, B., Faems, D., Leten, B., & Van Looy, B. 2014. Co-ownership of intellectual property: Exploring the value-appropriation and value-creation implications of co-patenting with different partners. ***Research Policy***, 43(5): 841–852.

Ben Letaifa, S., & Rabeau, Y. 2013. Too close to collaborate? How geographic proximity could impede entrepreneurship and innovation. ***Journal of Business Research***, 66(10): 2071–2078.

Bengtsson, M., & Kock, S. 2000. "Coopetition" in business networks—to cooperate and compete simultaneously. ***Industrial Marketing Management***, 29(5): 411–426.

Benneworth, P., & Ratinho, T. 2014. Reframing the role of knowledge parks and science cities in knowledge-based urban development. ***Environment and Planning C: Government and Policy***, *32*(5), 784–808.

Bentler, P. M., & Chou, C.-P. 1987. Practical issues in structural modeling. ***Sociological Methods & Research***, 16(1): 78–117.

Berchicci, L. 2013. Towards an open R&D system: Internal R&D investment, external knowledge acquisition and innovative performance. ***Research Policy***, 42(1): 117–127.

Bessant, J. 1999. The rise and fall of "Supernet": A case study of technology transfer policy for smaller firms. ***Research Policy***, 28(6): 601–614.

Bianchi, M., Campodall'Orto, S., Frattini, F., & Vercesi, P. 2010. Enabling open innovation in small- and medium-sized enterprises: How to find alternative applications for your technologies. ***R and D Management***, 40(4): 414–431.

Bierly, P., & Chakrabarti, A. 1996. Generic knowledge strategies in the U.S. pharmaceutical industry. ***Strategic Management Journal***, 17(S2): 123–135.

Bigliardi, B., Dormio, A. I., Nosella, A., & Petroni, G. 2006. Assessing science and technology parks' performances: Directions from selected Italian case studies. ***Technovation***, 26(4): 489–505.

Birkinshaw, J., Hamel, G., & Mol, M. J. 2008. Management Innovation. ***Academy of Management Review***, *33*(4), 825–845.

Bloom, N., & Reenen, J. Van. 2007. Measuring and explaining management practices across firms and countries. ***The Quarterly Journal of Economics***, *122*(4), 1351–1408.

Bloom, N., Schankerman, M., & Van Reenen, J. 2013. Identifying technology spillovers and product market rivalry. ***Econometrica***, 81(4): 1347–1393.

Blyler, M., & Coff, R. W. 2003. Dynamic capabilities, social capital, and rent appropriation: Ties that split pies. ***Strategic Management Journal***, 24(7): 677–686.

Bollen, K. A. 1989. ***Structural equations with latent models***. New York, NY: John Wiley & Sons, Ltd.

Boschma, R. 2005. Proximity and innovation: A critical assessment. ***Regional Studies***, 39(1): 61–74.

Brandenburger, A. M., & Nalebuff, B. J. 1996. ***Co-opetition***. New York, NY: Doubleday.

Brass, D., & Galaskiewicz, J. 2004. Taking stock of networks and organizations: A multilevel perspective. ***Academy of Management Journal***, *47*(6), 795–817.

Breschi, S., & Lissoni, F. 2009. Mobility of skilled workers and co-invention networks: An anatomy of localized knowledge flows. ***Journal of Economic Geography***, 9(4): 439–468.

Brioschi, F., Brioschi, M. S., & Cainelli, G. 2002. From the industrial district to the district group: An insight into the evolution of capitalism in Italy. ***Regional Studies***, 36(9): 1037–1052.

Brooking, A. 1997. The management of intellectual capital. ***Long Range Planning***, 30(3): 364–365.

Brouwer, E., & Kleinknecht, A. 1999. Innovative output, and a firm's propensity to patent. ***Research Policy***, 28(6): 615–624.

Browne, M. W. 1982. Covariance structures. In D. M. Hawkins (Ed.), ***Topic in Applied Multivariate Analysis***: 72–141. Cambridge: Cambridge University Press.

Browne, M. W., & Cudeck, R. 1993. Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), ***Testing Structural Equation Models***: 136–162. Newbury Park, CA: SAGE Publications Inc.

Brunswicker, S., & Vanhaverbeke, W. 2015. Open innovation in small and medium-sized enterprises (SMEs): External knowledge sourcing strategies and internal organizational facilitators. ***Journal of Small Business Management***, 53(4): 1241–1263.

Bullinger, H.-J., Auernhammer, K., & Gomeringer, A. 2004. Managing innovation networks in the knowledge-driven economy. ***International Journal of Production Research***, 42(17): 3337–3353.

Burk, D. L. 2008. The role of patent law in knowledge codification. ***Berkeley Technology Law Journal***, 23(3): 1009–1034.

Burt, R. S. 1992. ***Structural holes: The social structure of competition***. Cambridge, MA: Harvard University Press.

Cabrera, E. F., & Cabrera, A. 2005. Fostering knowledge sharing through people management practices. ***International Journal of Human Resource Management***, 16(5): 720–735.

Camagni, R. 1991. Local milieu, uncertainty and innovation networks: Towards a new dynamic theory of economic space. ***Innovation Networks: Spatial Perspectives***: 121–144. London: Belhaven Press.

Camisón-Zornoza, C., Lapiedra-Alcamí, R., Segarra-Ciprés, M., & Boronat-Navarro, M. 2004. A meta-analysis of innovation and organizational size. ***Organization Studies***, 25(3): 331–361.

Campanella, F., Rosaria Della Peruta, M., & Del Giudice, M. 2014. Creating conditions for innovative performance of science parks in Europe. How manage the intellectual capital for converting knowledge into organizational action. ***Journal of Intellectual Capital***, *15*(4), 576–596.

Camps, S., & Marques, P. 2014. Exploring how social capital facilitates innovation: The role of innovation enablers. ***Technological Forecasting and Social Change***, 88: 325–348.

Cantner, U., Joel, K., & Schmidt, T. 2011. The effects of knowledge management on innovative success – An empirical analysis of German firms. ***Research Policy***, 40(10): 1453–1462.

Cantù, C. 2010. Exploring the role of spatial relationships to transform knowledge in a business idea — Beyond a geographic proximity. ***Industrial Marketing Management***, *39*(6), 887–897.

Capaldo, A., & Petruzzelli, A. M. 2014. Partner geographic and organizational proximity and the innovative performance of knowledge-creating alliances. ***European Management Review***, 11(1): 63–84.

Caputo, M., Lamberti, E., Cammarano, A., & Michelino, F. 2016. Exploring the impact of open innovation on firm performances. ***Management Decision***, 54(7): 1788–1812.

Carlos, A., Júnior, P., Porto, G. S., Pacífico, O., Pereira, A., & Júnior, S. 2015. Project stakeholder management: a case study of a Brazilian science park. ***Journal of Technology Management & Innovation***, *10*(1), 39–50.

Carmeli, A., & Azeroual, B. 2009. How relational capital and knowledge combination capability enhance the performance of work units in a high technology industry. ***Strategic Entrepreneurship Journal***, 3(1): 85–103.

Carmona-Lavado, A., Cuevas-Rodríguez, G., & Cabello-Medina, C. 2010. Social and organizational capital: Building the context for innovation. ***Industrial Marketing Management***, 39(4): 681–690.

Carrillo, J. E., & Franza, R. M. 2006. Investing in product development and production capabilities: The crucial linkage between time-to-market and ramp-up time. ***European Journal of Operational Research***, 171(2): 536–556.

Cassiman, B., & Veugelers, R. 2002. R&D cooperation and spillovers: Some empirical evidence. ***The American Economic Review***, 92(4): 1169–1184.

Castellacci, F., & Zheng, J. 2010. Technological regimes, Schumpeterian patterns of innovation and firm-level productivity growth. ***Industrial and Corporate Change***, 19(6): 1829–1865.

Castro, G. M. 2015. Knowledge management and innovation in knowledge-based and high-tech industrial markets: The role of openness and absorptive capacity. ***Industrial Marketing Management***, 47: 143–146.

Cepeda-Carrion, G., Cegarra-Navarro, J. G., & Jimenez-Jimenez, D. 2012. The effect of absorptive capacity on innovativeness: Context and information systems capability as catalysts. ***British Journal of Management***, 23(1): 110–129.

Chang, Y.-C. C., Chang, H.-T. T., Chi, H.-R. R., Chen, M.-H. H., & Deng, L.L. L. 2012. How do established firms improve radical innovation performance? The organizational capabilities view. ***Technovation***, 32(7–8): 441–451.

Chau, V. S., Gilman, M., & Serbanica, C. 2016. Aligning university–industry interactions: The role of boundary spanning in intellectual capital transfer. ***Technological Forecasting and Social Change***. 123: 199-209.

Chen, J., Chen, Y., & Vanhaverbeke, W. 2011. The influence of scope, depth, and orientation of external technology sources on the innovative performance of Chinese firms. ***Technovation***, 31(8): 362–373.

Cheng, C. C. J., & Shiu, E. C. 2015. The inconvenient truth of the relationship between open innovation activities and innovation performance. ***Management Decision***, 53(3): 625–647.

Chesbrough, H. 2002. Graceful exits and foregone opportunities: Xerox's management of its technology spinoff organizations. ***Business History Review***, 76(4): 803–808.

Chesbrough, H. 2003a. The era of open innovation. ***Sloan Management Review***, (Spring): 35–41.

Chesbrough, H. 2003b. ***Open innovation: The new imperative for creating and profiting from technology***. Boston, MA: Harvard Business School Press.

Chesbrough, H. 2011. *Open services innovation: Rethinking your business to grow and compete in a new era*. Boston, MA: Harvard Business press.

Chesbrough, H. 2017. The future of open innovation. ***Research-Technology Management***, 60(1): 35–38.

Chesbrough, H. W. 2006a. ***Open business models: How to thrive in the new innovation landscape***. Harvard, MA: Harvard Business School Press.

Chesbrough, H. W. 2006b. Open innovation: A new paradigm for understanding industrial innovation. In H. W. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), ***Open Innovation: Researching a New Paradigm***. Oxford: Oxford University Press.

Chesbrough, H. W. 2007. Why companies should have open business models. ***MIT Sloan Management Review***, 48(2): 21–8.

Chesbrough, H. W., & Appleyard, M. M. 2007. Open innovation and strategy. ***California Management Review***, 50(1): 57–76.

Chesbrough, H. W., & Crowther, A. K. 2006. Beyond high-tech: Early adopters of open innovation in other industries. ***R&D Management***, 36(3): 229–236.

Chesbrough, H. W., & Prencipe, A. 2008. Networks of innovation and modularity: A dynamic perspective. ***International Journal of Technology Management***, 42(4): 414–425.

Chesbrough, H., & Bogers, M. 2014. Explicating open innovation: Clarifying an emerging paradigm for understanding innovation. In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), ***New Frontiers in Open Innovation*** (1st ed.): 3–28. Oxford: Oxford University Press.

Chiang, Y.-H. H., & Hung, K.P. P. 2010. Exploring open search strategies and perceived innovation performance from the perspective of inter-organizational knowledge flows. ***R&D Management***, 40(3): 292–299.

Chiaroni, D., Chiesa, V., & Frattini, F. 2011. The open innovation journey: How firms dynamically implement the emerging innovation management paradigm. ***Technovation***, 31(1): 34–43.

Chin, W. W. 1998. The partial least squares approach to structural equation modeling. In G. A. Marcoulides (Ed.), ***Modern Methods for Business Research***. London: Psychology Press.

Chin, W. W. 2010. How to write up and report PLS analyses. In E. V. Vinzi, W. W. Chin, J. Henseler, & H. Wang (Eds.), ***Handbook of Partial Least Squares***: 655–690. Berlin, Heidelberg: Springer Berlin Heidelberg.

Chin, W. W., & Newsted, P. R. 1999. Structural equation modelling analysis with small samples using partial least squares. In R. H. Hoyle (Ed.), ***Statistical Strategies for Small Sample Research***: 307–341. Thousand Oaks, CA: SAGE Publications Ltd.

Chordá, I. M. 1996. Towards the maturity stage: An insight into the performance of French Technopoles. ***Technovation***, 16(3): 143–152.

Christensen, C. M., & Bower, J. L. 1996. Customer power, strategic investment, and the failure of leading firms. ***Strategic Management Journal***, 17(3): 197–218.

Christensen, J. F., Olesen, M. H., & Kjær, J. S. 2005. The industrial dynamics of open innovation—Evidence from the transformation of consumer electronics. ***Research Policy***, 34(10): 1533–1549.

Chung, S., & Kim, G. M. 2003. Performance effects of partnership between manufacturers and suppliers for new product development: The supplier's standpoint. ***Research Policy***, 32(4): 587–603.

Churchill, G. A. 1979. A paradigm for developing better measures of marketing constructs. ***Journal of Marketing Research***, 16(1): 64–73.

Clark, K. B. 1989. Project scope and project performance: The effect of parts strategy and supplier involvement on product development. ***Management Science***, 35(10): 1247–1263.

Cohen, W. M., & Levinthal, D. A. 1990. Absorptive capacity: A new perspective on learning and innovation. ***Administrative Science Quarterly***, 35(1): 128–152.

Colombo, M. G., & Delmastro, M. 2002. How effective are technology incubators? Evidence from Italy. ***Research Policy***, 31(7): 1103–1122.

Colombo, M. G., Croce, A., & Murtinu, S. 2014. Ownership structure, horizontal agency costs and the performance of high-tech entrepreneurial firms. ***Small Business Economics***, 42(2): 265–282.

Coombs, R., Harvey, M., & Tether, B. S. 2003. Analysing distributed processes of provision and innovation. ***Industrial and Corporate Change***, 12(6): 1125–1155.

Corsaro, D., Ramos, C., Henneberg, S. C., & Naudé, P. 2012. The impact of network configurations on value constellations in business markets — The case of an innovation network. ***Industrial Marketing Management***, *41*(1), 54–67.

Cronbach, L. J. 1951. Coefficient Alpha and the internal structure of tests. ***Psychometrika***, 16(3): 297–334.

Cruz-González, J., López-sáez, P., Navas-lópez, J. E., & Delgado-Verde, M. 2015. Open search strategies and firm performance: The different moderating role of technological environmental dynamism. ***Technovation***, 35: 32–45.

D'Este, P., & Patel, P. 2007. University–industry linkages in the UK: What are the factors underlying the variety of interactions with industry? ***Research Policy***, 36(9): 1295–1313.

Daft, R. L., & Weick, K. E. 1984. Toward a model of organizations as interpretation systems. ***The Academy of Management Review***, 9(2): 284–295.

Dahlander, L., & Gann, D. M. 2010. How open is innovation? ***Research Policy***, 39(6): 699–709.

Dahlander, L., O'Mahony, S., & Gann, D. M. 2016. One foot in, one foot out: How does individuals' external search breadth affect innovation outcomes? ***Strategic Management Journal***, 37(2): 280–302.

Damanpour, F. 1992. Organizational size and innovation. ***Organization Studies***, 13(3): 375–402.

Davenport, S. 2005. Exploring the role of proximity in SME knowledge-acquisition. ***Research Policy***, 34(5): 683–701.

Dawson, J. F. 2014. Moderation in management research: What, why, when, and how. ***Journal of Business and Psychology***, 29(1): 1–19.

Dess, G. G., & Beard, D. W. 1984. Dimensions of organizational task environments. ***Administrative Science Quarterly***, 29(1): 52–73.

Dess, G. G., Ireland, R. D., & Hitt, M. A. 1990. Industry effects and strategic management research. ***Journal of Management***, 16(1): 7–27.

Dettwiler, P., Lindelöf, P., & Löfsten, H. 2006. Utility of location: A comparative survey between small new technology-based firms located on and off Science and technology parks—Implications for facilities management. ***Technovation***, 26(4): 506–517.

DeVellis, R. F. 2011. ***Scale Development: Theory and Applications*** (3rd ed.). Thousand Oaks, CA: SAGE Publications Inc.

Dickson, P. H., Weaver, K. M., & Hoy, F. 2006. Opportunism in the R&D alliances of SMES: The roles of the institutional environment and SME size. ***Journal of Business Venturing***, 21(4): 487–513.

Diez, J. R. 2000. Innovative networks in manufacturing: Some empirical evidence from the metropolitan area of Barcelona. ***Technovation***, 20(3): 139–150.

Díez-Vial, I., & Fernández-Olmos, M. 2015. Knowledge spillovers in science and technology parks: How can firms benefit most? ***The Journal of Technology Transfer***, 40(1): 70–84.

Díez-Vial, I., & Montoro-Sánchez, Á. 2016. How knowledge links with universities may foster innovation: The case of a science park. ***Technovation***, 50(Supplement C): 41–52.

Doloreux, D. 2004. Regional networks of small and medium sized enterprises: Evidence from the Metropolitan Area of Ottawa in Canada. ***European Planning Studies***, 12(2): 173–189.

Drechsler, W., & Natter, M. 2012. Understanding a firm's openness decisions in innovation. ***Journal of Business Research***, 65(3): 438–445.

Driffield, N., Mickiewicz, T., & Temouri, Y. 2016. Ownership control of foreign affiliates: A property rights theory perspective. ***Journal of World Business***, 51(6): 965–976.

Droge, C., Calantone, R., & Harmancioglu, N. 2008. New product success: Is it really controllable by managers in highly turbulent environments? ***Journal of Product Innovation Management***, 25(3): 272–286.

Du, J., Leten, B., & Vanhaverbeke, W. 2014. Managing open innovation projects with science-based and market-based partners. ***Research Policy***, 43(5): 828–840.

Duncan, R. B. 1972. Characteristics of organizational environments and perceived environmental uncertainty. ***Administrative Science Quarterly***, 17(3): 313–327.

Dutton, J. E., Fahey, L., & Narayanan, V. K. 1983. Toward understanding strategic issue diagnosis. ***Strategic Management Journal***, 4(4): 307–323.

Dyer, J. H., & Singh, H. 1998. The relational view: Cooperative strategy and sources of interorganizational competitive advantage. ***Academy of Management Review***, 23(4): 660–679.

Edvinsson, L., & Malone, M. S. 1997. ***Intellectual capital: Realizing your company's true value by finding its hidden brainpower***. New York, NY: Harper Business.

Edvinsson, L., & Sullivan, P. 1996. Developing a model for managing intellectual capital. ***European Management Journal***, 14(4): 356–364.

Edwards, J. R., & Lambert, L. S. 2007. Methods for integrating moderation and mediation: A general analytical framework using moderated path analysis. ***Psychological Methods***, 12(1): 1–22.

Efendic, A., Mickiewicz, T., & Rebmann, A. 2015. Growth aspirations and social capital: Young firms in a post-conflict environment. ***International Small Business Journal***, 33(5): 537–561.

Eisenhardt, K. M., & Martin, A. J. 2000. Dynamic capabilities: What are they? ***Strategic Management Journal***, 21: 1105–1121.

Elenkov, D. S. 1997. Strategic uncertainty and environmental scanning: The case for institutional influences on scanning behavior. ***Strategic Management Journal***, 18(4): 287–302.

Engelman, R. M., Fracasso, E. M., Schmidt, S., & Zen, A. C. 2017. Intellectual capital, absorptive capacity and product innovation. ***Management Decision***, 55(3): 474–490.

Enkel, E., Gassmann, O., & Chesbrough, H. 2009. Open R&D and open innovation: Exploring the phenomenon. ***R & DManagement***, 39(4): 311–316.

Eppinger, E., & Vladova, G. 2013. Intellectual property management practices at small and medium-sized enterprises. ***International Journal of Technology Management***, 61(1): 64.

Escribano, A., Fosfuri, A., & Tribó, J. A. 2009. Managing external knowledge flows: The moderating role of absorptive capacity. ***Research Policy***, 38(1): 96–105.

Esposito Vinzi, V., Chin, W. W., Henseler, J., & Wang, H. 2010. ***Handbook of partial least squares: Concepts, methods and applications. Springer Handbooks of Computational Statistics***. London: Springer Berlin Heidelberg.

Estrin, S., Mickiewicz, T., & Stephan, U. 2016. Human capital in social and commercial entrepreneurship. ***Journal of Business Venturing***, 31(4): 449–467.

European Commission. 2006. ***RICARDIS: Reporting intellectual capital to augment research, development and innovation in SMEs***. Brussels: European Commission.

European Commission. 2015. ***User guide to the SME Definition***. Luxembourg: European Commission.

Eurostat. 2014. ***Eurostat indicators: Aggregation of the manufacturing industry according to technological intensity and service industry according of High-tech industry and knowledge - intensive services***. Luxembourg: Eurostat.

Fabrizio, K. R. 2006. The use of university research in firm innovation. In H. W. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), ***Open Innovation: Researching a New Paradigm***: 134–160. Oxford: Oxford University Press.

Faems, D., De Visser, M., Andries, P., & Van Looy, B. 2010. Technology alliance portfolios and financial performance: Value-enhancing and cost-increasing effects of open innovation. ***Journal of Product Innovation Management***, 27(6): 785–796.

Faems, D., Janssens, M., Madhok, A., & Van Looy, B. 2008. Toward an integrative perspective on alliance governance: Connecting contract design, trust dynamics, and contract application. ***Academy of Management Journal***, *51*(6), 1053–1078.

Felsenstein, D. 1994. University-related science and technology parks - “seedbeds” or “enclaves” of innovation? ***Technovation***, 14(2): 93–110.

Ferreras-Méndez, J. L., Fernández-Mesa, A., & Alegre, J. 2016. The relationship between knowledge search strategies and absorptive capacity: A deeper look. ***Technovation***.

Fey, C. F., & Birkinshaw, J. 2005. External sources of knowledge, governance mode, and R&D performance. ***Journal of Management***, 31(4): 597–621.

Field, A. 2013. ***Discovering statistics using IBM SPSS statistics***. London: SAGE Publications Ltd.

Filatotchev, I., Liu, X., Lu, J., and Wright, M. 2011. Knowledge spillovers through human mobility across national borders: Evidence from Zhongguancun Science Park in China. ***Research Policy***, 40(3): 453–462.

Fini, R., Grimaldi, R., Santoni, S., & Sobrero, M. 2011. Complements or substitutes? The role of universities and local context in supporting the creation of academic spin-offs. ***Research Policy***, *40*(8), 1113–1127.

Fleming, L., & Sorenson, O. 2004. Science as a map in technological search. ***Strategic Management Journal***, 25(8–9): 909–928.

Forés, B., & Camisón, C. 2016. Does incremental and radical innovation performance depend on different types of knowledge accumulation capabilities and organizational size? ***Journal of Business Research***, 69(2): 831–848.

Fornell, C., & Bookstein, F. L. 1982. Two structural equation models: LISREL and PLS applied to consumer exit-voice theory. ***Journal of Marketing Research***, 19(4): 440–452.

Fornell, C., & Larcker, D. F. 1981. Evaluating structural equation models with unobservable variables and measurement error. ***Journal of Marketing Research***, 18(1): 39–50.

Foss, N. J., Laursen, K., & Pedersen, T. 2011. Linking customer interaction and innovation: The mediating role of new organizational practices. ***Organization Science***, 22(4): 980–999.

Franzoni, C., & Sauermann, H. 2014. Crowd science: The organization of scientific research in open collaborative projects. ***Research Policy***, 43(1): 1–20.

Freel, M. S., & Harrison, R. T. 2006. Innovation and cooperation in the small firm sector: Evidence from "Northern Britain." ***Regional Studies***, 40(4): 289–305.

Freel, M. S., & Robson, P. J. A. 2004. Small firm innovation, growth and performance. ***International Small Business Journal***, 22(6): 561–575.

Freel, M., & Robson, P. J. 2016. Appropriation strategies and open innovation in SMEs. ***International Small Business Journal***, 35(5): 578–596.

Freeman, J., Carroll, G. R., & Hannan, M. T. 1983. The liability of newness: Age dependence in organizational death rates. ***American Sociological Review***, *48*(5), 692–710.

Frishammar, J., Ericsson, K., & Patel, P. C. 2015. The dark side of knowledge transfer: Exploring knowledge leakage in joint R&D projects. ***Technovation***, *41*, 75–88.

Fu, X. 2012. How does openness affect the importance of incentives for innovation? ***Research Policy***, 41(3): 512–523.

Fuentelsaz, L., Gomez, J., & Polo, Y. 2003. Intrafirm diffusion of new technologies: an empirical application. ***Research Policy***, 32(4): 533–551.

Fukugawa, N. 2006. Science and technology parks in Japan and their value-added contributions to new technology-based firms. ***International Journal of Industrial Organization***, 24(2): 381–400.

Füller, J., & Matzler, K. 2007. Virtual product experience and customer participation—A chance for customer-centred, really new products. ***Technovation***, 27(6): 378–387.

Funk, R. J. 2014. Making the most of where you are: Geography, networks, and innovation in organizations. ***Academy of Management Journal***, *57*(1), 193–222.

Gans, J. S., & Stern, S. 2003. The product market and the market for "ideas": Commercialization strategies for technology entrepreneurs. ***Research Policy***, 32(2 SPEC.): 333–350.

Garriga, H., von Krogh, G., & Spaeth, S. 2013. How constraints and knowledge impact open innovation. ***Strategic Management Journal***, 34(9): 1134–1144.

Gassmann, O. 2006. Editorial: Opening up the innovation process: Towards an agenda. ***R and D Management***, 36(3): 223–228.

Gassmann, O., Enkel, E., & Chesbrough, H. 2010. The future of open innovation. ***R&D Management***, 40(3): 213–221.

Gately, C. G., & Cunningham, J. A. 2014. Building intellectual capital in incubated technology firms. ***Journal of Intellectual Capital***, *15*(4), 516–536.

Gavetti, G., & Levinthal, D. 2000. Looking forward and looking backward: Cognitive and experiential search. ***Administrative Science Quarterly***, *45*(1), 113–137.

Geisser, S. 1975. The predictive sample reuse method with applications. ***Journal of the American Statistical Association***, 70(350): 320–328.

Germain, R., Dröge, C., & Daugherty, P. J. 1994. The effect of just-in-time selling on organizational structure: An empirical investigation. ***Journal of Marketing Research***, 31(4): 471–483.

Gkypali, A., Kokkinos, V., Bouras, C., & Tsekouras, K. 2016. Science and technology parks and regional innovation performance in fiscal austerity era: Less is more? ***Small Business Economics***, 47(2): 313–330.

Glückler, J. 2013. Knowledge, networks and space: Connectivity and the problem of non-interactive learning. ***Regional Studies***, 47(6): 880–894.

Goerzen, A., & Beamish, P. W. 2005. The effect of alliance network diversity on multinational enterprise performance. ***Strategic Management Journal***, 26(4): 333–354.

Götz, O., Liehr-Gobbers, K., & Krafft, M. 2010. Evaluation of structural equation models using the Partial Least Squares (PLS) approach. In V. Esposito Vinzi, W. W. Chin, J. Henseler, & H. Wang (Eds.), ***Handbook of Partial Least Squares***: 691–711. Berlin, Heidelberg: Springer Berlin Heidelberg.

Grando, A., & Belvedere, V. 2006. District's manufacturing performances: A comparison among large, small-to-medium-sized and district enterprises. ***International Journal of Production Economics***, 104(1): 85–99.

Granovetter, M. 1985. Economic action and social structure: The problem of embeddedness. ***American Journal of Sociology***, 91(3): 481–510.

Grant, R. M. 1991. The resource-based theory of competitive advantage: Implications for strategy formulation. ***California Management Review***, 33(3): 114–135.

Grant, R. M. 1996. Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. ***Organization Science***, 7(4): 375–387.

Greco, M., Grimaldi, M., & Cricelli, L. 2016. An analysis of the open innovation effect on firm performance. ***European Management Journal***, 34(5): 501–516.

Green, K. M., Covin, J. G., & Slevin, D. P. 2008. Exploring the relationship between strategic reactiveness and entrepreneurial orientation: The role of structure-style fit. ***Journal of Business Venturing***, 23(3): 356–383.

Grimpe, C., & Sofka, W. 2009. Search patterns and absorptive capacity: Low- and high-technology sectors in European countries. ***Research Policy***, 38(3): 495–506.

Gronum, S., Verreynne, M. L., & Kastelle, T. 2012. The role of networks in small and medium-sized enterprise innovation and firm performance. ***Journal of Small Business Management***, 50(2): 257–282.

Gupta, A. K., & Govindarajan, V. 1984. Business unit strategy, managerial characteristics, and business unit effectiveness at strategy implementation. ***The Academy of Management Journal***, 27(1): 25–41.

Hagedoorn, J. 1993. Understanding the rationale of strategic technology partnering: Interorganizational modes of cooperation and sectoral differences. ***Strategic Management Journal***, 14(5): 371–385.

Hagedoorn, J., & Zobel, A.-K. 2015. The role of contracts and intellectual property rights in open innovation. ***Technology Analysis & Strategic Management***, 27(9): 1050–1067.

Hagedoorn, J., Cloodt, D., & van Kranenburg, H. 2005. Intellectual property rights and the governance of international R&D partnerships. ***Journal of International Business Studies***, 36(2): 175–186.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. 2014. ***Multivariate data analysis*** (7th ed.). Essex: Pearson.

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. 2017a. ***A primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*** (2nd ed.). Thousand Oaks, CA: SAGE Publications Ltd.

Hair, J. F., Sarstedt, M., Ringle, C. M., & Gudergan, S. P. 2017b. ***Advanced issues in Partial Least Squares Structural Equation Modeling***. Thousand Oaks, CA: SAGE Publications Ltd.

Hall, B., Helmers, C., Rogers, M., & Sena, V. 2014. The choice between formal and informal intellectual property: A review. ***Journal of Economic Literature***, 52(2): 375–423.

Han, C., Porterfield, T., & Li, X. 2012. Impact of industry competition on contract manufacturing: An empirical study of U.S. manufacturers. ***International Journal of Production Economics***, 138(1): 159–169.

Hansson, F., Husted, K., & Vestergaard, J. 2005. Second generation science and technology parks: From structural holes jockeys to social capital catalysts of the knowledge society. ***Technovation***, 25(9): 1039–1049.

Hardesty, D. M., & Bearden, W. O. 2004. The use of expert judges in scale development. ***Journal of Business Research***, 57(2): 98–107.

Harison, E., & Koski, H. 2010. Applying open innovation in business strategies: Evidence from Finnish software firms. ***Research Policy***, 39(3): 351–359.

Harman, H. H. 1967. ***Modern factor analysis***. Chicago, IL: University of Chicago Press.

Harrison, J. S., Hitt, M. A., Hoskisson, R. E., & Ireland, R. D. 2001. Resource complementarity in business combinations: Extending the logic to organizational alliances. ***Journal of Management***, 27(6): 679–690.

Helfat, C. E., Finkelstein, S., Mitchell, W., Peteraf, M. A., Singh, H., et al. 2007. ***Dynamic capabilities: Understanding strategic chance in organizations***. New York, NY: John Wiley & Sons, Ltd.

Henkel, J. 2006. Selective revealing in open innovation processes: The case of embedded Linux. ***Research Policy***, 35(7): 953–969.

Henkel, J., Baldwin, C. Y., & Shih, W. C. 2013. IP modularity: Profiting from innovation by aligning product architecture with intellectual property. ***California Management Review***, 55(4): 65–82.

Henkel, J., Schöberl, S., & Alexy, O. 2014. The emergence of openness: How and why firms adopt selective revealing in open innovation. ***Research Policy***, 43(5): 879–890.

Henseler, J., & Fassott, G. 2010. Testing Moderating Effects in PLS path models: An illustration of available procedures. In V. Esposito Vinzi, W. W. Chin, J. Henseler, & H. Wang (Eds.), ***Handbook of Partial Least Squares***: 713–735. Berlin, Heidelberg: Springer Berlin Heidelberg.

Henseler, J., Ringle, C. M., & Sinkovics, R. R. 2009. The use of Partial Least Squares Path Modeling in international marketing. In R. R. Sinkovics & P. N. Ghauri (Eds.), ***New Challenges to International Marketing (Advances in International Marketing, Volume 20)***: 277–319. Bingley: Emerald Group Publishing Limited.

Henttonen, K., Hurmelinna-Laukkanen, P., & Ritala, P. 2016. Managing the appropriability of R&D collaboration. ***R&D Management***, 46(S1): 145–158.

Hernández-Espallardo, M., Sánchez-Pérez, M., & Segovia-López, C. 2011. Exploitation- and exploration-based innovations: The role of knowledge in inter-firm relationships with distributors. ***Technovation***, 31(5): 203–215.

Hertzfeld, H. R., Link, A. N., & Vonortas, N. S. 2006. Intellectual property protection mechanisms in research partnerships. ***Research Policy***, 35(6): 825–838.

Hewitt-Dundas, N. 2006. Resource and capability constraints to innovation in small and large plants. ***Small Business Economics***, 26(3): 257–277.

Hienerth, C. 2006. The commercialization of user innovations: The development of the rodeo kayak industry. ***R and D Management***, 36(3): 273–294.

Hillebrand, B., & Biemans, W. G. 2004. links between internal and external cooperation in product development: An exploratory study. ***Journal of Product Innovation Management***, 21(2): 110–122.

Hinkin, T. R. 1998. A brief tutorial on the development of measures for use in survey questionnaires. ***Organizational Research Methods***, 1(1): 104–121.

Hochleitner, F. P., Arbussà, A., & Coenders, G. 2017. Inbound open innovation in SMEs: Indicators, non-financial outcomes and entry-timing. ***Technology Analysis & Strategic Management***, 29(2): 204–218.

Hohberger, J., Almeida, P., & Parada, P. 2015. The direction of firm innovation: The contrasting roles of strategic alliances and individual scientific collaborations. ***Research Policy***, 44(8): 1473–1487.

Hormiga, E., Batista-Canino, R. M., & Sánchez-Medina, A. 2011. The impact of relational capital on the success of new business start-ups. ***Journal of Small Business Management***, 49(4): 617–638.

Howells, J. 2006. Intermediation and the role of intermediaries in innovation. ***Research Policy***, 35(5): 715–728.

Hsieh, K.N., & Tidd, J. 2012. Open versus closed new service development: The influences of project novelty. ***Technovation***, 32(11): 600–608.

Hsu, L.C., & Wang, C.H. 2012. Clarifying the effect of intellectual capital on performance: The mediating role of dynamic capability. ***British Journal of Management***, 23(2): 179–205.

Hu, L., & Bentler, P. M. 1995. Evaluating model fit. In R. H. Hoyle (Ed.), ***Structural Equation Modeling: Concepts, Issues, and Applications***: 76–99. Thousand Oaks, CA.

Huang, F., & Rice, J. 2009. The role of absorptive capacity in facilitating "open innovation" outcomes: A study of Australian SMES in the manufacturing sector. ***International Journal of Innovation Management***, 13(2): 201–220.

Huang, Y., & Wu, Y. J. 2010. Intellectual capital and knowledge productivity: The Taiwan biotech industry. ***Management Decision***, 48(4): 580–599.

Huber, G. P., & Power, D. J. 1985. Retrospective reports of strategic-level managers: Guidelines for increasing their accuracy. ***Strategic Management Journal***, 6(2): 171–180.

Huergo, E., & Jaumandreu, J. 2004. How does probability of innovation change with firm age? ***Small Business Economics***, 22(3): 193–207.

Huggins, R., & Johnston, A. 2009. Knowledge networks in an uncompetitive region: SME innovation and growth. ***Growth and Change***, *40*(2), 227–259.

Huggins, R., & Weir, M. 2007. Managing intellectual assets in SMEs: Evaluating the scope for policy intervention. ***International Journal of Learning and Intellectual Capital***, *4*(4), 412–429.

Huggins, R., & Weir, M. 2012. Intellectual assets and small knowledge-intensive business service firms. ***Journal of Small Business and Enterprise Development***, *19*(1), 92–113.

Hughes, M., Morgan, R. E., Ireland, R. D., & Hughes, P. 2014. Social capital and learning advantages: A problem of absorptive capacity. ***Strategic Entrepreneurship Journal***, 8(3): 214–233.

Hung, C.-L. 2017. Social networks, technology ties, and gatekeeper functionality: Implications for the performance management of R&D projects. ***Research Policy***, 46(1): 305–315.

Hung, K. P., & Chou, C. 2013. The impact of open innovation on firm performance: The moderating effects of internal R&D and environmental turbulence. ***Technovation***, 33(10–11): 368–380.

Hurmelinna, P., Kyläheiko, K., & Jauhiainen, T. 2007. The janus face of the appropriability regime in the protection of innovations: Theoretical re-appraisal and empirical analysis. ***Technovation***, 27(3): 133–144.

Hurmelinna-Laukkanen, P., Olander, H., Blomqvist, K., & Panfilii, V. 2012. Orchestrating R&D networks: Absorptive capacity, network stability, and innovation appropriability. ***European Management Journal***, 30(6): 552–563.

Hurmelinna-Laukkanen, P., Sainio, L. M., & Jauhiainen, T. 2008. Appropriability regime for radical and incremental innovations. ***R&D Management***, 38(3): 278–289.

Huselid, M. A. 1995. The impact of human resource management practices on turnover, productivity, and corporate financial performance. ***Academy of Management Journal***, *38*(3), 635–672.

Hwang, J., & Lee, Y. 2010. External knowledge search, innovative performance and productivity in the Korean ICT sector. ***Telecommunications Policy***, 34(10): 562–571.

Hyvattinen, H. 2006. Interface standards and creating innovation markets - Implications on SMEs in a technology programme. ***Technovation***, *26*(2), 262–273.

Iansiti, M. 1997. ***Technology integration: Making critical choices in a dynamic world***. Boston, MA: Harvard Business School Press.

Isaksson, O. H. D., Simeth, M., & Seifert, R. W. 2016. Knowledge spillovers in the supply chain: Evidence from the high-tech sectors. ***Research Policy***, 45(3): 699–706.

Jaffe, A. B. 1986. Technological opportunity and spillovers of R & D: Evidence from firms' patents, profits, and market value. ***The American Economic Review***, *76*(5), 984–1001.

James, S. D., Leiblein, M. J., & Lu, S. 2013. How firms capture value from their innovations. ***Journal of Management***, 39(5): 1123–1155.

Jansen, J. J. P., van den Bosch, F. a J., & Volberda, H. W. 2005. Managing potential and realised absorptive capacity: How do organisational antecedents matter? ***Academy of Management Journal***, 48(6): 999–1015.

Jaworski, B., & Kohli, A. K. 1993. Market orientation: Antecedents and consequences. ***The Journal of Marketing***, 57(3): 53–70.

Jensen, P. H., & Webster, E. 2009. Knowledge management: Does capture impede creation? ***Industrial and Corporate Change***, 18(4): 701–727.

Jiménez-Jiménez, D., & Sanz-Valle, R. 2008. Could HRM support organizational innovation? ***The International Journal of Human Resource Management***, 19(7): 1208–1221.

Jolink, M., & Dankbaar, B. 2010. Creating a climate for inter-organizational networking through people management. ***The International Journal of Human Resource Management***, 21(9): 1436–1453.

Kaminski, P. C., de Oliveira, A. C., & Lopes, T. M. 2008. Knowledge transfer in product development processes: A case study in small and medium enterprises (SMEs) of the metal-mechanic sector from São Paulo, Brazil. ***Technovation***, 28(1): 29–36.

Kang, S.-C., Morris, S. S., & Snell, S. A. 2007. Relational archetypes, organizational learning, and value creation: Extending the human resource architecture. ***The Academy of Management Review***, 32(1): 236–256.

Katila, R. 2002. New product search over time: Past ideas in their prime? ***Academy of Management Journal***, 45(5): 995–1010.

Katila, R., & Ahuja, G. 2002. Something old, something new: A longitudinal study of search behavior and new product introduction. ***Academy of Management Journal***, 45(6): 1183–1194.

Katila, R., Rosenberger, J. D., & Eisenhardt, K. M. 2008. Swimming with Sharks: Technology ventures, defense mechanisms and corporate relationships. ***Administrative Science Quarterly***, 53(2): 295–332.

Katz, M. L., & Shapiro, C. 1986. Technology adoption in the presence of network externalities. ***Journal of Political Economy***, 94(4): 822–841.

Katz, R., & Allen, T. J. 1982. Investigating the Not Invented Here (NIH) syndrome: A look at the performance, tenure, and communication patterns of 50 R&D project groups. ***R&D Management***, 12(1): 7–20.

Kauffeld-Monz, M. 2005. Knowledge spillovers within regional networks of innovation and the contribution made by public research. ***IUP Journal of Knowledge Management***, 7(3&4): 41–63.

Kaufman, A., Wood, C. H., & Theyel, G. 2000. Collaboration and technology linkages: A strategic supplier typology. ***Strategic Management Journal***, 21(6): 649–663.

Kaufmann, A., & Tödtling, F. 2001. Science–industry interaction in the process of innovation: The importance of boundary-crossing between systems. ***Research Policy***, 30(5): 791–804.

Kaufmann, A., & Tödtling, F. 2002. How effective is innovation support for SMEs? An analysis of the region of Upper Austria. ***Technovation***, 22(3): 147–159.

Keeble, D., & Wilkinson, F. 1999. Collective learning and knowledge development in the evolution of regional clusters of high technology SMEs in Europe. ***Regional Studies***, 33(4): 295–303.

Kelley, D. 2009. Adaptation and organizational connectedness in corporate radical innovation programs. ***Journal of Product Innovation Management***, 26(5): 487–501.

Keupp, M. M., & Gassmann, O. 2009. Determinants and archetype users of open innovation. ***R&D Management***, 39(4): 331–341.

Khavandkar, E., & Khavandkar, J. 2015. Diffusion of intellectual capital exploitation practices in knowledge ecosystems: Insights from ICT SMEs located in the UK science and technology parks. ***11th Interdisciplinary Workshop on Intangibles, Intellectual Capital and Extra-Financial Information***. Athens: European Institute for Advanced Studies in Management.

Khavandkar, E., & Khavandkar, J. 2016. Intellectual capital management practices, proximity and adoption mechanisms in knowledge ecosystems: SMEs perspective. ***12th Interdisciplinary Workshop on Intangibles, Intellectual Capital and Extra-Financial Information***. Saint Petersburg: European Institute for Advanced Studies in Management.

Khavandkar, E., Theodorakopoulos, N., & Khavandkar, J. 2016. Intellectual capital management practices, diffusion kinetics and adaptation mechanisms in knowledge ecosystems: The influencing shapers of co-specialization in SMES. ***RENT XXX - Research in Entrepreneurship and Small Business***. Antwerp: European Institute for Advanced Studies in Management.

Khavandkar, E., Theodorakopoulos, N., Hart, M., & KhavandKar, J. 2014. Capacity building for diffusion of intellectual capital management practices in science and technology parks. ***RENT XXVIII - Research in Entrepreneurship***

and Small Business. Luxembourg City: European Institute for Advanced Studies in Management.

Khavandkar, E., Theodorakopoulos, N., Hart, M., & Preston, J. 2016. Leading the diffusion of intellectual capital management practices in science and technology parks. In H. Shipton, P. Budhwar, P. Sparrow, & A. Brown (Eds.), ***Human Resource Management, Innovation and Performance***: 213–231. London: Palgrave Macmillan UK.

Khavandkar, J. 2013. Intellectual capital, higher education, science and technology parks and techno-based enterprises. In J. Khavandkar (Ed.), ***Intellectual capital management: Global perspectives on higher education, science and technology***: 3–11. Tehran: ISESCO and UNESCO.

Khavandkar, J., Khavandkar, E., & Motaghi, A. 2013. ***Intellectual capital: Management, development and measurement models*** (3rd ed.). Tehran: Ministery of Science, Research and Technology.

Kimberly, J. R., & Evanisko, M. J. 1981. Organizational innovation: The influence of individual, organizational and contextual factors on hospital adoption of technological and administrative innovations. ***Academy of Management Journal***, 24(4): 689–713.

Klein, B., Crawford, R. G., & Alchian, A. A. 1978. Vertical integration, appropriable rents, and the competitive contracting process. ***The Journal of Law & Economics***, 21(2): 297–326.

Kline, D. 2003. Sharing the corporate crown jewels. ***MIT Sloan Management Review***, 44(3): 89–93.

Kline, S. J., & Rosenberg, N. 1986. An overview of innovation. In R. Landau & N. Rosenberg (Eds.), ***The positive sum strategy: harnessing technology for economic growth***. Washington, DC: National Academy Press.

Knudsen, M. P., & Mortensen, T. B. 2011. Some immediate – but negative – effects of openness on product development performance. ***Technovation***, 31(1): 54–64.

Koberg, C. S., Detienne, D. R., & Heppard, K. A. 2003. An empirical test of environmental, organizational, and process factors affecting incremental and radical innovation. ***The Journal of High Technology Management Research***, 14(1): 21–45.

Kobrin, S. J. 1991. An empirical analysis of the determinants of global integration. ***Strategic Management Journal***, 12(S1): 17–31.

Kogut, B. 1988. Joint ventures: Theoretical and empirical perspectives. ***Strategic Management Journal***, 9(4): 319–332.

Kogut, B. 2000. The networks as knowledge: generative rules and the emergence of structure, ***Strategic Management Journal***, 21(3): 405–425.

Köhler, C., Sofka, W., & Grimpe, C. 2012. Selective search, sectoral patterns, and the impact on product innovation performance. ***Research Policy***, 41(8): 1344–1356.

Kostova, T., & Roth, K. 2003. Social Capital in Multinational Corporations and a Micro-Macro Model of Its Formation. ***The Academy of Management Review***, 28(2): 297–317.

Krippendorff, K. 2007. Computing Krippendorff's alpha reliability. Departmental papers (ASC). http://repository.upenn.edu/asc_papers/43 [accessed: 03.010.2015].

Kumar, N., Stern, L. W., & Achrol, R. S. 1992. Assessing Reseller Performance from the Perspective of the Supplier. ***Journal of Marketing Research***, 29(2): 238–253.

Lagendijk, A., & Oinas, P. 2005. Proximity, external relations, and local economic development. In A. Lagendijk & P. Oinas (Eds.), ***Proximity, Distance and Diversity. Issues on Economic Interaction and Local Development***: 3–22. Farnham: Ashgate Publishing.

Lai, H.-C., & Shyu, J. Z. 2005. A comparison of innovation capacity at science and technology parks across the Taiwan Strait: the case of Zhangjiang High-Tech Park and Hsinchu Science-based Industrial Park. ***Technovation***, *25*(7), 805–813.

Lane, P. J., & Lubatkin, M. 1998. Relative absorptive capacity and interorganizational learning. ***Strategic Management Journal***, 19(5): 461–477.

Lane, P. J., Koka, B. R., & Pathak, S. 2006. The reification of Absorptive Capacity: A critical review and rejuvenatino of the construct. ***Academy of Management Review***, 31(4): 833–863.

Laursen, K. 2012. Keep searching and you'll find: What do we know about variety creation through firms' search activities for innovation? ***Industrial and Corporate Change***, 21(5): 1181–1220.

Laursen, K., & Salter, A. 2004. Searching high and low: What types of firms use universities as a source of innovation? ***Research Policy***, 33(8): 1201–1215.

Laursen, K., & Salter, A. 2006. Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. ***Strategic Management Journal***, 27(2): 131–150.

Laursen, K., & Salter, A. J. 2014. The paradox of openness: Appropriability, external search and collaboration. ***Research Policy***, 43(5): 867–878.

Lavie, D. 2006. The competitive advantage of interconnected firms: An Extension of the Resource-based view. ***The Academy of Management Review***, 31(3): 638–658.

Lavie, D., Haunschild, P. R., & Khanna, P. 2012. Organizational differences, relational mechanisms, and alliance performance. ***Strategic Management Journal***, 33(13): 1453–1479.

Lawson, B., Samson, D., & Roden, S. 2012. Appropriating the value from innovation: Inimitability and the effectiveness of isolating mechanisms. ***R&D Management***, 42(5): 420–434.

Lazzarotti, V., & Manzini, R. 2009. Different modes of open innovation: A theoretical framework and an empirical study. ***International Journal of Innovation Management***, 13(4): 615–636.

Lazzarotti, V., Manzini, R., & Pellegrini, L. 2011. Firm-specific factors and the openness degree: A survey of Italian firms. ***European Journal of Innovation Management***, 14(4): 412–434.

Lazzarotti, V., Manzini, R., & Pellegrini, L. 2015. Is your open-innovation successful? The mediating role of a firm's organizational and social context. ***The International Journal of Human Resource Management***, 26(19): 2453–2485.

Leana, C. R., & van Buren, H. J. 1999. Organizational social capital and employment practices. ***The Academy of Management Review***, 24(3): 538–555.

Lee, J.-S., Park, J.-H., & Bae, Z.-T. 2017. The effects of licensing-in on innovative performance in different technological regimes. ***Research Policy***, 46(2): 485–496.

Lee, S., Park, G., Yoon, B., & Park, J. 2010. Open innovation in SMEs—An intermediated network model. ***Research Policy***, 39(2): 290–300.

Legislation.gov.uk. 2006. ***Companies Act 2006***.

Leiponen, A., & Byma, J. 2009. If you cannot block, you better run: Small firms, cooperative innovation, and appropriation strategies. ***Research Policy***, 38(9): 1478–1488.

Leiponen, A., & Helfat, C. E. 2010. Innovation objectives, knowledge sources, and the benefits of breadth. ***Strategic Management Journal***, 31(2): 224–236.

Leischnig, A., Geigenmueller, A., & Lohmann, S. 2014. On the role of alliance management capability, organizational compatibility, and interaction quality in interorganizational technology transfer. ***Journal of Business Research***, 67(6): 1049–1057.

Leitner, K. H. 2011. The effect of intellectual capital on product innovativeness in SMEs. ***International Journal of Technology Management***, 53(1): 1–18.

Leonard-Barton, D. 1992. Core capabilities and core rigidities: A paradox in managing new product development. ***Strategic Management Journal***, 13(S1): 111–125.

Levin, D. Z., & Cross, R. 2004. The strength of weak ties you can trust: the mediating role of trust in effective knowledge transfer. ***Management Science***, 50(11): 1477–1490.

Levin, R. C., Klevorick, A. K., Nelson, R. R., & Winter, S. G. 1987. Appropriating the returns from industrial research and development. ***Brookings Papers on Economic Activity***, (3): 783–831.

Levinthal, D. A., & March, J. G. 1993. The myopia of learning. ***Strategic Management Journal***, 14(S2): 95–112.

Levitt, B., & March, J. G. 1988. Organizational learning. ***Annual Review of Sociology***, 14(1): 319–338.

Li, Q., Maggitti, P. G., Smith, K. G., Tesluk, P. E., & Katila, R. 2013. Top management attention to innovation: The role of search selection and intensity in new product introductions. ***Academy of Management Journal***, 56(3): 893–916.

Li, T., & Calantone, R. J. 1998. The impact of market knowledge competence on new product advantage: Conceptualization and empirical examination. ***Journal of Marketing***, 62(4): 13–29.

Liebeskind, J. P. 1996. Knowledge, strategy, and the theory of the firm. ***Strategic Management Journal***, *17*(S2), 93–107.

Liefner, I., Hennemann, S., & Xin, L. 2006. Cooperation in the innovation process in developing countries: Empirical evidence from Zhongguancun, Beijing. ***Environment and Planning A***, 38(1): 111–130.

Lin, R., Che, R., & Ting, C. 2012. Turning knowledge management into innovation in the high-tech industry. ***Industrial Management & Data Systems***, 112(1): 42–63.

Lindelöf, P., & Löfsten, H. 2001. Science parks in Sweden - industrial renewal and development? ***R&D Management***, *31*(3), 309–322.

Lindelöf, P., & Löfsten, H. 2004. Proximity as a resource base for competitive advantage: University–industry links for technology transfer. ***The Journal of Technology Transfer***, 29(3): 311–326.

Link, A. N., & Scott, J. T. 2003. U.S. science and technology parks: The diffusion of an innovation and its effects on the academic missions of universities. ***International Journal of Industrial Organization***, *21*(9), 1323–1356.

Lippman, S. A., & Rumelt, R. P. 1982. Uncertain imitability: An analysis of interfirm differences in efficiency under competition. ***The Bell Journal of Economics***, 13(2): 418–438.

Liu, C.-H. 2013. The processes of social capital and employee creativity: Empirical evidence from intraorganizational networks. ***The International Journal of Human Resource Management***, 24(20): 3886–3902.

Löfsten, H., & Lindelöf, P. 2001. Science and technology parks in Sweden – Industrial renewal and development? ***R&D Management***, 31(3): 309–322.

Löfsten, H., & Lindelöf, P. 2002. Science and technology parks and the growth of new technology-based firms—academic-industry links, innovation and markets. ***Research Policy***, 31(6): 859–876.

Löfsten, H., & Lindelöf, P. 2003. Determinants for an entrepreneurial milieu: Science and technology parks and business policy in growing firms. ***Technovation***, 23(1): 51–64.

Löfsten, H., & Lindelöf, P. 2005. R&D networks and product innovation patterns—academic and non-academic new technology-based firms on Science and technology parks. ***Technovation***, 25(9): 1025–1037.

Love, J. H., & Roper, S. 2004. The organisation of innovation: Collaboration, cooperation and multifunctional groups in UK and German manufacturing. ***Cambridge Journal of Economics***, 28(3): 379–395.

Love, J. H., & Roper, S. 2015. SME innovation, exporting and growth: A review of existing evidence. ***International Small Business Journal***, 33(1): 28–48.

Love, J. H., Roper, S., & Vahter, P. 2014. Learning from openness: The dynamics of breadth in external innovation linkages. ***Strategic Management Journal***, 35(11): 1703–1716.

Lyles, M. A., & Schwenk, C. R. 1992. Top management, strategy and organizational knowledge structures. ***Journal of Management Studies***, 29(2): 155–174.

Lynn, G. S., Morone, J., & Paulson, A. S. 1996. Marketing and discontinuous innova- tion: the probe and learn process. ***California Management Review***, 38(3): 8–37.

Lynn, L. H., Mohan Reddy, N., & Aram, J. D. 1996. Linking technology and institutions: The innovation community framework. ***Research Policy***, 25(1): 91–106.

Macdonald, S. 1987. British Science and technology parks: Reflections on the Politics of High Technology. ***R&D Management***, 17(1): 25–37.

MacKinnon, D. P., Lockwood, C. M., Hoffmann, J. M., West, S. G., & Sheets, V. 2002. A comparison of methods to test the significance of mediation and other intervening variable effects. ***Psychological Methods***, 7(1): 83–104.

Madrid-Guijarro, A., Garcia, D., & Van Auken, H. 2009. Barriers to innovation among Spanish manufacturing SMEs. ***Journal of Small Business Management***, 47(4): 465–488.

Maes, J., & Sels, L. 2014. SMEs' radical product innovation: The role of internally and externally oriented knowledge capabilities. ***Journal of Small Business Management***, 52(1): 141–163.

Malairaja, C., & Zawdie, G. 2008. Science and technology parks and university–industry collaboration in Malaysia. ***Technology Analysis & Strategic Management***, 20(6): 727–739.

Malhotra, N. K., Kim, S. S., & Patil, A. 2006. Common method variance in IS research: A comparison of alternative approaches and a reanalysis of past research. ***Management Science***, 52(12): 1865–1883.

Malmberg, A., & Maskell, P. 2002. The elusive concept of localization economies: Towards a knowledge-based theory of spatial clustering. ***Environment and Planning A***, 34(3): 429–449.

Mansfield, E., Schwartz, M., & Wagner, S. 1981. Imitation costs and patents: An empirical study. ***The Economic Journal***, *91*(364), 907–918.

March, J. G. 1991. Exploration and exploitation in organizational learning. ***Organization Science***.

Mardia, K. V. 1970. Measures of multivariate skewness and kurtosis with applications. ***Biometrika***, 57(3): 519–530.

Martin, S., & Scott, J. T. 2000. The nature of innovation market failure and the design of public support for private innovation. ***Research Policy***, 29(4): 437–447.

Martín-de Castro, G. 2015. Knowledge management and innovation in knowledge-based and high-tech industrial markets: The role of openness and absorptive capacity. ***Industrial Marketing Management***, 47(Supplement C): 143–146.

Martini, A., Neirotti, P., & Appio, F. P. 2017. Knowledge searching, integrating and performing: Always a tuned trio for innovation? ***Long Range Planning***, 50(2): 200–220.

Masiello, B., Izzo, F., & Canoro, C. 2015. The structural, relational and cognitive configuration of innovation networks between SMEs and public research organisations. ***International Small Business Journal***, 33(2): 169–193.

Más-Ruiz, F. J., Nicolau-Gonzálbez, J. L., & Ruiz-Moreno, F. 2005. Asymmetric rivalry between strategic groups: response, speed of response and ex ante vs. ex post competitive interaction in the Spanish bank deposit market. ***Strategic Management Journal***, *26*(8), 713–745.

Massey, D., Quintas, P., & Wield, D. 1992. ***High tech fantasies: Science and technology parks in society, science and space***. London: Routledge.

Matt, M., & Wolff, S. 2004. Incentives, coordination and learning in government-sponsored vs. spontaneous inter-firm research cooperation. ***International Journal of Technology Management***, *27*(8), 694–711.

McClelland, G. H., & Judd, C. M. 1993. Statistical difficulties of detecting interactions and moderator effects. ***Psychological Bulletin***, 114(2): 376–390.

McGrath, R. G. 2001. Exploratory learning, innovative capacity and managerial oversight. ***The Academy of Management Journal***, 44(1): 118–131.

Mention, A. L. 2011. Co-operation and co-opetition as open innovation practices in the service sector: Which influence on innovation novelty? ***Technovation***, 31(1): 44–53.

Mesquita, L. F., & Lazzarini, S. G. 2008. Horizontal and vertical relationship in developing economies: implications for SMEs' access to global markets. ***Academy of Management Journal,*** *51*(2), 359–380.

Mian, S. A. 1996. Assessing value-added contributions of university technology business incubators to tenant firms. ***Research Policy***, 25(3): 325–335.

Mina, A., Bascavusoglu-Moreau, E., & Hughes, A. 2014. Open service innovation and the firm's search for external knowledge. ***Research Policy***, 43(5): 853–866.

Miotti, L., & Sachwald, F. 2003. Co-operative R&D: Why and with whom?: An integrated framework of analysis. ***Research Policy***, 32(8): 1481–1499.

Miozzo, M., Desyllas, P., Lee, H., & Miles, I. 2016. Innovation collaboration and appropriability by knowledge-intensive business services firms. ***Research Policy***, 45(7): 1337–1351.

Mitchell, R. K., Mitchell, J. R., & Smith, J. B. 2008. Inside opportunity formation: Enterprise failure, cognition, and the creation of opportunities. ***Strategic Entrepreneurship Journal***, 2(3): 225–242.

Mole, K. F., Hart, M. & Roper, S. 2014. When moving information online diminishes change: advisory services to SMEs. ***Policy Studies****, 35(2), 172–191.*

Molina-Morales, F. X., García-Villaverde, P. M., & Parra-Requena, G. 2014. Geographical and cognitive proximity effects on innovation performance in SMEs: A way through knowledge acquisition. ***International Entrepreneurship and Management Journal***, 10(2): 231–251.

Monck, C. S. P., Porter, R. B., Quintas, P., Storey, D., & Wynarczyk, P. 1988. ***Science and technology parks and the growth of high-technology firms***. London: Croom Helm.

Monteiro, L. F., Mol, M. J., & Birkinshaw, J. 2017. Ready to be open? Explaining the firm-level barriers to benefiting from openness to external knowledge. ***Long Range Planning***, 50(2): 282–295.

Moodysson, J. 2008. principles and practices of knowledge creation: On the organization of "Buzz" and "Pipelines" in life science communities. ***Economic Geography***, 84(4): 449–469.

Mu, J., & Di Benedetto, C. A. 2011. Strategic orientations and new product commercialization: Mediator, moderator, and interplay. ***R and D Management***, 41(4): 337–359.

Musteen, M., Ahsan, M., & Park, T. 2017. SMEs, intellectual capital, and offshoring of service activities: An empirical investigation. ***Management International Review***, 57(4): 603–630.

Nadkarni, S., & Narayanan, V. K. 2007. Strategic schemas, strategic flexibility, and firm performance: the moderating role of industry clockspeed. ***Strategic Management Journal***, *28*(3), 243–270.

Nahapiet, J., & Ghoshal, S. 1998. Social capital, intellectual capital, and the organizational advantage. ***The Academy of Management Review***, 23(2): 242–266.

Narula, R. 2004. R&D collaboration by SMEs: New opportunities and limitations in the face of globalisation. ***Technovation***, *24*(2), 153–161.

Netemeyer, R. G., Bearden, W. O., & Sharma, S. 2003. ***Scaling Procedures: Issues and Applications***. Thousand Oaks, CA: SAGE Publications Inc.

Neuhäusler, P. 2012. The use of patents and informal appropriation mechanisms—Differences between sectors and among companies. ***Technovation***, 32(12): 681–693.

Nieto, M. J., & Santamaría, L. 2007. The importance of diverse collaborative networks for the novelty of product innovation. ***Technovation***, 27(6–7): 367–377.

Noh, Y. 2015. Financial effects of open innovation in the manufacturing industry. ***Management Decision***, 53(7): 1527–1544.

Nunnally, J. C., & Bernstein, I. H. 1994. ***Psychometric Theory*** (3rd ed.). New York, NY: McGraw-Hill.

Oakey, R. P. 2013. Open innovation and its relevance to industrial research and development: The case of high-technology small firms. ***International Small Business Journal***, 31(3): 319–336.

OECD. 2005. ***Oslo manual: Guidelines for collecting and interpreting innovation data***. Paris: OECD Publishing.

Onkelinx, J., Manolova, T. S., & Edelman, L. F. 2015. Human capital and SME internationalization: Empirical evidence from Belgium. ***International Small Business Journal***, 0266242615591856-.

Pallant, J. 2013. ***SPSS survival manual: Step-by-step guide to data analysis*** (5th ed.). Maidenhead: McGraw-Hill.

Parida, V., Westerberg, M., & Frishammar, J. 2012. Inbound open innovation activities in high-tech SMEs: the impact on innovation performance. ***Journal of Small Business Management***, 50(2): 283–309.

Parra-Requena, G., Molina-Morales, F. X., & García-Villaverde, P. M. 2010. The mediating effect of cognitive social capital on knowledge acquisition in clustered firms. ***Growth and Change***, 41(1): 59–84.

Patel, P. C., Fernhaber, S. A., McDougall-Covin, P. P., & van der Have, R. P. 2014. Beating competitors to international markets: The value of geographically balanced networks for innovation. ***Strategic Management Journal***, 35(5): 691–711.

Pavitt, K. 1984. Sectoral patterns of technical change: Towards a taxonomy and a theory. ***Research Policy***, 13(6): 343–373.

Pavitt, K. 1998. technologies, products and organization in the innovating firm: what Adam Smith tells us, and Joseph Schumpeter doesn't. ***Industrial and Corporate Change***, *7*(3), 433–452.

Pekkarinen, S., & Harmaakorpi, V. 2006. Building regional innovation networks: The definition of an age business core process in a regional innovation system. ***Regional Studies***, 40(4): 401–413.

Peltoniemi, M. 2006. Preliminary theoretical framework for the study of business ecosystems. ***Emergence: Complexity & Organization***, *8*(1), 10–19.

Penin, J. 2005. Patents versus ex post rewards: A new look. ***Research Policy***, 34(5): 641–656.

Peres, W., & Stumpo, G. 2000. Small and Medium-Sized manufacturing enterprises in Latin America and the Caribbean under the new economic model. ***World Development***, *28*(9), 1643–1655.

Petroni, G., Venturini, K., & Verbano, C. 2012. Open innovation and new issues in R&D organization and personnel management. ***The International Journal of Human Resource Management***, 23(1): 147–173.

Pfeffer, J., & Salancik, G. R. 1978. ***The external control of organizations***. New York, NY: Harper & Row.

Phelps, C., Heidl, R., & Wadhwa, A. 2012. Knowledge, networks, and knowledge networks. ***Journal of Management***, 38(4): 1115–1166.

Phillimore, J. 1999. Beyond the linear view of innovation in science park evaluation an analysis of Western Australian Technology Park. ***Technovation***, 19(11): 673–680.

Pisano, G. 2006. Profiting from innovation and the intellectual property revolution. ***Research Policy***, 35(8): 1122–1130.

Pisano, G. P., & Teece, D. J. 2007. How to capture value from innovation: Shaping intellectual property and industry architecture. ***California Management Review***, *50*(1), 278–296.

Pisano, G., & Verganti., R. 2008. Which kind of collaboration is right for you? ***Harvard Business Review***, 86(12): 78–87.

Podolny, J. M. 1994. Market uncertainty and the social character of economic exchange. ***Administrative Science Quarterly***, 39(3): 458–483.

Podsakoff, P. M., & Organ, D. W. 1986. Self-reports in organizational research: Problems and prospects. ***Journal of Management***, 12(4): 531–544.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. 2003. Common method biases in behavioral research: A critical review of the literature and recommended remedies. ***Journal of Applied Psychology***, 88(5): 879–903.foss

Porter, M. E. 1980. ***Competitive strategy: Techniques for analyzing industry and competitors***. New York, NY: Harper & Row.

Porter, M. E. 2001. Strategy and the Internet. ***Harvard Business Review***, *79*(3), 62–79.

Porter, M., & Ketels, C. H. M. 2003. *UK competitiveness: Moving to the next stage*. DTI Economics Paper.

Powel, J., & Swart, J. 2010. The elephant in the room: The implications of axiomatic approaches to knowedge scaling upon network learning and organizational knowledge. ***European Journal of International Management***, *4*(6), 621–643.

Powell, W. W., Koput, K. W., & Smith-Doerr, L. 1996. Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. ***Administrative Science Quarterly***, 41(1): 116–145.

Praest Knudsen, M., & Bøtker Mortensen, T. 2011. Some immediate but negative effects of openness on product development performance. ***Technovation***, 31(1): 54–64.

Priem, R. L., & Butler, J. E. 2001. Is the Resource-based "View" a useful perspective for strategic management research? ***The Academy of Management Review***, 26(1): 22–40.

Propris, L. De. 2002. Types of innovation and inter-firm co-operation. ***Entrepreneurship & Regional Development***, 14(4): 337–353.

Quinn, R. E., & Rohrbaugh, J. 1983. A spatial model of effectiveness criteria: Towards a competing values approach to organizational analysis. ***Management Science***, 29(3): 363–377.

Qureshi, I., & Compeau, D. 2009. Assessing between-group differences in information systems research: A comparison of covariance- and component-based SEM. ***MIS Quarterly***, 33(1): 197–214.

Radosevic, S., & Myrzakhmet, M. 2009. Between vision and reality: Promoting innovation through Technoparks in an emerging economy. ***Technovation***, 29(10): 645–656.

Ragatz, G. L., Handfield, R. B., & Petersen, K. J. 2002. Benefits associated with supplier integration into new product development under conditions of technology uncertainty. ***Journal of Business Research***, 55(5): 389–400.

Ramirez, M., & Li, X. 2009. Learning and sharing in a Chinese high-technology cluster: A study of inter-firm and intra-firm knowledge flows between R&D employees. ***New Technology, Work and Employment***, 24(3): 277–296.

Ratinho, T., & Henriques, E. 2010. The role of science and technology parks and business incubators in converging countries: Evidence from Portugal. ***Technovation***, *30*(4), 278–290.

Real, J. C., Roldán, J. L., & Leal, A. 2014. From entrepreneurial orientation and learning orientation to business performance: Analysing the mediating role of organizational learning and the moderating effects of organizational size. ***British Journal of Management***, 25(2): 186–208.

Reed, K. K., Lubatkin, M., & Srinivasan, N. 2006. Proposing and testing an Intellectual Capital-based view of the firm. ***Journal of Management Studies***, 43(4): 867–893.

Reuer, J. J., Zollo, M., & Singh, H. 2002. Post-formation dynamics in strategic alliances. ***Strategic Management Journal***, 23(2): 135–151.

Revilla, A. J., & Fernández, Z. 2012. The relation between firm size and R&D productivity in different technological regimes. ***Technovation***, *32*(11), 609–623.

Ringle, C. M., Wende, S., & Will, A. 2005. ***SmartPLS 2.0 (M3) beta***. Hamburg. http://www.smartpls.de.

Ritala, P., & Hurmelinna-Laukkanen, P. 2009. What's in it for me? Creating and appropriating value in innovation-related coopetition. ***Technovation***, 29(12): 819–828.

Roper, S., & Hewitt-Dundas, N. 2013. Catalysing open innovation through publicly-funded R&D: A comparison of university and company-based research centres. ***International Small Business Journal***, 31(3): 275–295.

Roper, S., & Hewitt-Dundas, N. 2015. Knowledge stocks, knowledge flows and innovation: Evidence from matched patents and innovation panel data. ***Research Policy***, 44(7): 1327–1340.

Roper, S., Love, J., & Bonner, K. 2016. ***Local and firm-level influences on innovation performance: Linkages, climate and externalities climate and externalities***. no. 40, Innovation and Exporting Series, The Enterprise Research Centre. https://www.enterpriseresearch.ac.uk/wp-content/uploads/2016/04/ERC-ResPap40-RoperLoveBonner.pdf [accessed: 08.10.2016].

Roper, S., Vahter, P., & Love, J. H. 2013. Externalities of openness in innovation. ***Research Policy***, 42(9): 1544–1554.

Rosenkopf, L., & Nerkar, A. 2001. Beyond local search: Boundary-spanning, exploration, and impact in the optical disk industry. ***Strategic Management Journal***, 22(4): 287–306.

Rosenkopf, L., Metiu, A., & George, V. P. 2001. From the bottom up? Technical committee activity and alliance formation. ***Administrative Science Quarterly***, 46(4): 748–772.

Rossi, C., Cricelli, L., Grimaldi, M., & Greco, M. 2015. The strategic assessment of intellectual capital assets: An application within Terradue Srl. ***Journal of Business Research***, 69(5): 1598–1603.

Rothaermel, F. T. 2001. Complementary assets, strategic alliances, and the incumbent's advantage: An empirical study of industry and firm effects in the biopharmaceutical industry. ***Research Policy***, 30(8): 1235–1251.

Rothaermel, F. T., & Deeds, D. L. 2004. Exploration and exploitation alliances in biotechnology: A system of new product development. ***Strategic Management Journal***, 25(3): 201–221.

Rungtusanatham, M., Anderson, J. C., & Dooley, K. J. 1999. Towards measuring the "SPC implementation/practice" construct: Some evidence of measurement quality. ***International Journal of Quality & Reliability Management***, 16(4): 301–329.

Sammarra, A., & Biggiero, L. 2008. Heterogeneity and specicity of inter-firm knowledge flows in innovation networks. ***Journal of Management Studies***, 45(4): 800–829.

Sánchez, P., Chaminade, C., & Olea, M. 2000. Management of intangibles – An attempt to build a theory. ***Journal of Intellectual Capital***, 1(4): 312–327.

Santamaria, L., & Surroca, J. 2011. Matching the goals and impacts of R&D collaboration. ***European Management Review***, 8(2): 95–109.

Savino, T., Messeni Petruzzelli, A., & Albino, V. 2017. Search and recombination process to innovate: A review of the empirical evidence and a research agenda. ***International Journal of Management Reviews***, 19(1): 54–75.

Sawang, S., & Unsworth, K. L. 2011. Why adopt now? Multiple case studies and survey studies comparing small, medium and large firms. ***Technovation***, *31*(10), 554–559.

Schilling, M. A. 1998. Technological lockout: An integrative model of the economic and strategic factors driving technology success and failure. ***The Academy of Management Review***, 23(2): 267–284.

Schumpeter, J. A. 1934. ***The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle***. New Brunswick, NJ: Transaction Books.

Schwartz, M., Peglow, F., Fritsch, M., & Günther, J. 2012. What drives innovation output from subsidized R&D cooperation? - Project-level evidence from Germany. ***Technovation***, 32(6): 358–369.

Scott, W. R. 1977. Effectiveness of organizational effectiveness studies. In P. S. Goodman & J. M. Pennings (Eds.), ***New Perspectives on Organizational Effectiveness***. San Francisco, CA: Jossey-Bass.

Shapiro, S. S., & Wilk, M. B. 1965. An analysis of variance test for normality (Complete Samples). ***Biometrika***, 52(3/4): 591–611.

Shin, D. 2001. An alternative approach to developing science parks: A case study from Korea. ***Regional Science***, *80*(1), 103–111.

Shipilov, A., & Danis, W. 2006. TMG social capital, strategic choice and firm performance. ***European Management Journal***, 24(1): 16–27.

Sidhu, J. S., Commandeur, H. R., & Volberda, H. W. 2007. The multifaceted nature of exploration and exploitation: Value of supply, demand, and spatial search for innovation. ***Organization Science***, 18(1): 20–38.

Siegel, D. S., Waldman, D., & Link, A. 2003. Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: An exploratory study. ***Research Policy***, 32(1): 27–48.

Siegel, D. S., Westhead, P., & Wright, M. 2003. Science and technology parks and the performance of new technology-based firms: A review of recent U.K. evidence and an agenda for future research. ***Small Business Economics***, 20(2): 177–184.

Simard, C., & West, J. 2006. Knowledge networks and the geographic locus of innovation. In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), ***Open Innovation: Researching a New Paradigm***: 220–240. Oxford University Press.

Simonin, B. L. 1999. Ambiguity and the process of knowledge transfer in strategic alliances. ***Strategic Management Journal***, 20(7): 595–623.

Sinkula, J. M. 1994. Market information processing and organizational learning. ***Journal of Marketing***, 58(1): 35–45.

Sirén, C. A., Kohtamaki, M., & Kuckertz, A. 2012. Exploration and exploitation strategies, profit performance, and the mediating role of strategic learning: Escaping the exploration trap. ***Strategic Entrepreneurship Journal***, 6: 18–41.

Sisodiya, S. R., Johnson, J. L., & Grégoire, Y. 2013. Inbound open innovation for enhanced performance: Enablers and opportunities. ***Industrial Marketing Management***, 42(5): 836–849.

Smallbone, D., North, D., Roper, S., & Vickers, I. 2003. Innovation and the use of technology in manufacturing plants and SMEs: An interregional comparison. ***Environment and Planning C: Government and Policy***, 21(1): 37–52.

Smith, K. G., Collins, C. J., & Clark, K. D. 2005. Existing knowledge, knowledge creation capability, and the rate of new product introduction in high-technology firms. ***Academy of Management Journal***, 48(2): 346–357.

Soetanto, D., & Jack, S. 2016. The impact of university-based incubation support on the innovation strategy of academic spin-offs. ***Technovation***, 50(Supplement C): 25–40.

Somaya, D. 2012. Patent strategy and management. ***Journal of Management***, 38(4): 1084–1114.

Song, M., Droge, C., Hanvanich, S., & Calantone, R. 2005. Marketing and technology resource complementarity: An analysis of their interaction effect in two environmental contexts. ***Strategic Management Journal***, 26(3): 259–276.

Spithoven, A., Vanhaverbeke, W., & Roijakkers, N. 2013. Open innovation practices in SMEs and large enterprises. ***Small Business Economics***, 41(3): 537–562.

Squicciarini, M. 2008. Science and technology parks' tenants versus out-of-Park firms: who innovates more? A duration model. ***The Journal of Technology Transfer***, 33(1): 45–71.

Srivastava, M. K., & Gnyawali, D. R. 2011. When do relational resources matter? Leveraging portfolio technological resources for breakthrough innovation. ***Academy of Management Journal***, 54(4): 797–810.

Starbuck, W. H. 2004. Methodological challenges posed by measures of performance. ***Journal of Management and Governance***, 8(4): 337–343.

Stefan, I., & Bengtsson, L. 2016. Appropriability: A key to opening innovation internationally? ***International Journal of Technology Management***, 71(3/4): 232.

Stefan, I., & Bengtsson, L. 2017. Unravelling appropriability mechanisms and openness depth effects on firm performance across stages in the innovation process. ***Technological Forecasting and Social Change***, 120: 252–260.

Sternberg, R. 1999. Innovative linkages and proximity: Empirical results from recent surveys of small and medium sized firms in German regions. ***Regional Studies***, 33(6): 529–540.

Stewart, T. A. 1997. ***Intellectual capital***. New York, NY: Doubleday-Currency.

Stewart, T. A. 1998. ***Intellectual capital: The new wealth of organization***. London: Doubleday Business.

Stone, M. 1974. Cross-validatory choice and assessment of statistical predictions. ***Journal of the Royal Statistical Society. Series B (Methodological)***, 36(2): 111–147.

Storper, M. 1999. The resurgence of regional economics: Ten years later. In T. J. Barnes & M. S. Gertler (Eds.), ***The New Industrial Geography: Regions, Regulations and Institutions***. London: Routledge.

Subramaniam, M., & Youndt, M. A. 2005. The influence of intellectual capital on the types of innovative capabilities. ***Academy of Management Journal***, 48(3): 450–463.

Sveiby, K. E. 1998. Intellectual capital: Thinking ahead. ***Australian CPA***, 68(5): 18–22.

Swart, J., & Kinnie, N. 2010. Organisational learning, knowledge assets and HR practices in professional service firms. ***Human Resource Management Journal***, 20(1): 64–79.

Sydler, R., Haefliger, S., & Pruksa, R. 2014. Measuring intellectual capital with financial figures: Can we predict firm profitability? ***European Management Journal***, 32(2): 244–259.

Szulanski, G. 1996. Exploring internal stickiness: Impediments to the transfer of best practice within the firm. ***Strategic Management Journal***, 17(S2): 27–43.

Tabachnick, B. G., & Fidell, L. S. 2013. ***Using multivariate statistics***. Essex: Pearson.

Teece, D. J. 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. ***Research Policy***, 15(6): 285–305.

Teece, D. J. 1998. Capturing value from knowledge assets: the new economy, markets for know-how, and intangible assets. ***California Management Review***, 40(3): 55–79.

Teece, D. J. 2007. Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. ***Strategic Management Journal***, 28(13): 1319–1350.

Teece, D. J., & Pisano, G. P. 2007. How to capture value from innovation: shaping intellectual property and industry architecture. ***California Management Review***, 50(1): 278–296.

Teece, D. J., Pisano, G., & Shuen, A. 1997. Dynamic capabilities and strategic management. ***Strategic Management Journal***, 18(7): 509–533.

Teece, D., & Pisano, G. 1998. The dynamic capabilities of firms: an introduction. In G. Dosi, D. J. Teece, & J. Chytry (Eds.), ***Technology, Organization, and Competitiveness***. Oxford: Oxford University Press.

Teirlinck, P., & Spithoven, A. 2013. Research collaboration and R&D outsourcing: Different R&D personnel requirements in SMEs. ***Technovation***, *33*(4–5), 142–153.

Tenenhaus, M., Vinzi, V. E., Chatelin, Y.-M., & Lauro, C. 2005. PLS path modeling. ***Computational Statistics & Data Analysis***, 48(1): 159–205.

Teng, B.-S. 2007. Corporate entrepreneurship activities through strategic alliances: A resource-based approach toward competitive advantage. ***Journal of Management Studies***, 44(1): 119–142.

Terjesen, S., & Patel, P. C. 2015. In search of process innovations: The role of search depth, search breadth, and the industry environment. ***Journal of Management***, 43(5): 1421–1446.

Tether, B. S. 2005. Do Services Innovate (Differently)? Insights from the European Innobarometer Survey. ***Industry and Innovation***, *12*(2), 153–184.

Tether, B. S. 2002. Who co-operates for innovation, and why: An empirical analysis. ***Research Policy***, 31(6): 947–967.

Tether, B. S., & Tajar, A. 2008. Beyond industry–university links: Sourcing knowledge for innovation from consultants, private research organisations and the public science-base. ***Research Policy***, 37(6): 1079–1095.

Theodorakopoulos, N., Ram, M., & Beckinsale, M. 2013. Human resource development for inclusive procurement by intermediation: a situated learning theory application. ***The International Journal of Human Resource Management***, 24(12): 2321.

Thomä, J., & Bizer, K. 2013. To protect or not to protect? Modes of appropriability in the small enterprise sector. ***Research Policy***, 42(1): 35–49.

Thorpe, R., & Holt, R. 2005. Using knowledge within small and medium-sized firms: A systematic review of the evidence. ***International Journal of Management Reviews***, 7(4): 257–281.

Todorova, G., & Durisin, B. 2007. Note absorptive capacity: Valuing a reconceptualization. ***Academy of Management Review***, 32(3): 774–786.

Tödtling, F., Lehner, P., & Kaufmann, A. 2009. Do different types of innovation rely on specific kinds of knowledge interactions? ***Technovation***, 29(1): 59–71.

Tomlinson, P. R., & Fai, F. M. 2013. The nature of SME co-operation and innovation: A multi-scalar and multi-dimensional analysis. ***International Journal of Production Economics***, 141(1): 316–326.

Tortoriello, M., & Krackhardt, D. 2010. Activating cross-boundary knowledge: The role of Simmelian ties in the generation of innovations. ***Academy of Management Journal***, *53*(1), 167–181.

Tranfield, D., Denyer, D., & Smart, P. 2003. Towards a methodology for developing evidence-informed management knowledge by means of systematic review *. ***British Journal of Management***, 14: 207–222.

Trimble, M. 2015. Advancing national intellectual property policies in a transnational context. ***Maryland Law Review***, 74(2): 203–257.

UKSPA. 2011. ***Annual statistics 2010 - 2011***. Essex.

Un, C. A., Cuervo-Cazurra, A., & Asakawa, K. 2010. R&D collaborations and product innovation. ***Journal of Product Innovation Management***, 27(5): 673–689.

Vahter, P., Love, J. H., & Roper, S. 2014. Openness and innovation performance: Are small firms different? ***Industry and Innovation***, 21(7–8): 553–573.

van de Vrande, V., de Jong, J. P. J., Vanhaverbeke, W., & de Rochemont, M. 2009. Open innovation in SMEs: Trends, motives and management challenges. ***Technovation***, 29(6): 423–437.

Van Dierdonck, R., Debackere, K., & Rappa, M. A. 1991. An assessment of science and technology parks: Towards a better understanding of their role in the diffusion of technological knowledge. ***R&D Management***, 21(2): 109–124.

Van Wijk, R., Jansen, J. J., & Lyles, M. A. 2008. Inter-and intra-organizational knowledge transfer a meta-analytic review and assessment of its antecedents and consequences. ***Journal of Management Studies***, 45(4): 830–853.

Vanderstraeten, J., & Matthyssens, P. 2012. Service-based differentiation strategies for business incubators: Exploring external and internal alignment. ***Technovation***, 32(12): 656–670.

Vásquez-Urriago, Á. R., Barge-Gil, A., & Modrego Rico, A. 2016. Science and technology parks and cooperation for innovation: Empirical evidence from Spain. ***Research Policy***, 45(1): 137–147.

Vásquez-Urriago, Á. R., Barge-Gil, A., Rico, A. M., & Paraskevopoulou, E. 2014. The impact of science and technology parks on firms' product innovation: empirical evidence from Spain. ***Journal of Evolutionary Economics***, 24(4): 835–873.

Vedovello, C. 1997. Science and technology parks and university-industry interaction: Geographical proximity between the agents as a driving force. ***Technovation***, 17(9): 491–531.

Veer, T., Lorenz, A., & Blind, K. 2016. How open is too open? The mitigating role of appropriation mechanisms in R&D cooperation settings. ***R and D Management***, 46: 1113–1128.

Venkatraman, N., & Ramanujam, V. 1986. Measurement of business performance in strategy research: A comparison of approaches. ***The Academy of Management Review***, 11(4): 801–814.

Veugelers, R., & Cassiman, B. 1999. Make and buy in innovation strategies: Evidence from Belgian manufacturing firms. ***Research Policy***, 28(1): 63–80.

Veugelers, R., & Cassiman, B. 2005. R&D cooperation between firms and universities: Some empirical evidence from Belgian manufacturing. ***International Journal of Industrial Organization***, 23(5): 355–379.

Villasalero, M. 2014. University knowledge, open innovation and technological capital in Spanish science parks. ***Journal of Intellectual Capital***, *15*(4), 479–496.

von Hippel, E. 1976. The dominant role of users in the scientific instrument innovation process. ***Research Policy***, 5(3): 212–239.

von Hippel, E. 1986. Lead users: A source of novel product concepts. ***Management Science***, 32(7): 791–805.

von Hippel, E. 1988. ***The sources of innovation***. New York, NY: Oxford University Press.

von Hippel, E. 2005. ***Democratizing innovation***. Cambridge, MA: MIT Press.

von Hippel, E., & von Krogh, G. 2006. Free revealing and the private-collective model for innovation incentives. ***R and D Management***, 36(3): 295–306.

Vossen, R. W. 1998. Relative strengths and weaknesses of small firms in innovation. ***International Small Business Journal***, 16(3): 88–94.

Wagner, S. M. 2013. Partners for business-to-business service innovation. ***IEEE Transactions on Engineering Management***.

West, B., Hillenbrand, C., Money, K., Ghobadian, A., & Ireland, R. D. 2016. Exploring the impact of social axioms on firm reputation: A stakeholder perspective. ***British Journal of Management***, 27(2): 249–270.

West, J., & Bogers, M. 2014. Leveraging external sources of innovation: A review of research on open innovation. ***Journal of Product Innovation Management***, 31(4): 814–831.

West, J., & Gallagher, S. 2006. Challenges of open innovation: The paradox of firm investment in open-source software. ***R&D Management***, 36(3): 319–331.

West, J., Salter, A., Vanhaverbeke, W., & Chesbrough, H. 2014. Open innovation: The next decade. ***Research Policy***, 43(5): 805–811.

Westhead, P. 1997. R&D "inputs" and "outputs" of technology-based firms located on and off science and technology parks. ***R&D Management***, 27(1): 45–62.

Westhead, P., & Batstone, S. 1999. Perceived benefits of a managed science park location. ***Entrepreneurship & Regional Development***, 11(2): 129–154.

Westhead, P., & Storey, D. J. 1994. ***An assessment of firms located on and off science and technology parks in the United Kingdom***. London: HMSO.

Westhead, P., & Storey, D. J. 1995. Links between higher education institutions and high technology firms. ***Omega***, 23(4): 345–360.

Whitley, R. 2002. Developing innovative competences: The role of institutional frameworks. ***Industrial and Corporate Change***, 11(3): 497–528.

Williamson, O. E. 1985. ***The economic institutions of capitalism***. New York, NY: Free Press.

Wright, M., Liu, X., Buck, T., & Filatotchev, I. 2008. Returnee entrepreneurs, science park location choice and performance: An analysis of high-technology SMEs in China. ***Entrepreneurship Theory and Practice***, 32(1): 131–155.

Xia, T. 2013. Absorptive capacity and openness of small biopharmaceutical firms - a European Union-United States comparison. ***R and D Management***, 43(4): 333–351.

Xia, T., & Roper, S. 2016. Unpacking open innovation: absorptive capacity, exploratory and exploitative openness, and the growth of entrepreneurial biopharmaceutical firms. ***Journal of Small Business Management***, 54(3): 931–952.

Yang, C.-C., & Lin, C. Y.-Y. 2009. Does intellectual capital mediate the relationship between HRM and organizational performance? Perspective of a healthcare industry in Taiwan. ***The International Journal of Human Resource Management***, 20(9): 1965–1984.

Yang, J., Brashear, T. G., & Asare, A. 2015. The value relevance of brand equity, intellectual capital and intellectual capital management capability. ***Journal of Strategic Marketing***, 23(6): 543–559.

Youndt, M. A., Subramaniam, M., & Snell, S. A. 2004. Intellectual capital profiles: An examination of investments and returns. ***Journal of Management Studies***, 41(2): 335–361.

Yu, S. H. 2013. Social capital, absorptive capability, and firm innovation. ***Technological Forecasting and Social Change***, 80(7): 1261–1270.

Zahra, S. A., & George, G. 2002. Absorptive capacity: A review, reconceptualization, and extension. ***The Academy of Management Review***, 27(2): 185–203.

Zahra, S. A., & Nambisan, S. (2012). Entrepreneurship and strategic thinking in business ecosystems. ***Business Horizons***, *55*(3), 219–229.

Zaichkowsky, J. L. 1985. Measuring the Involvement Construct. ***Journal of Consumer Research***, 12(3): 341–352.

Zeng, S. X., Xie, X. M., & Tam, C. M. 2010. Relationship between cooperation networks and innovation performance of SMEs. ***Technovation***, 30(3): 181–194.

Zobel, A. K., Lokshin, B., & Hagedoorn, J. 2017. Formal and informal appropriation mechanisms: The role of openness and innovativeness. ***Technovation***, 59(October 2014): 44–54.

Zobel, A.K., Balsmeier, B., & Chesbrough, H. 2016. Does patenting help or hinder open innovation? Evidence from new entrants in the solar industry. ***Industrial and Corporate Change***, 25(2): 307–331.

Appendix. A

UKSTP SURVEY

Survey of
SCIENCE AND TECHNOLOGY PARKS
UNITED KINGDOM
Aston Business School . Aston University
WWW.UKSTPSURVEY.CO.UK

[Date]

«Company_name»

«Address»

Dear «Full_Name»

Aston Business School is undertaking research that aims to better understand the business practices of companies located in knowledge and tech-based ecosystems, such as **«the name of science and technology park»**, in the UK. We would be most grateful if you could complete the questionnaire provided by the link below.

https://www.surveymonkey.com/s/UK-STP

Completing the questionnaire is a very easy task – it only takes a few minutes. You can skip those questions that do not apply to your organisation. Although none of these questions deal with propriety or sensitive issues, your response will be anonymised. We are interested in general patterns and trends, not specific individuals or organisations.

On completion of this study, we can send you a copy of the final report, so that you can compare your own practice with your counterparts. If you would like us to do this, you will need to provide us with your contact details.

If you require any further information about this study or have queries regarding your participation, please do not hesitate to contact us at esg-scienceparksproject@aston.ac.uk, or visit the survey home page: www.ukstpsurvey.co.uk.

Thank you in advance.

Yours sincerely,

UKSTP SURVEY

Address: Economics & Strategy Group, Aston Business School, Aston University, Birmingham, B4 7ET
Phone: +44 (0) 121 204 3007 . Website: www.ukstpsurvey.org . Email: esg-scienceparksproject@aston.ac.uk

Aston Business School

Survey of SCIENCE AND TECHNOLOGY PARKS UNITED KINGDOM

Aston Business School . Aston University

WWW.UKSTPSURVEY.CO.UK

UKSTP SURVEY

Aston Business School

The UK Science and Technology Parks Survey

1. What is the main sector your business operates in?

2. What year was your current business established?

3. What year did you enter the science park?

4. Approximately, how many employees work at your company (full-time equivalent)?

5. Is your enterprise part of a larger firm?

- ○ Yes
- ○ No

6. In which geographical markets does this business sell goods and/or services? (Please check all that apply)

- ☐ UK regional within approximately 100 miles of this business
- ☐ UK national
- ☐ EU
- ☐ Other countries

7. During the last three years, were any of your goods and services innovations, ... (Please check all that apply)

- ☐ New to your market? (This business introduced a new good or service to the market before competitors)
- ☐ Only new to this business? (This business introduced a new good or service that was essentially the same as a good or service already available from competitors)

8. What is approximately the percentage of this business`s revenues from products and services that were:

	N/A	0-5(%)	5-10(%)	10-20(%)	20-30(%)	30-40(%)	40-50(%)	over 50(%
New to the market (introduced during the previous three years)	○	○	○	○	○	○	○	○
Only new to this business (introduced during the previous three years)	○	○	○	○	○	○	○	○

9. How effective were the following methods for maintaining or increasing the competitiveness of product and process innovations?

	Not at All Important	Low Importance	Slightly Important	Neutral	Moderately Important	Very Important	Extremely Important
Complexity of goods or services introduced by your company	○	○	○	○	○	○	○
Copyright	○	○	○	○	○	○	○
Design registration	○	○	○	○	○	○	○
Lead time advantages	○	○	○	○	○	○	○
Patents	○	○	○	○	○	○	○
Secrecy (include non-disclosure agreements)	○	○	○	○	○	○	○
Trademarks	○	○	○	○	○	○	○

10. How would you assess your firm's business environment, over the last three years, using the following statements?

	Strongly Disagree	Moderately Disagree	Somewhat Disagree	Neither Disagree, Nor Agree	Somewhat Agree	Moderately Agree	Strongly Agree
Product/Service demand is hard to forecast.	○	○	○	○	○	○	○
Actions of competitors are generally quite easy to predict.	○	○	○	○	○	○	○
Customer requirement and preferences are hard to forecast.	○	○	○	○	○	○	○
The set of competitors in my industry has remained relatively constant	○	○	○	○	○	○	○
Our industry is very stable with very little change resulting from major economic, technological, social, or political forces.	○	○	○	○	○	○	○

11. To what extent do you agree with the following items describing your organisation?

	Strongly Disagree	Moderately Disagree	Somewhat Disagree	Neither Disagree, Nor Agree	Somewhat Agree	Moderately Agree	Strongly Agree
Much of our organisation's knowledge and information is contained in manuals, databases, etc.	○	○	○	○	○	○	○
Our employees apply knowledge from one area of the company to problems and opportunities that arise in another.	○	○	○	○	○	○	○
Our employees are creative and bright.	○	○	○	○	○	○	○
Our employees are experts in their particular jobs and functions.	○	○	○	○	○	○	○
Our employees are highly skilled.	○	○	○	○	○	○	○
Our employees are on par with the best in our industry.	○	○	○	○	○	○	○
Our employees are keen to explore new ideas by thinking outside the box.	○	○	○	○	○	○	○
Our employees are skilled at collaborating with each other to diagnose and solve problems.	○	○	○	○	○	○	○
Our employees interact and exchange ideas with people from different areas of the company.	○	○	○	○	○	○	○
Our employees cultivate and utilize variety of sources for new ideas, knowledge and solutions.	○	○	○	○	○	○	○

	Strongly Disagree	Moderately Disagree	Somewhat Disagree	Neither Disagree, Nor Agree	Somewhat Agree	Moderately Agree	Strongly Agree
Our employees partner with customers, suppliers, alliance partners, etc., to develop solutions and obtain new ideas.	○	○	○	○	○	○	○
Our employees share information and learn from one another.	○	○	○	○	○	○	○
Our firm uses patents, licenses or other forms of intellectual property(IP) protection as a way to preserve knowledge.	○	○	○	○	○	○	○
Our organisation periodically embeds much of its knowledge and information in structures, systems, and processes.	○	○	○	○	○	○	○
Our organisation's culture (stories, rituals) contains ways of doing business, valuable ideas etc.	○	○	○	○	○	○	○
Our organisation actively uses management initiatives to monitor development of new information, knowledge, practices etc.	○	○	○	○	○	○	○
Our organisation systematically monitors the value of its stock of knowledge, and its fitness for purpose.	○	○	○	○	○	○	○
Our organisation effectively communicates the value of its stock of knowledge to the stakeholders.	○	○	○	○	○	○	○

12. Over the last three years, how important to your business's innovation and learning have been each of the following off-site/external information sources (from outside the park)?

	Very Unimportant	Moderately Unimportant	Slightly Unimportant	Neither Important, Nor Unimportant	Slightly Important	Moderately Important	Very Important
External(Off-site) Clients or Customers from the Private Sector	○	○	○	○	○	○	○
External(Off-site) Clients or Customers from the Public Sector	○	○	○	○	○	○	○
External(Off-site) Competitors	○	○	○	○	○	○	○
Other External(Off-site) Businesses in Your Sector that are not Direct Competitors	○	○	○	○	○	○	○
Other External(Off-site) Enterprises in other Sectors	○	○	○	○	○	○	○
External (Off-site) Suppliers of Equipment, Materials, Components, or Software	○	○	○	○	○	○	○

13. Over the last three years, how important to your business's innovation and learning have been each of the following on-site/internal information sources (from inside the park)?

	Very Unimportant	Moderately Unimportant	Slightly Unimportant	Neither Important, Nor Unimportant	Slightly Important	Moderately Important	Very Important
On-site Clients or Customers from the Private Sector	○	○	○	○	○	○	○
On-site Clients or Customers from the Public Sector	○	○	○	○	○	○	○
On-Site Competitors	○	○	○	○	○	○	○
Other On-site Businesses in Your Sector that are not Direct Competitors	○	○	○	○	○	○	○
Other On-site Enterprises in other Sectors	○	○	○	○	○	○	○
On-site Suppliers of Equipment, Materials, Components, or Software	○	○	○	○	○	○	○

14. Over the last three years, how important to your business's innovation and learning have been each of the following information sources (both on-site and/or off-site sources)?

	Very Unimportant	Moderately Unimportant	Slightly Unimportant	Neither Important, Nor Unimportant	Slightly Important	Moderately Important	Very Important
Commercial Laboratories or R&D Enterprises	◯	◯	◯	◯	◯	◯	◯
Experts, Consultants or Advisors	◯	◯	◯	◯	◯	◯	◯
Financial Institutions and Banks	◯	◯	◯	◯	◯	◯	◯
Incubators or Innovation Centres (or similar on-site facilities)	◯	◯	◯	◯	◯	◯	◯
Local and national Government	◯	◯	◯	◯	◯	◯	◯
Park Management or Centre Management	◯	◯	◯	◯	◯	◯	◯
Universities or Local Academics	◯	◯	◯	◯	◯	◯	◯
Professional and Industry/Trade Associations	◯	◯	◯	◯	◯	◯	◯
Public Research Organisations	◯	◯	◯	◯	◯	◯	◯
Conferences and Meetings	◯	◯	◯	◯	◯	◯	◯
Fairs and Exhibitions	◯	◯	◯	◯	◯	◯	◯
Specific Databases Available to On-site Firms	◯	◯	◯	◯	◯	◯	◯
Publicly Available Databases	◯	◯	◯	◯	◯	◯	◯
Scientific Journals and Trade/Technical Publications	◯	◯	◯	◯	◯	◯	◯
Trainings or External Sources of Professional Know-How	◯	◯	◯	◯	◯	◯	◯
Internal Sources of Specialist Know-How (from your own business or enterprise group)	◯	◯	◯	◯	◯	◯	◯

15. How would you assess your firm's development over the last three years, relative to that of your competitors in terms of ...

	Much Worse	Moderately Worse	Slightly worse	About the Same	Slightly Better	Moderately Better	Much Better
Adaptability to Market Changes	○	○	○	○	○	○	○
Image of the Firm and its Products/Services	○	○	○	○	○	○	○
Quality of Products/Services	○	○	○	○	○	○	○
Market Share	○	○	○	○	○	○	○
Turnover Growth	○	○	○	○	○	○	○
Profitability	○	○	○	○	○	○	○
Sales	○	○	○	○	○	○	○
Overall Performance	○	○	○	○	○	○	○

16. We welcome your comments or suggestions (please add your comments below)

17. Your time and effort in completing this questionnaire is very much appreciated. If you agree to receive the optional report assessing your company in comparison with the final results of the survey, Please select `Yes` otherwise please select `No`.

○ Yes ○ No

18. If you have agreed to receive the specific report, please provide us with your contact details(to avoid duplication, will be removed from database):

Company Name

Thank you for taking the time to share your knowledge and experience with us.

Please click "DONE" to send your answers.

If you require any further information about this study or have queries regarding your participation, please do not hesitate to contact us at: (esg-scienceparksproject@aston.ac.uk); for more information please visit: www.ukstpsurvey.co.uk

Aston Business School

Address: Economics and Strategy Group, Aston Business School, Aston University, Birmingham, B4 7ET
Tel: +44 (0) 121 204 3007 Email: esg-sciparksproject@aston.ac.uk
Website: www.ukstpsurvey.co.uk

UKSTP SURVEY

SURVEY OF SCIENCE AND TECHNOLOGY PARKS UNITED KINGDOM

Phase I: Ecosystems and Co-evolution

2015-2017

UKSTPSURVEY

Aston Business School

Aston Business School . Aston University

WWW.UKSTPSURVEY.ORG

UKSTP
SURVEY
2015-2017

INTRODUCTION TO THE UNITED KINGDOM SCIENCE AND TECHNOLOGY PARKS SURVEY (UKSTP SURVEY)

UKSTP SURVEY
2015-2017

The United Kingdom Science and Technology Parks Survey (UKSTP Survey) is a new survey initiated at Aston Business School to provide a means to measuring the levels and types of innovation activities among companies located in Science and Technology Parks in the United Kingdom, with previous wave conducted in 2015. The UKSTP Survey is used to collect information about business practices of onsite businesses located in science and technology parks in the United Kingdom. It also provides data on on-site companies' cooperative and coopetitive innovation activities, appropriability strategies and Intellectual Capital Management, and factors that may affect these sets of practices. The data obtained from the UKSTP SURVEY also provides important information for updating the statistical records with regard to the internal structure of on-site enterprises and individual science and/or technology parks at which enterprises operate. Such information is important in producing regional analyses of business data, and benchmarks for gauging the regional, sector and size-related performance. The United Kingdom Science and Technology Parks survey (UKSTP SURVEY) aims to provide an independent insight into a variety of policy-related issues regarding the management and economics of Innovation in science and technology park ecosystems in the United Kingdom.
The objectives of the UKSTP Survey can be categorised under three broad headings:

- Providing a detailed understanding of onsite businesses' innovation driven plans, activities, inputs and outputs across various sectors;

- Providing benchmarks for gauging the magnitude of the science and technology parks` regional and sector-related performance;

- Providing evidence-based policy and practice recommendations to inform policy development and implementation at national, regional and local levels;

Aston Business School

Survey of
SCIENCE AND TECHNOLOGY PARKS
UNITED KINGDOM
Aston Business School . Aston University

THE UKSTP SURVEY: SCALE AND SCOPE

The United Kingdom Science and Technology Parks Survey (UKSTP Survey) aims to provide a detailed understanding of onsite companies' business perceptions and innovation driven plans. The UKSTP data source will be valuable to the Government, national and regional policy makers, businesses, and other science and technology park`s stakeholders in helping to guide regional development policies and support SMEs' growth in all parts of the United Kingdom.
The UKSTP samples from the population of companies located in science and technology parks in the United Kingdom. The sample design is a stratified one with two stratification dimensions. Strata are defined in terms of:

Region (East Midlands, East of England, Greater London, North East, North West, Northern Ireland, Scotland, South East, South West, Wales, West Midlands, Yorkshire & Humberside);

Standard Industrial Classification (four-digit SIC level).

In each wave of the UKSTP Survey, a sample is drawn from the United Kingdom Science and Technology Parks Complete Database (UKSTPC). UKSTPC is a company database listing over 6500 companies located in science parks, technology parks, research parks, incubators, innovation centres, accelerators around the United Kingdom. The UKSTPC database was developed as part of the UKSTP research project at Aston Business School. The UKSTP Survey was first conducted in 2015 and results for that year will become available in 2017.

SELECTION CRITERIA

Companies from various industrial sectors and regions located in one of the Science and Technology Parks in the United Kingdom.

TAKING PART IN THE UKSTP SURVEY

The survey is voluntary by invitation; however, your cooperation in completing the questionnaire would be appreciated. If would like to participate, please visit the Get Involved pages on this website

HOW IS THE UKSTP SURVEY UNDERTAKEN?

The survey is online at present. However, you can request a printed questionnaire, or print off the questionnaire and send it to us by post. Large print questionnaire is also available on request. Alternatively, Skype or phone interviews can also be arranged upon your request. Please let us know, by completing the registration form, whether you would prefer to complete the survey online, using a paper questionnaire, or over the phone(telephone interview).

THE UKSTP SURVEY: SCALE AND SCOPE

AT WHAT LEVEL IS THE SURVEY COMPLETED?

Executive director/proprietor/owner level.

IS THE UKSTP SURVEY CONFIDENTIAL AND SECURE?

Your data will be treated in strict confidence. None of the questions deal with propriety or sensitive issues and your response will be anonymised. We are interested in general patterns and trends, not specific individuals or organisations. The data collected are used for research purposes only.

IS THE UKSTP SURVEY EASY TO COMPLETE?

Completing the UKSTP questionnaire is a very easy task. We do not expect you to go to any great expense or spend an inordinate amount of time obtaining the information required.

WHAT INCENTIVES DOES THE UKSTP SURVEY PROVIDE FOR RESPONDENTS?

On completion of this study, we can send you a copy of the final report, so that you can compare your own practice with your counterparts.

CAN I GIVE YOU FEEDBACK ON THE DESIGN OF THE QUESTIONNAIRES?

Yes. We appreciate the time you take to complete our questionnaires. Please complete our online contact form to submit your suggestions, or send an email directly to esg-sciparksproject@aston.ac.uk

WHAT IF I NEED FURTHER HELP AND INFORMATION?

If you require any further information about this study or have queries regarding your participation, please do not hesitate to contact us on 0845 601 3034; email: esg-sciparksproject@aston.ac.uk; or alternatively fill out the contact form.

THE UNITED KINGDOM SCIENCE AND TECHNOLOGY PARKS COMPLETE DATABASE (UKSTPC DATABASE)

UKSTPC DATABASE 2015-2017

In each wave of the UKSTP Survey, a sample is drawn from the United Kingdom Science and Technology Parks Complete (UKSTPC) Database. The UKSTPC is a company database listing over 6000 companies located in: Science Parks, Technology Parks, Research Parks, Innovation Parks, Incubators, Innovation Centres and Accelerators around the United Kingdom. The UKSTPC database was developed as part part of the UKSTP research project at Aston Business School. The UKSTPC database covers companies located in:

NORTHERN IRELAND
Northern Ireland Science Park
The Innovation Centre (Derry~Londonderry)
The Ulster Science & Technology Park

NORTH WEST OF ENGLAND
Alderley Park - BioHub
Hexagon Tower
InfoLab21 (Lancaster University)
Innospace (Manchester Metropolitan University Incubator)
Lancaster Environment Centre (Lancaster University)
Liverpool Innovation Park
Liverpool Science Park
Manchester Science Park
MEDCity-Mancester
Merseybio Business Incubator
Riverside Innovation Centre (University of Chester)
Salford Innovation Park
Sci-Tech Daresbury
Stockport Business & Innovation Centre
The Heath Business & Technical Park
The MedTECH Centre
The Rural Business Centre (Myerscough College)
The University of Manchester Innovation Centre
Thornton Science Park
UCLan Media Factory
University of Central Lancashire
Wavertree Technology Park
Westlakes Science & Technology Park

WEST MIDLANDS
Birmingham Research Park
Birmingham Science Park Aston
Coventry Innovation Village
Coventry University Technology Park
Keele University Science and Business Park

SCOTLAND
Aberdeen Energy and Innovation Parks
Alba Innovation Centre
BioCity (Scotland)
CENSIS (Innovation Centre for Sensor & Imaging Systems)
Dundee Technopole
Edinburgh BioQuarter
Edinburgh Napier University Incubator
Edinburgh Technopole
Elvingston Science Centre
European Marine Science Park
Glasgow Caledonian University Incubator
Heriot-Watt University Research Park
Hillington Park Innovation Centre
Pentlands Science Park
Roslin BioCentre
Scottish Enterprise Technology Park
Stirling University Innovation Park
Strathclyde University Incubator
University of Glasgow Business Incubator
West of Scotland Science Park

NORTH EAST OF ENGLAND
Corbridge Business Centre
John Buddle Work Village
NETPark – The North East Technology Park
Newcastle Science Central
The North East Business & Innovation Centre (BIC)
Sunderland Science Park
Wilton Centre

YORKSHIRE & HUMBERSIDE
3M Buckley Innovation Centre (3MBIC)
Enterprise and Innovation Hub - Leeds Beckett University
Leeds Innovation Centre
Listerhills Science Park
Newlands Science Park

THE UNITED KINGDOM SCIENCE AND TECHNOLOGY PARKS COMPLETE DATABASE (UKSTPC DATABASE)

UKSTPC DATABASE 2015-2017

In each wave of the UKSTP Survey, a sample is drawn from the United Kingdom Science and Technology Parks Complete (UKSTPC) Database. The UKSTPC is a company database listing over 6000 companies located in: Science Parks, Technology Parks, Research Parks, Innovation Parks, Incubators, Innovation Centres and Accelerators around the United Kingdom. The UKSTPC database was developed as part part of the UKSTP research project at Aston Business School. The UKSTPC database covers companies located in:

WEST MIDLANDS
Longbridge Technology Park
Malvern Hills Science Park
MIRA Technology Park
Staffordshire Technology Park
Stoneleigh Park
University of Warwick Science Park
University of Wolverhampton Science Park

SOUTH WEST OF ENGLAND
Bristol & Bath Science Park
Bristol SETsquared Centre
Exeter Innovation Centre
Exeter Science Park
Formation Zone at Plymouth University.
Health and Wellbeing Innovation Centre
Plymouth Science Park
SETsquared in Bath
Tetricus Science Park
The Pool Innovation Centre
The Tremough Innovation Centre

WALES
Bridge Innovation Centre
Cardiff Business Technology Centre
Cardiff Medicentre
CBTC2
Gwaun Elai Medi Science Campus
Menai Science Park
OpTIC
Pencoed Technology Park
SONY UK TEC Business Incubation Centre
Technium Digital
Technium Springboard
Technium Swansea
The University of Glamorgan's Business Incubator

SOUTH EAST OF ENGLAND
Begbroke Science Park
Bicester Innovation Centre - Oxfordshire
Bracknell Enterprise & Innovation Hub

YORKSHIRE & HUMBERSIDE
Sheffield Technology Parks
The Advanced Manufacturing Park (AMP)
The Sheffield Bioincubator
York Science Park Ltd
National Agri-food Innovation Campus
The Enterprise Centre - University of Hull

EAST MIDLANDS
BioCity Nottingham
Caswell Science and Technology Park
De Montfort University's Innovation Centre
Harborough Innovation Centre
iCon Environmental Innovation Centre (The University Of Northampton)
Lincoln Science and Innovation Park
Loughborough University Science and Enterprise Parks
Mansfield i-Centre
MediCity Nottingham
Newark Beacon
No.1 Nottingham Science Park
Portfolio Innovation Centre
SATRA Innovation Park
Scott-Bader Innovation Centre
Silverstone Technology Park
Tapton Park Innovation Centre
The Chesterfield Innovation Centre
The Hive Business Centre (Nottingham Trent University)
University of Derby Incubator
University of Lincoln Sparkhouse Incubator
University of Nottingham Innovation Park
Worksop Turbine

EAST OF ENGLAND
Adastral Park
Babraham Research Campus
BioPark
Cambridge Biomedical Campus

THE UNITED KINGDOM SCIENCE AND TECHNOLOGY PARKS COMPLETE DATABASE (UKSTPC DATABASE)

UKSTPC DATABASE 2015-2017

In each wave of the UKSTP Survey, a sample is drawn from the United Kingdom Science and Technology Parks Complete (UKSTPC) Database. The UKSTPC is a company database listing over 6000 companies located in: Science Parks, Technology Parks, Research Parks, Innovation Parks, Incubators, Innovation Centres and Accelerators around the United Kingdom. The UKSTPC database was developed as part part of the UKSTP research project at Aston Business School. The UKSTPC database covers companies located in:

SOUTH EAST OF ENGLAND

Cherwell Innovation Centre
Culham Innovation Centre
Culham Science Centre
Discovery Park
Fareham Innovation Centre
Harwell Innovation Centre
Kent Science Park
Langstone Technology Park
Nucleus Business and Innovation Centre
Ocean Village Innovation Centre
One St Aldates - Oxfordshire
Oxford Centre for Innovation
Oxford Science Park
Portsmouth Technopole
Royal Holloway Enterprise Centre
SETsquared in Surrey
Southampton SETsquared Centre
Surrey Research Park
Sussex Innovation Centre (Falmer)
Thames Valley Science Park
University of Southampton Science Park
Witney Business & Innovation Centre

EAST OF ENGLAND

Cambridge Business Park
Cambridge Science Park
Chesterford Research Park
Colworth Science Park
Cranfield University Technology Park
Granta Park
Hethel Engineering Centre
Newark Beacon - Nottinghamshire
Norwich Research Park
St. John's Innovation Centre
Stevenage Bioscience Catalyst
The University of Essex Research Park

LONDON AND GREATER LONDON

Accelerator London Metropolitan University
Brunel Science Park
CEME Innovation Centre
IDEALondon (University College London)
Imperial College Incubator
Knowledge Dock (University of East London)
Lee Valley Technopark
South Bank Technopark
The London BioScience Innovation Centre (LBIC)
The QMB Innovation Centre (Queen Mary University of London)

2015 SURVEY OF UNITED KINGDOM SCIENCE AND TECHNOLOGY PARKS (UKSTP2015 SURVEY)

The first phase of the United Kingdom Science and Technology Parks Survey (UKSTP2015 Survey: Ecosystems and Co-evolution) was announced in April 2015, and launched on June 1, 2015. Aston Business School conducted the first United Kingdom Science and Technology Parks Survey (UKSTP2015 Survey) to gather information about current business practices of small and medium-sized enterprises (SMEs) located in science and technology parks in the United Kingdom. The main objective of the first United Kingdom Science and Technology Parks Survey was to explore the potential dynamics of innovation activities in science and technology park ecosystems, being generated by a range of co-evolution opportunities among onsite small and medium sized businesses and between them and other internal and external stakeholders, which associated with the development innovation architecture in onsite SMEs. The UKSTP2015 Survey focused on the ways in which the living life of science and technology park ecosystems orchestrates on-site SMEs` management insights and innovation activities.

The UKSTP2015 data will provide a means to measuring the types and trends in innovation activity among on-site SMEs located in the United Kingdom Science and Technology Parks. These data were collected separately for each region and through a parallel online survey. The UKSTP2015 questionnaire was developed through detailed consultation and piloted before finalising.
The UKSTP2015 survey targeted senior managers, and collected information from a representative sample of onsite SMEs in each region (i.e. East Midlands, East of England, Greater London, North East, North West, Northern Ireland, Scotland, South East, South West, Wales, West Midlands, Yorkshire & Humberside). The survey asked business managers and owners about a range of key issues, including: perceived environmental dynamism,

2015 SURVEY OF UNITED KINGDOM SCIENCE AND TECHNOLOGY PARKS (UKSTP2015 SURVEY)

intellectual capital management practices, cooperative and coopetitive innovation activities, appropriability strategies and business performance.

The sample of on-site SMEs is drawn from the United Kingdom Science and Technology Parks Complete Database (UKSTPC); the UKSTPC database covers all businesses located in science and technology, Innovation Centres and Incubators in the United Kingdom. Primary data were collected between June and October 2015. The UKSTP Survey covered on-site SMEs (in three size classes of: 1–10 employees, 10–50 employees, and 50–250 employees) in sections C and G-U of the UK standard industrial classification of economic activities (SIC 2007); The UKSTP2015 Survey`s sectoral coverage was as follows:

Manufacturing(Section C), Wholesale and retail trade; repair of motor vehicles and motorcycles(Section G), Transportation and storage(Section H), Accommodation and food service activities (Section I), Information and communication(Section J), Financial and insurance activities (Section K), Real estate activities(Section L), Professional, scientific and technical activities (Section M), Administrative and support service activities(Section N), Public administration and defence; compulsory social security (Section O), Education (Section P), Human health and social work activities (Section Q), Arts, entertainment and recreation (Section R), Other service activities (Section S), Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use (Section T:), Activities of extraterritorial organizations and bodies(Section U); excluding sections A(agriculture, forestry and fishing), B(Mining and quarrying), D(electricity, gas, steam and air conditioning supply), E(Water supply; sewerage, waste management and remediation activities), F(Construction)). As an additional incentive, all respondents were promised a complimentary summary of the results.

UKSTP2015 SURVEY FAQS

Aston Business School is conducting the UKSTP2015 Survey (phase I: Ecosystems and Co-evolution) to gather information about current business practices of small and medium-sized enterprises (SMEs) located in science and technology parks in the United Kingdom. The UKSTP 2015 Survey focuses on the ways in which the living life of science and technology park ecosystems orchestrates on-site SMEs` management insights and innovation activities.

The UKSTP samples from the population of small and medium-sized enterprises located in science and technology parks in the United Kingdom. For each wave of the UKSTP Survey, a sample is drawn from the United Kingdom Science and Technology Parks Complete Database (UKSTPC). Below you can find answers to some frequently asked questions about the UKSTP2015 Survey. If you don't find the answer to your question on this page or about UKSTP pages, please contact us.

SELECTION CRITERIA

SMEs from various industrial sectors and regions located in one of the Science and Technology Parks in the United Kingdom.

SURVEY TIMESCALE

Important dates are shown below.
Data Collection Opens: Monday, 1 June, 2015
Zone 1: Northern Ireland, Scotland, North East.
Zone 2: North West, Yorkshire & Humberside, East Midlands.
Zone 3: Wales, West Midlands, South West.
Zone 4: East of England, South East, London.
Final Call: Wednesday, 7 October, 2015.
Data Collection Final Close: Tuesday, 20 October, 2015.

UKSTP2015 SURVEY FAQS

TAKING PART IN THE UKSTP SURVEY

The survey is voluntary by invitation; however, your cooperation in completing the questionnaire would be appreciated. If would like to participate, please visit the "Get Involved" page on this website.

HOW IS THE UKSTP SURVEY UNDERTAKEN?

The survey is online at present. However, you can request a printed questionnaire, or print off the questionnaire and send it to us by post. Large print questionnaire is also available on request. Alternatively, Skype or phone interviews can also be arranged upon your request. Please let us know (by completing the registration form) whether you would prefer to complete the survey online, using a paper questionnaire, or over the phone(telephone interview).

AT WHAT LEVEL IS THE SURVEY COMPLETED?

Proprietor/Owner level/Executive Director.

IS THE UKSTP SURVEY CONFIDENTIAL AND SECURE?

Your data will be treated in strict confidence. None of the questions deal with propriety or sensitive issues and your response will be anonymised. We are interested in general patterns and trends, not specific individuals or organisations. The data collected are used for research purposes only.

IS THE UKSTP SURVEY EASY TO COMPLETE?

Completing the UKSTP questionnaire is a very easy task. We do not expect you to go to any great expense or spend an inordinate amount of time obtaining the information required. On average, it takes respondents about “6 minutes” to complete the questionnaire. You can also skip those questions that do not apply to your organisation.

WHAT INCENTIVES DOES THE UKSTP SURVEY PROVIDE FOR RESPONDENTS?

On completion of this study, we can send you a copy of the final report, so that you can compare your own practice with your counterparts.

CAN I GIVE YOU FEEDBACK ON THE DESIGN OF THE QUESTIONNAIRES?

Yes. We appreciate the time you take to complete our questionnaires. Please complete our online contact form to submit your suggestions, or send an email directly to esg-sciparksproject@aston.ac.uk

UKSTP2015 SURVEY FAQS

WHAT IF I NEED FURTHER HELP AND INFORMATION?

If you require any further information about this study or have queries regarding your participation, please do not hesitate to contact us on 0845 601 3034; email: esg-sciparksproject@aston.ac.uk; or alternatively fill out the contact form.

Aston Business School . Aston University

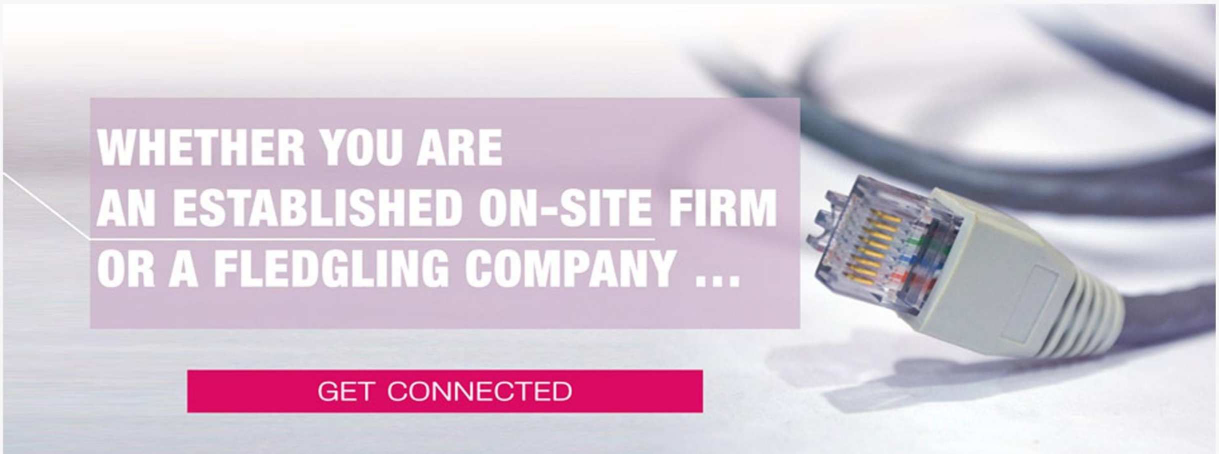
WWW.UKSTPSURVEY.CO.UK

@UKSTPSURVEY

THE UKSTP SURVEY REGISTRATION

UKSTP SURVEY
2015-2017

Your invaluable input plays a key role in the United Kingdom Science and Technology Parks Survey's success in monitoring and evaluation of innovation policies in science and technology parks in the United Kingdom. This will help us to form a better picture of drivers and barriers to innovation and innovation policies at local and regional levels, and provide evidence-based policy and practice recommendations to inform policy development and implementation. All participating companies will receive an exclusive commentary and a complimentary summary of the results. If you would like to take part in the next UKSTP Survey, please register your interest by completing the registration form (http://ukstpsurvey.co.uk/survey-registration.html). Your data will be treated in strict confidence and published on an anonymous basis only.



Aston Business School
Aston Business School . Aston University
WWW.UKSTPSURVEY.CO.UK
@UKSTPSURVEY

UKSTP SURVEY

2015-2017

Aston Business School

Aston Business School . Aston University

WWW.UKSTPSURVEY.ORG

@UKSTPSURVEY