Article:
Ovuakporie, OD, Gopalakrishna Pillai, K, Wang, C et al. (1 more author) (2021) Differential Moderating Effects of Strategic and Operational Reconfiguration on the Relationship between Open Innovation Practices and Innovation Performance. Research Policy, 50 (1). 104146. ISSN 0048-7333

https://doi.org/10.1016/j.respol.2020.104146

Differential Moderating Effects of Strategic and Operational Reconfiguration on the Relationship between Open Innovation Practices and Innovation Performance

Oghogho Destina Ovuakporie[a], Kishore Gopalakrishna Pillai[b], Chengang Wang[c], Yingqi Wei[d]

[a] Leicester Castle Business School, De Montfort University, Gateway House, Leicester, LE1 9BH, UK
[b] Amrita School of Business, Amrita Vishwa Vidyapeetham, Coimbatore, India
[c] University of Bradford School of Management, Emm Lane, Bradford, West Yorkshire, BD9 4JL, UK
[d] Leeds University Business School, University of Leeds, Leeds, West Yorkshire, LS6 1AN, UK

ABSTRACT

This paper examines the relationship between open innovation (OI) practices (inbound and coupled) and innovation performance in service firms. Specifically, it invokes a dynamic capabilities perspective to propose the differential moderating effects of two forms of reconfiguration capabilities, strategic reconfiguration capability (SRC) and operational reconfiguration capability (ORC), on the focal relationship. Based on a sample of service sector firms drawn from the UK Community Innovation Survey, our analysis shows the positive combinative effects of SRC and coupled OI on radical innovation outcomes and those of ORC and coupled OI on incremental innovation outcomes. The findings of differential moderating effects underscore the need to assess the boundary conditions within which OI positively impacts on innovation outcomes and offer insights to managers on the importance of strategic and operational reconfiguration capabilities for achieving better innovation outcomes from OI practices.

Keywords: Open Innovation, Innovation Performance, Dynamic Capabilities, Strategic Reconfiguration, Operational Reconfiguration

JEL classification codes: O3, L2, L80

Differential Moderating Effects of Strategic and Operational Reconfiguration on the Relationship between Open Innovation Practices and Innovation Performance

1. Introduction

The business environment is dynamic due to changing consumer needs and rapid market development and technological advancement. Firms are looking for effective approaches to adapt to these changes in order to remain competitive (Chesbrough, 2003; Wang et al., 2015; West et al., 2014). One approach is the adoption of open innovation (OI) practices that advocate the use of both internal and external information/knowledge and the combination of internal and external paths to market for exploitation of innovation (Chesbrough, 2003). The openness aspect of innovation is represented by the information/knowledge flows across the permeable boundary of the firm. These information/knowledge flows may involve inflow into the firm (inbound OI), outflow for purposively pursuing commercialisation or obtaining financial or non-financial benefits (outbound OI), and both inflow and outflow for co-innovation with partners through structured inter-organisational relationships (coupled OI) (Gassmann and Enkel, 2004). Concomitant to firms' increasing use of OI is the growing academic research on this concept and its impact on firm performance (Bogers et al., 2018; Gassmann et al., 2010a; Huizingh, 2011; West and Bogers, 2017; West et al., 2014).

OI has been shown to provide benefits to adopting firms through the mechanisms of resource acquisition, organisational learning and networked relationships (Bigliardi and Galati, 2016; Cassiman and Valentini, 2016; Garriga et al., 2013; Laursen and Salter, 2006). OI allows firms to tap into widely dispersed knowledge across multiple organisations, acquire complementary resources, share costs and risks associated with R&D, realise learning effects or even compress learning curves and benefit from spillover effects associated with networks. But there are also noticeable challenges centred on mostly transaction and organisational costs. As OI involves intentional transfer of knowledge, there is also a risk of knowledge leakage resulting in no/little financial returns to the firm, loss of control of collaboration and coordination, and the creation of potential competitors (Dahlander and Gann, 2010). Cognitive, organisational, cultural and institutional differences hinder OI effectiveness. Relevant capabilities are therefore required to optimise values of external information/knowledge to achieve successful innovation outcomes (Cheng and Huizingh, 2014; Dahlander and Gann, 2010; Mahdad et al., 2019; West and Gallagher, 2006). However, issues surrounding these capabilities remain under researched. Recognising this, Vanhaverbeke and Cloodt (2014) and West and Bogers (2017) propose the use of dynamic capabilities (DCs) perspective as a theoretical foundation and call for more research to explicitly link DCs to OI. In response to this call, this paper adopts the DCs perspective to investigate the moderating effect of two forms of reconfiguration capabilities, strategic reconfiguration capability (SRC) and operational reconfiguration capability (ORC), on the relationships between OI and innovation outcomes.

SRC refers to the ability to adjust strategies in response to changing environments (Lutjen et al., 2019; Wu et al., 2012). Today's firms pursue multiple strategies, not just profit maximisation. Examples of non-financial strategies include market penetration, customer satisfaction, creating new products, services or business models, cash flow and sustainability. The rapid pace of changes in the business environment means that firms need to understand their own strategic needs and adjust strategic plans according to information gathered and synthesised from internal and external sources in a timely and effective manner to align strategies with the external environment and maintain competitiveness (Douma et al., 2000; Jantunen et al., 2005; Teece, 2017; Wang et al., 2015). Macpherson et al. (2004), for example, studied RWL, a British company supplying technical products as well as undertaking manufacturing, and revealed that, as the firm grew bigger,

the size of the firm and the mundane management activities essential for business operations restricted technological collaboration with business partners in their extended business networks. It was the firm's SRC that enabled it to create entrepreneurial space within the firm, undertake organizational restructuring and implement a management information system. Consequently, the conjunction of SRC and coupled OI led to successful innovation outcomes.

ORC is conceptualised as the ability of a firm to reconfigure its operational resources, processes and routines in order to achieve transformations in response to environmental changes and to restore fit between operations and market environment (Biesenthal et al., 2019; Flynn et al., 2010; Helfat and Winter, 2011; Jantunen et al., 2012; Jantunen et al., 2005; Jantunen et al., 2018; O'Reilly and Tushman, 2008). Jantunen et al. (2012) presented four firms in the Scandinavian magazine-publishing industry. Facing complex, transient business environment threatened by the increased use of online media and international brands, all firms had operational reconfiguration routines in the form of formalized systems in information/knowledge management, leadership practices, asset co-specialization and resource reconfiguration that specified the way in which changes could be regularly made. A notable example across them all was the practice of resource reconfiguration to increase the use of freelancers and other external resources (e.g. outsourced coding work and paid bloggers) and the investment in new platforms. The ORC enabled firms to remain competitive despite intensified competition through facilitating and controlling changes and keeping operations relevant and effective, consequently, leading to "better asset co-specialization within the companies" (Jantunen et al., 2012, p. 151).

SRC and ORC involve differentiated sets of skills, processes, and routines which are essential to reconfigure firms' strategies and operations optimally, allowing them to effectively interact with other economic agents in a dynamic environment and to take advantage of inter-organisational knowledge transactions (Berchicci, 2013; Cheng et al., 2016; Grimaldi et al., 2013). As mentioned above, when firms open their boundaries to external collaborations, both opportunities and challenges arise. Firms thus need to leverage reconfiguration capabilities to effectively adapt to the changing environment so as to simultaneously exploit opportunities and overcome challenges presented by OI for realizing successful innovation outcomes. For example, in the aforementioned case of RWL, the firm built up extensive business networks and had R&D collaborations with suppliers and customers who operated along the whole of the supply chain. This coupled OI setting helped with access to external knowledge resources, but was not a guarantee of innovation outcomes (Mahdad et al., 2019). In this case, the combination of SRC and coupled OI enabled the firm to embark on a transformational trajectory and orchestrate resources to overcome 'crisis of knowledge' in a combined context that requires the understanding of specific knowledge domains and the ability to act within a particular institutional environment and community of practice to deliver successful innovation. It is also SRC that enabled RWL to deal with challenges associated with OI and act as "a knowledge integrator rather than a knowledge owner … reflecting[ing] a sophisticated understanding of the changing competitive landscape" (Macpherson et al., 2004, p.173). Similarly, in the examples presented by Jantunen et al. (2012), ORC helped two companies, *Square Media* and *Triangle Corporation,* take advantage of inbound OI practices for innovation. They engaged in dialogues with customers (readers and advertisers) to identify their values and needs and acquired innovation-related inputs from complementors and suppliers. *Square Media* took the R&D process related to obtaining external knowledge furthest and achieved radical online innovation, while external engagement was a flexible and informal process in *Triangle Corporation* which achieved incremental innovation outcomes.

To the best of our knowledge, no prior evidence exists on the combinative effects of reconfiguration capabilities and OI on innovation outcomes. This deficiency in the literature needs to be addressed, since the increasing adoption of OI by

firms as an alternative route to innovation or as a complement for internal R&D requires improved understanding of the boundary conditions under which OI impacts on innovation performance. To fill the research gap, this paper investigates how SRC and ORC exert combinative effects with OI on innovation outcomes. In terms of the type of OI, we focus on inbound and coupled OI because they are both closely related to firm innovation performance, while outbound OI is more about external exploitation of internal knowledge for commercial benefits through selling patents, direct licensing or other means (Gassmann and Enkel, 2004; Greco, 2015; Huizingh, 2011). In terms of innovation outcomes, we distinguish between radical and incremental innovations (Laursen and Salter, 2006; Myhren, 2018; Parida et al., 2012; Ritala and Hurmelinna-Laukkanen, 2013). Radical innovation delivers innovative results that are new and often involves breakthrough technologies and customer benefits that significantly change the way products and services are used and experienced. Incremental innovation produces outcomes that depart minimally from existing ones, which may also enhance customer experience but does not fundamentally deviate or disrupt from existing knowledge and technologies. Based on the DCs perspective, we will hypothesise and analyse the impact of two types of OI on two types of innovation performance and the moderating role of two types of DCs.

The empirical context is service sector firms in the UK. Despite the service sector growing rapidly and making major contribution to economic development, particularly in developed countries (Battisti et al., 2015; Chen et al., 2016; Mina et al., 2014), research on innovation in service firms remains limited (Castro et al., 2011; Gallouj and Djellal, 2018; West and Bogers, 2017). Innovation in services is inherently different from innovation in manufacturing (Battisti et al., 2015; Lutjen et al., 2019; Mina et al., 2014; Randhawa and Scerri, 2015) because the peculiarities and specificities of services including simultaneity, inseparability, intangibility/perishability and heterogeneity (Battisti et al., 2015; Gallouj and Weinstein, 1997; Gallouj and Windrum, 2009; Jaw et al., 2010) propel services to be usually location-bound and information-intensive and involve strong human interactions. At first sight, service firms may be more likely to adopt OI practices and leverage dynamic capabilities for innovation than manufacturing firms so as to create value through customisation, personalisation, stakeholder engagement and improved standards of service provision and minimize the risk of rigidities through continuous feedback loops of interactions and adjustments (Agarwal and Selen, 2009; Battisti et al., 2015; Chesbrough, 2010; Kindström et al., 2013; Lutjen et al., 2019; Mina et al., 2014; Salunke et al., 2011; West and Bogers, 2017). However, the intangible and heterogenous nature of services, relative to manufacturing products, makes it particularly challenging to manage customer interface for innovation (Chen et al., 2016; Randhawa and Scerri, 2015). The perishability feature entails that service innovation is more difficult to protect than product innovation. While these could be the barriers of OI practices, SRC/ORC can be leveraged in overcoming the barriers and maximising the utilities of OI for successful innovation in services. SRC is pivotal for readjusting strategic goals and reconfiguring resources that transform firms on the basis of OI in responding to the different possibilities that are present in the external environment, while the intangibility nature of services makes ORC particularly important to utilise intangible resources for operational reconfiguration (Agarwal and Selen, 2009; Flynn et al., 2010; Jantunen et al., 2005; Jantunen et al., 2018; Macpherson et al., 2004). Thus, the unique characteristics of services necessitate a study to focus on the complementarity between DCs and OI in innovation in service firms.

We select a sample of service firms from the UK Community Innovation Surveys. The service sector is particularly important to the UK[1] with the economy experiencing structural shift away from manufacturing towards services (Mina et al., 2014). Also affecting services is the inextricable interaction among new technologies, human capital and increased

[1] The service sector contributed to 77% of UK's gross value added and 83% of employment for 2015 compared to manufacturing sector's contribution of 10% gross value added and 8% employment (BIS, 2015).

complexity of the productive systems, the globalisation of markets, the changing role of the state, and societal and environmental challenges (Gallouj and Djellal, 2018; Gallouj et al., 2015), which all drive and shape service innovation. UK's services, therefore, offer a context of environmental dynamism, much suitable to study the role of dynamic capabilities in the relationship between OI and innovation performance. We find that both inbound and coupled OI have a positive impact on innovation outcomes. But the degree of the impact of coupled OI is noticeably higher than that of inbound OI on radical innovation, nevertheless their effects on incremental innovation are not statistically different from each other. SRC strengthens the positive effects of coupled OI on radical innovation outcomes while ORC does that to the impact of both inbound and coupled OI on incremental innovation outcomes.

The contribution of this study to the field of OI is threefold. First, by invoking DCs perspective, a systematic examination of the role of DCs in the focal relationship between OI and innovation performance is facilitated. This promotes the uptake of theoretical understanding at the intersection of DCs and OI literatures. Second, we examine the conditional effects of SRC and ORC on two types of innovation performance, radical and incremental, which helps clarify their influences on innovation performance and gain an insight on the moderators in OI processes, a much under-researched area noted by West and Bogers (2017). Third, we provide sound empirical evidence of the focal effects by conducting a large sample analysis focusing on service firms which is relatively in short supply in OI studies (Huizingh, 2011; van de Vrande et al., 2009). Our research findings should also be of relevance to manufacturing sector which has witnessed the major shift from product-centeredness to a product-and-service orientation (Kindström et al., 2013) and from doing it alone to partnering with service firms (Vendrell-Herrero et al., 2018), particularly in high-velocity industries (e.g. high-tech industries) which emphasise the brisk and discontinuous changes in consumer demand, market competition and technological shift. Our analyses also have significant implications for managerial practice, particularly on how firms maximize the benefits from their OI activities. Addressing the issue of dynamic environments, organisations should focus on enhancing capabilities for innovation, which will help managers derive more concrete benefits.

2. Literature Review and Hypothesis Development

2.1. Open Innovation in Services and Dynamic Capabilities for Open Innovation

The concept of OI is first defined by Chesbrough (2003) as "a paradigm that assumes that firms can 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" (p. xxiv). Existing OI research is centred on three key themes: technology, business models, and users and communities. Technology research primarily focuses on technology exploration (e.g. van de Vrande et al., 2009) and technology exploitation (e.g. Tsai and Wang, 2009). Business models primarily focus on the exploitation of knowledge (e.g. Chesbrough, 2006) and appropriability (e.g. Dahlander and Gann, 2010; Miozzo et al., 2016). User and communities research examines how organisations collaborate with customers, suppliers and other external partners in the exploration of new ideas and knowledge and generate value for themselves (e.g. Eiteneyer et al., 2019). West et al. (2014) conduct a review on the contributions and evolution of OI research and identified emerging themes and areas where further research is required. In response to this review, this paper aims to contribute to two of the themes, i.e. the integration of OI with established theories of innovation, management and economics, and the application of OI to new contexts. The former is achieved through adopting the DCs perspective and the latter through the examination of services.

The peculiarities and specificities of services include simultaneity, inseparability, intangibility/perishability and heterogeneity (Battisti et al., 2015; Gallouj and Weinstein, 1997; Gallouj and Windrum, 2009; Jaw et al., 2010; Randhawa and Scerri, 2015). Simultaneity means that services tend to be produced, delivered and consumed simultaneously. Inseparability refers to the difficulty of separating service production from service consumption. As a result, service encounters are often characterized by active involvement between service providers and customers. Intangibility/perishability signifies that services are intangible and cannot be inventoried like products. Heterogeneity means that services tend to have greater variance in quality, compared to products, because of human intervention. These characteristics lead services to be usually location-bound and information-intensive and involve strong human interactions with a wide range of people including customers, employees, supplier and partners in an innovative service process (Chen et al., 2016), and as a result, innovation in services is inherently different from innovation in manufacturing (Battisti et al., 2015; Lillis et al., 2015; Lutjen et al., 2019; Mina et al., 2014; Randhawa and Scerri, 2015). In comparison to the latter, the former is more challenging as a result of its complexity and fuzziness, requires more and deeper engagement of network partners and involves more dynamic, unpredictable and less standardized processes. Empirical evidence revealed that manufacturing firms have a greater tendency to carry out technological innovation than service firms, while service firms are more inclined to implement non-technological innovation than manufacturing firms (Castro et al., 2011; Mina et al., 2014; Vergori, 2014) and the relational nature of services is reflected in their higher level of engagement in OI relative to manufacturing firms (Mina et al., 2014).

Service innovation can take many forms involving the development of new services, new ways of producing and delivering services, new forms of interaction with clients, and new forms of commercialization and marketing strategies (Amara et al., 2009; Randhawa and Scerri, 2015). OI practices are adopted by service firms to create value through customisation, personalisation and improved standards of service provision (Battisti et al., 2015; Chesbrough, 2010; Lutjen et al., 2019; Mina et al., 2014; West and Bogers, 2017). Jaw et al. (2010) show that both perishability and heterogeneity of services have a positive impact on service innovation. For example, to lower perishability, new service products focusing on providing faster and more efficient automation activities, e.g. online banking and online shopping that complement onsite services, are created in collaboration with partners in the entire value chain network. To lower heterogeneity and achieve more consistent service performance, new service processes can be established, e.g. McDonald's standard operating procedures (SOPs). However, the intangible and heterogeneous nature of services makes it challenging to manage customer interface and communication for OI (Randhawa and Scerri, 2015). Service firms need to sense customer needs and technological options that enable innovative offering and reconfigure their strategies and operations in responding to changes in the marketplace. However, as services are intangible, firms need to engage in open and collaborative customer-supplier exchanges, which is an interactive, dynamic, complex process of knowledge exchanges across parties in the value chain, so as to effectively synergise internal and external resources for OI (Randhawa and Scerri, 2015). It is also challenging to assess the quality of service innovation because it is often evaluated on the basis of customer perception (Lillis et al., 2015; Tidd and Bessant, 2013). The services' perishability feature makes innovation in services more difficult to protect than product innovation, creating uncertainties in utilizing OI for innovation. Therefore, the complexity and fuzziness related to innovation in services require firms to have capabilities to manage and coordinate OI activities for value creation and performance enhancement (Lutjen et al., 2019).

Capabilities are built on the resources and competences of the organisation and can be developed through the integration of specialist knowledge within and outside the organisational boundaries. We invoke the dynamic capabilities (DCs) perspective to discuss the combinative role that DCs and OI play in generating innovation outcomes. DCs propose an

approach of flexibility, transformation, and reconfiguration that has increasingly become relevant to innovation as the global economy becomes more open and the sources of innovation more widely distributed among various institutions (e.g. Agarwal and Selen, 2009; Biesenthal et al., 2019; Chang et al., 2012; Chen et al., 2016; Cheng et al., 2016; Grimaldi et al., 2013; Kandemir and Acur, 2012; Li-Ying et al., 2016; Lutjen et al., 2019; Teece, 2017). The DCs perspective considers the changing nature of the business environment in which firms operate and also offers insights into organisational competences, resources and structures required for the effective adoption of OI practices in firms (Teece, 2017). DCs also address some of the important elements of OI such as the balance between internal and external knowledge, the important role of the business model, and the adoption of OI as a way to access and integrate external technology (Vanhaverbeke and Cloodt, 2014). OI encourages the inflow and outflow of knowledge from external sources. When an organisation opens its boundaries to external collaboration to accelerate knowledge acquisition and utilisation, a wide range of new opportunities for adapting internal resources and capabilities emerges (Chesbrough, 2003). However, this requires the leverage of DCs for successful exploitation and exploration of ideas and opportunities to quickly adapt to changing situations (Cheng and Huizingh, 2014; Lutjen et al., 2019; West and Gallagher, 2006). Therefore, the DCs and OI are closely aligned as both constructs are concerned with strategic responses to changes and the effective management of innovation in dynamic environments.

DCs can be defined as the "capacity (1) to sense and shape opportunities and threats, (2) to seize opportunities, and (3) to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise's intangible and tangible assets" (Teece, 2007, p. 1319). The first dimension of DCs, sensing capabilities, refers to firms creating innovation opportunities through the combination of internal knowledge (R&D activities) and external knowledge (Teece, 2007). External knowledge is acquired through tapping into the research output of external sources and also learning about customer needs and market/technological development. The reliance on external knowledge associated with sensing capability is aligned with OI, where external knowledge is equally important in the innovation process. Once an opportunity is sensed, the second dimension of DCs, seizing capabilities, come to play through the introduction of new products, processes, or services (Teece, 2007). This entails making the right decisions regarding the investment in technology, complementary assets and commercialisation activities as multiple and sometimes competing investment paths are possible. Thus, the ability of a firm to create, refine and replace business models is fundamental to the seizing capability. Business model also plays a key role in OI (Liao et al., 2019; Vanhaverbeke and Cloodt, 2014). However, the seizing dimension is largely focused on internal paths to market, whereas OI emphasises both internal and external paths to market (Chesbrough, 2003). The third dimension of DCs, reconfiguration capability, is concerned with the ability of a firm to reconfigure strategies and operations by continuous renewal and modification of its resources and assets in order to maintain competitiveness in a rapidly changing and turbulent environment (Teece, 2007). Reconfiguration is essential to maintain evolutionary fitness and to escape unfavourable path dependencies (Lutjen et al., 2019). Achieving decentralisation and near decomposability is one of the micro-foundations underlying this dimension. This can be explicitly linked to OI since it also relies on a distributed model of innovation where the firms access and integrate external knowledge.

Premised on the DCs perspective, we focus on reconfiguration capabilities in our discussion of the OI-innovation outcomes relationship. as they are higher order DCs that have the ability to strengthen sensing and seizing capabilities (Ambrosini et al., 2009; Jantunen et al., 2012; Schilke, 2014; Wang and Ahmed, 2007). Reconfiguration capabilities can assist firms to quickly adapt to the changing environment so as to successfully recognise and exploit opportunities and overcome challenges presented by OI for improving firm's innovation performance (Chang et al., 2012; Grimaldi et al.,

2013; Jantunen et al., 2012; Jantunen et al., 2005; Li-Ying et al., 2016; Lutjen et al., 2019; Teece, 2007). Additionally, as noted by Kindström et al. (2013), focusing on sensing and seizing capabilities helps produce a short-term competitive advantage, but reconfiguring provides sustainable advantages.

Reconfiguration capabilities have two dimensions, strategic and operational. As defined in the introduction, SRC refers to the ability to dynamically adjust strategies in response to marketplace dynamics. ORC is conceptualised as the ability of a firm to reconfigure its operational resources, processes and routines in order to achieve transformations in response to environmental changes and to restore fit between operations and market environment. The rapid pace of changes in the business environment means that firms need to understand their own strategic needs and opportunities and adjust strategic plans and operations in a timely fashion to respond to information gathered and synthesised from internal and external sources so as to align strategies and operations with the external environment (Douma et al., 2000; Helfat and Peteraf, 2003; Wang and Ahmed, 2007). SRC and ORC are important to OI as they are capabilities involving differentiated sets of skills, processes, and routines which are essential for configuring firms' operations and strategies optimally, allowing them to effectively interact with partners, customers and suppliers in a dynamic environment and to take advantage of inter-organisational knowledge transmissions (Berchicci, 2013; Cheng et al., 2016; Grimaldi et al., 2013). This can be particularly relevant in the context of services.

The specific characteristics of services (simultaneity, inseparability, and intangibility/perishability and heterogeneity) introduce perceived ambiguity, perceived risk, and complexity in processing information and decision making, and as a result, increase the level of uncertainty. This exacerbates challenges associated with OI that arise due to cognitive, organisational, cultural and institutional differences, hindering firms from identifying and integrating valuable knowledge and to benefiting from OI. Therefore, in order to maximise the opportunities and manage the challenges, service firms need capabilities, perhaps more so than manufacturing firms, to make strategic and/or operational changes (Lutjen et al., 2019).

SRC is pivotal for readjusting strategic goals and reconfiguring resources to meet changes in dynamic environments (Jantunen et al., 2005; Macpherson et al., 2004). A firm's strategies determine its operational directions and policies and have great importance in determining its business success. Yen et al. (2012) show that strategic orientation, defined as the strategic directions executed by a firm to generate proper behaviours, is fundamental for firms adopting service innovation. Cheng and Huizingh (2014)'s empirical tests based on a sample of Asian service firms establish that strategic orientation enhances the effectiveness of OI on service innovation performance. As strategies need to be adaptive enough to accommodate dynamic environmental factors, SRC is essential for firms to reconfigure resources through the integration of internal and external knowledge and assets to achieve congruence with the environments effectively and deliver successful innovation outcomes (Lutjen et al., 2019).

Due to the intangible nature of services, ORC is particularly important to utilise intangible resources for innovation as a way to respond to the different possibilities that are present in the external environment (Agarwal and Selen, 2009; Flynn et al., 2010; Jantunen et al., 2018). The examples discussed in Jantunen et al. (2012) demonstrates the relevance of ORC in the service context, showing that ORC is firm-specific and reflected in the firm's ability to make changes to its operations in order to meet the demand of its customers. Despite different motives, all four case companies, at approximately the same time, made similar operational changes and adopted similar management and co-specialization

practices in response to environmental changes. Thus, both SRC and ORC are important and highly visible in the service context.

2.2 Open Innovation (OI) and Innovation Performance

OI can be broadly divided into inbound, outbound and coupled OI. In OI practices, knowledge is considered as an economic good, exchanged between a firm and external parties. As knowledge flows across the permeable boundary of a firm, inflow of external knowledge into the firm is classified as inbound OI, outflow of knowledge from the firm as outbound OI and the combination of both as coupled OI (Gassmann and Enkel, 2004). We focus only on inbound and coupled OI because they are both closely related to firm innovation performance, while outbound OI is more about external exploitation of internal knowledge for commercial benefits though selling patents, direct licensing or other means (Gassmann and Enkel, 2004; Huizingh, 2011). This is in line with existing research on OI and innovation performance which has almost exclusively focused on inbound OI and coupled OI. In a recent survey by Greco (2015) on European empirical evidence, only two out of sixty one articles examined outbound OI. Mazzola et al. (2012) conducted a systematic review of empirical studies published between 2003 and 2012 and also noticed the absence of research pertaining to outbound OI.

Theoretically, both inbound and coupled OI are expected to positively impact on innovation performance (West and Bogers, 2017). The main benefit mechanisms are resource acquisitions, organizational learning and networked relationships. As many knowledge sources necessary to achieve innovation can only be found outside the boundaries of the firm, engaging in inbound and coupled OI exposes firms to a new world of information/knowledge and offers them opportunities to develop and sustain resources and capabilities to transcend internal limitations. Innovation performance, thus, can be improved through increased access to knowledge and technology developed elsewhere, improved choices for renewing problem-solving capacities and ability to appropriate the returns from innovation (Berchicci, 2013; Laursen and Salter, 2006; Leiponen and Helfat, 2010). OI also helps firms broaden their mental models and enact learning because the exposure could prompt firms to question the present course of actions and the strategies and operational routines and processes behind them. OI, in essence, involves a creation of networks and networked relationships that tend to be greater than the aggregation of bilateral relationships (Dahlander and Gann, 2010; Eiteneyer et al., 2019). The difference between inbound and coupled OI is that the latter combines inbound and outbound OI through strategic alliances with complementary partners, universities and research institutes or by partnership with other companies including its competitors (Drechsler and Natter, 2012; Ritala and Hurmelinna-Laukkanen, 2013; Spithoven et al., 2013). The OI framework implicitly posits complementarity between inflows and outflows of knowledge, hence coupled OI, like inbound OI, can positively impact on innovation performance (Cassiman and Valentini, 2016).

Despite the broad recognition of the positive role played by OI in innovation performance, OI is not without pitfalls (Berchicci, 2013; Bigliardi and Galati, 2016; Chesbrough, 2003; Mahdad et al., 2019). The main cost mechanisms include transaction costs associated with searching and selecting suitable external knowledge and R&D partners and coordinating, managing and controlling R&D activities, and organizational costs attributable to the internal strategic, structural and operational transformation required to accommodate the new innovation system of OI (Cassiman and Valentini, 2016). Inbound OI may be associated with over-search problem, while coupled OI could suffer from over-collaboration problem (Greco et al., 2016). Collaboration and coordination with a portfolio of external partners could subject firms to too much information, too many ideas, too many choices and too many potentials, which makes filtering valuable knowledge and

making informed, economic rational decisions a challenging task (Parida et al., 2012). OI may also lead to an increase in costs and complexity as each external partner has their own idiosyncratic organisational structure and processes and cultural norms, therefore should be seen as a separate search space and requires individual attention (Cassiman and Valentini, 2016; Mahdad et al., 2019). Without sufficient engagement efforts with external partners, the variety of ideas stimulated by OI activities may just touch on shallow surfaces and not lead to successful innovation (Huang and Rice, 2009; Laursen and Salter, 2006). These engagement efforts could involve firms making strategic shifts (e.g. RWL) or operational changes (e.g. *Square Media* and *Triangle Corporation*). No doubt such alternations in firm's internal systems add costs (Berchicci, 2013; Cassiman and Valentini, 2016).

Empirical evidence based on European firms overwhelmingly show that inbound and coupled OI have a strong and positive impact on a firm's innovation performance. As revealed in Greco (2015)'s review, 21 journal articles (out of 23) found positive impact of inbound OI on innovation performance and 38 articles (out of 40) found positive impact of coupled OI. Outside the European context, the picture is mixed. Using a composite construct capturing inbound, outbound and coupled OI, Cheng and Huizingh (2014) find positive effects of OI on innovation performance in Taiwanese service firms. In terms of the effects of inbound OI, studies on Chinese companies report positive effects (Cheng et al., 2016; Li-Ying et al., 2016; Liao et al., 2019). In contrast, Tsai and Wang (2009) focusing on low- and medium-technology Taiwanese firms find that inbound OI has no significant impact. Huang and Rice (2009) find negative effects in Australian SMEs. In terms of the effects of coupled OI, Li-Ying et al. (2016) show that coupled OI negatively impacts on innovation, but Tsai and Wang (2009) reveal that coupled OI with suppliers, customers and competitors has no impact on innovation performance, while the collaboration with research institutions and universities has a negative impact. Notwithstanding the contradictory findings reported, the overwhelming evidence indicates that both inbound and coupled OI positively affect innovation outcomes. Therefore, we expect positive relationships between inbound and coupled OI and innovation outcomes.

Depending on the degree of novelty, the extant literature distinguishes innovation outcomes between radical and incremental innovation (Garriga et al., 2013; Laursen and Salter, 2006; Myhren, 2018; Oerlemans et al., 2013; Parida et al., 2012). Radical innovation is focused on the introduction of revolutionary and novel products and services. Incremental innovation is focused on improving existing products and services. In the context of service innovation, Gallouj and Weinstein (1997) suggest that radical innovation means introducing a new set of characteristics not related to existing ones and incremental innovation means improving performance of existing characteristics of the service. Radical and incremental innovation differs significantly in nature, process, and magnitude (McDermott and O'Connor, 2002). Radical innovation is about ground-breaking development and usually requires long-term development and heavy investment. In contrast, incremental innovation is about developing better solutions that are attractive and would add value to existing products and services and may offer immediate market value. Firms engaged in radical innovation tend to focus on exploration, flexibility-enhancing, and adaptive activities, whereas those in incremental innovation tend to focus on exploitative, efficient, and aligning activities (Chang et al., 2012). Radical innovations face a more rigorous and uncertain development process including complex customer adoption processes that require significant amount of resources than incremental innovations (McDermott and O'Connor, 2002). Radical innovation relies on tangible and intangible resources that are less standardised and more transaction specific (idiosyncratic) than incremental innovation. Often new procedures, routines, management practices and marketing skills are required for radical innovation.

Empirical studies have examined both types of innovation performance. In general, both inbound and coupled OI were found to positively impact on both types of innovation (Garriga et al., 2013; Greco, 2015; Laursen and Salter, 2006; Ritala and Hurmelinna-Laukkanen, 2013). Nevertheless, the degree of the positive effects seems to vary depending on the context being examined. For example, a study by Bayona-Sáez et al. (2013) on Spanish firms finds, in the full sample including all firms, both inbound and coupled OI positively affect radical and incremental innovation. However, in a sample confined to only agri-food firms, both inbound and coupled OI positively impact only on radical innovation. Greco et al. (2016) conduct a large sample examination of European firms and find that inbound OI affect both radical and incremental innovation and coupled OI is related only to radical innovation. Thus, despite the initial positive effects of OI on innovation performance, there are diminishing returns to OI. The equivocal findings in the literature suggest that we need to assess the impact of inbound and coupled OI on radical and incremental innovation separately.[2] We therefore propose the following hypotheses:

H1: *Inbound OI has positive effects on (a) radical innovation and (b) incremental innovation.*

H2: *Coupled OI has positive effects on (a) radical innovation and (b) incremental innovation.*

In the context of service firms, we would expect coupled OI, an integrated approach to innovation, that unite both inbound and outbound OI, to have a stronger effect than inbound OI on innovation outcomes. Relative to inbound OI which involves mostly sourcing knowledge, coupled OI offers a structured approach to engage in R&D collaboration (Drechsler and Natter, 2012; Ritala and Hurmelinna-Laukkanen, 2013; Spithoven et al., 2013). As mentioned above, the characteristics of services have profound implications to OI paradigm. The heavy customer-orientation, less standardized and more flexible offerings and the intangible and perishable nature of services exacerbate the need for structurally integrating customers and business partners into the innovation process so as to exchange tacit and explicit information/knowledge, engage in intensive communications and maintain a continuous feedback loop (Greco et al., 2016). Although coupled OI involves intentional transfer of knowledge, hence there is a risk of knowledge leakage with no return back to the firm and loss of control of collaboration and coordination (Drechsler and Natter, 2012), the formal governance structure somewhat mitigates the opportunist behaviours and facilitates the synergistic links between and reconciles the divergent, incompatible interests of all parties involved in the collaboration (Narula and Hagedoorn, 1999; Spithoven et al., 2013). Additional benefits associated with coupled OI also include improving learning effectiveness, the exploitation of economies of scale and scope in R&D and cost- and risk-sharing between partners (Frenz and Ietto-Gillies, 2009; Spithoven et al., 2013). Therefore, we propose the following hypothesis:

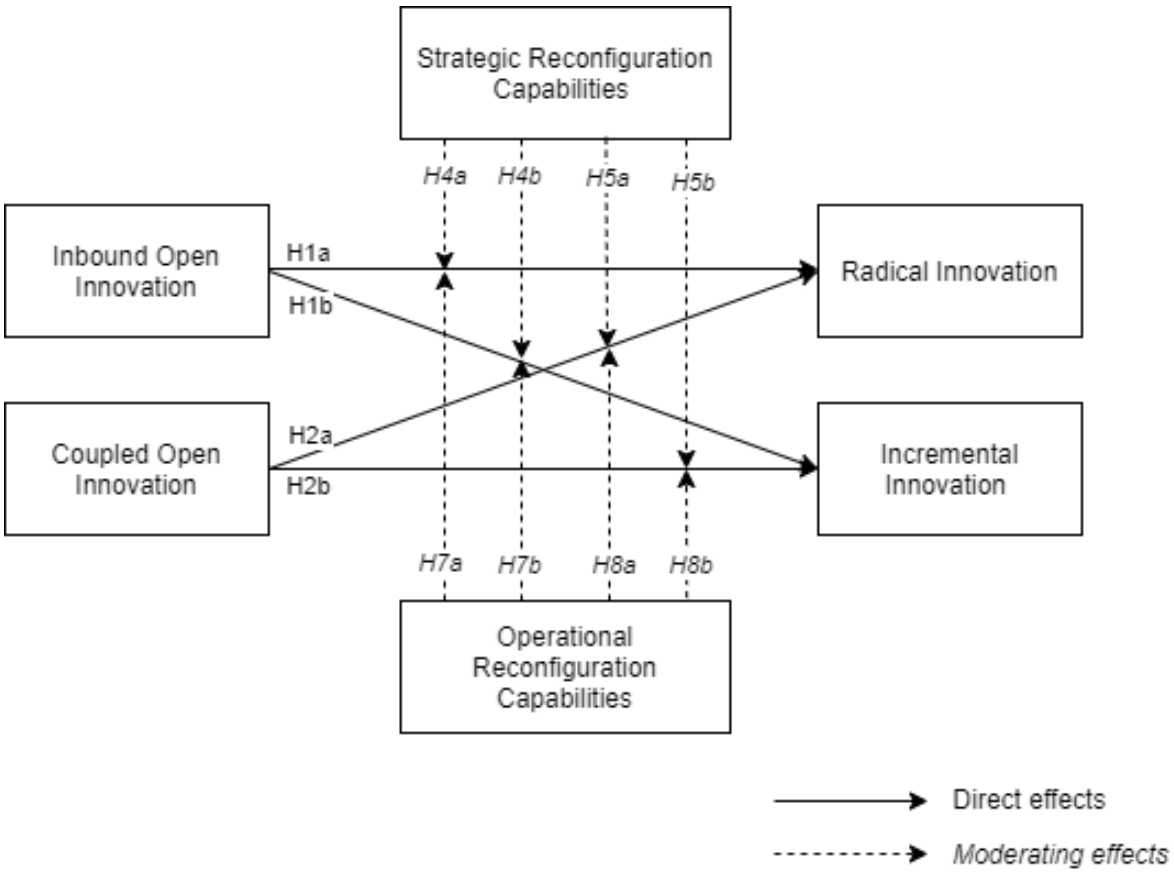
H3: *Coupled OI has stronger effects on (a) radical innovation and (b) incremental innovation than inbound OI.*

[2] Few papers develop hypotheses referring to the separate impact of inbound OI and coupled OI on radical and incremental innovation, respectively, with the exception of Greco et al. (2016) and Parida et al. (2012). Hypotheses in Greco et al. (2016) do not relate to differential effects of inbound and coupled on radical and incremental innovation. In the context of SMEs, Parida et al. (2012) develop hypotheses arguing inbound OI is more strongly associated with radical than incremental innovation. They differentiate the opposing effects of vertical technology collaboration (VTC) and horizontal technology collaboration (HTC) which tap into coupled OI and find that VTC is more strongly associated with incremental than radical innovation, while HTC is more strongly associated with radical than incremental innovation. As the SME context is central to these hypotheses, it is difficult to generalise these hypotheses to non-SME firms.

2.3 The Moderating Role of Strategic and Operational Reconfiguration Capabilities

The DCs perspective is one of the popular theoretical frameworks in the broad innovation research (Teece, 2017), but its application to the OI research is relatively limited as elaborated above. Our theoretical reasoning so far implicitly assumes that firms have DCs to transform OI to successful innovation outcomes through the mechanisms of resource acquisition, organisational learning and networked relationships. However, organisations vary by their DCs and the performance enhancing effects of DCs are not unconditional (Girod and Whittington, 2017; Ritala and Hurmelinna-Laukkanen, 2013; Schilke, 2014; Wilden et al., 2013). DCs are reflected by organisational change routines. While lower-order DCs are about firm's resource base and fundamentals, reconfiguration capabilities are higher-order DCs which can be leveraged to develop and analyse lower-order DCs, so as to understand what do or do not work and keep them from stagnating (Robertson et al., 2012; Schilke, 2014). This section explores the combinative effects of strategic and operational dimension of reconfiguration capabilities, i.e. SRC/ORC, and inbound/coupled OI on innovation outcomes, as illustrated in Figure 1.

Figure 1. Conceptual model



In the absence of an explicit strategic or operational shift that justifies OI adoption, the default option is to focus on "business as usual" or short-term strategies such as short-term profitability and cost control (O'Reilly and Tushman, 2008). With SRC/ORC, firms react to the dynamic environment and potential opportunities, *intending* to capture the value of external information/knowledge that is brought in through inbound and coupled OI and draw on novel combinations of the external and internal knowledge for successful innovation outcomes (Helfat and Peteraf, 2003; Wang et al., 2015). SRC/ORC therefore defines some boundaries on the effectiveness of OI for innovation outcomes.

2.3.1 Strategic Reconfiguration Capabilities (SRC)

Emerging market opportunities and threats often influence firms to make changes to their strategies as well as resource deployments to gain competitive advantage and increased synergy (Kandemir and Acur, 2012; Kindström et al., 2013; Wu et al., 2012). OI framework proposes that organisations need to constantly study their external environment to search for and rapidly respond to new ideas for exploration (which is associated with radical innovation) and exploitation (which is associated with incremental innovation) so as to enhance innovation performance (Chesbrough, 2003). Both exploration and exploitation can be facilitated by changes to strategy, internal systems, competencies and structures assisted by differentiated subunits with a common strategic goal (O'Reilly and Tushman, 2013). SRC enacts internal organizational transformation and reconfiguring processes, resources and activities that formalize OI as a long-term strategy and an integral part of firm's innovation strategy to avoid organisational inertia, market irrelevance and the loss of competitive advantages (Agarwal and Selen, 2009; Lutjen et al., 2019; Mahdad et al., 2019). It also facilitates actions and systematic verification of strategies that transform firms on the basis of OI (Grimaldi et al., 2013).

The case of RWL introduced in the Introduction provides an illustration of how SRC and coupled OI work together in facilitating successful innovation outcomes. The case of Curana also reveals that SRC can facilitate a firm's engagement in OI practices to explore and exploit opportunities for innovation (Vanhaverbeke, 2017). In response to increasing market competition and price pressure, Curana reconfigured its business strategy from an original equipment manufacturer (OEM) to an original brand management (OBM) strategy. These changes reframed things that the firm does and strengthened its collaboration efforts with several external partners to explore and exploit opportunities for innovation which subsequently improved its innovation outcomes.

As explained above, radical innovation is concerned with the experimentation with new alternatives and carries high risk and high uncertainty in terms of not only technology but also market success (Chang et al., 2012; McDermott and O'Connor, 2002). It departs from existing structural and technological principles and often requires organizations to strategically reconfigure resources to develop new procedures, routines, management practices and marketing skills. As such, in essence, radical innovation calls for firms to have strong SRC in place so as to strategically reconfigure their fundamentals and resources to maximise the benefits from OI. At the organisational level, this may also involve changes in organisational culture and mind-set (Chang et al., 2012; Mahdad et al., 2019; van de Vrande et al., 2009), and identity shift for the firm's stakeholders (O'Reilly and Tushman, 2008). For example, a survey study of managers with responsibility for new product development in service firms by de Brentani (2001) shows that, where radical innovations occurred with the use of OI, having a corporate culture that encouraged entrepreneurship and creativity led to a positive impact on the innovation outcomes and the role taken by senior managers in creating the vision was also pivotal. Lillis et al. (2015) conducted in-depth case studies of five service firms. In two cases, firms shifted from incremental innovators to radical innovators over the five-year period under investigation. Both firms, in response to market dynamics and the integration of OI, implemented strategic changes not only at the corporate level but also throughout the whole organisation in the areas of HR, communication and operations management, in addition to innovation. In contrast, McLaughlin et al. (2008) note that "established companies often lose the propensity to be (radically) innovative, as some of the cultural enablers of previous incremental changes become the current cultural inhibitors of radical innovation" (p. 300).

Incremental innovation is associated with the refinement and extension of existing technological profiles, which adds to existing competencies of firms (Robertson et al., 2012). In the context of OI, it is about acquiring external knowledge, recognising its value and integrating it into firm's *current* activities and routines. Incremental innovation is a more certain activity than radical innovation. Its requirement on SRC to strategically reconfigure existing resources lies in the areas of technical skills, knowledge, design and facilities. For example, in Lillis et al. (2015)'s study, three cases maintained their position as incremental innovators. During the investigation period, firms maintained their corporate strategy, nevertheless did strategically reconfigure HR, marketing and operations management so as to make improvements to existing products and services and further process innovation. Put differently, the strategic shift was more associated with functional areas, not the entire organisation.

The discussion, so far, reveals the interplay between SRC and inbound/coupled OI in influencing radical/incremental innovation. However, there is no systematic study that provides quantitative assessment on this. Noting the aforementioned case studies, we posit the positive combinative effects of SRC with inbound and coupled OI. As both inbound OI and coupled OI are about the inflows of external information/knowledge, there may be the need of strategic flexibility (Kindström et al., 2013; Macpherson et al., 2004; Nitzsche et al., 2016). Successful innovation outcomes can therefore be achieved through strategic fit which is enacted through the continuous evaluation and possibility adaption of firm's internal systems and external collaborations (Berchicci, 2013; Lutjen et al., 2019; Macpherson et al., 2004). The strategic fit not only complements to the mechanisms of resource acquisition, organisational learning and networked relationships discussed earlier, but also reinforces gains from these mechanisms (Berchicci, 2013; Jantunen et al., 2012; Macpherson et al., 2004; Wang et al., 2015; Wilden et al., 2013). Consequently, the combinative effects of SRC and inbound/coupled OI on radical/incremental innovation are likely to be positive. Moreover, following the point emphasised earlier that radical innovation (compared to incremental innovation) calls for firms to have strong SRC in place so as to strategically reconfigure their fundamentals and resources to maximise the benefits from OI, we expect that the combinative effects of SRC and inbound/coupled OI will have a greater effect on radical innovation in comparison to incremental innovation. Hence, we propose the following hypotheses:

H4: *The combinative effects of SRC and inbound OI positively affect (a) radical innovation and (b) incremental innovation; and (c) the effects are stronger for radical innovation than for incremental innovation.*

H5: *The combinative effects of SRC and coupled OI positively affect (a) radical innovation and (b) incremental innovation; and (c) the effects are stronger for radical innovation than for incremental innovation.*

Coupled OI, in essence, is about a focal firm having strategic R&D alliances with partners. Relative to inbound OI, the partnerships associated with coupled OI are longer-term and offer continuity and cost- and risk-sharing (Narula and Hagedoorn, 1999; Robertson et al., 2012; Sivusuo and Takala, 2018; Spithoven et al., 2013). This gives the focal firm more incentives to invest in leveraging SRC internally and aligning SRC with coupled OI practices (Douma et al., 2000). As coupled OI involves a formal structure, firms need to actively, strategically manage the alliance portfolio to ensure maximum value generation and minimise the significant costs associated with setting up and maintaining the strategic alliances (Cassiman and Valentini, 2016; Gassmann et al., 2010b; Oerlemans et al., 2013). Coupled OI also offers closer interactions with partners than inbound OI, creating a better context for effective resource acquisition and deep learning (Spithoven et al., 2013). SRC helps zoom in the opportunities and challenges of this context, consequently, placing the

focal firms in a better position to benefit from and mitigate risks associated with coupled OI. As such, we offer the following hypothesis:

H6: *The combinative effects of SRC and coupled OI on (a) radical innovation and (b) incremental innovation are stronger than those of SRC and inbound OI.*

2.3.2 Operational Reconfiguration Capabilities (ORC)

Operational capabilities enable firms to translate their strategies to actions through executing main operations function for intended purpose (Biesenthal et al., 2019; Helfat and Winter, 2011; Lillis et al., 2015; O'Reilly and Tushman, 2008). In the face of environmental dynamism, the DCs view emphasises ORC, arguing that firms need to reconfigure their operational resources, processes and routines in order to achieve internal and external transformations (Agarwal and Selen, 2009; Biesenthal et al., 2019; Cheng et al., 2016; Liao et al., 2019; Newey and Zahra, 2009; Teece, 2007). Through operational reconfiguration, firms can increase their process/routine efficiency and effectiveness and maximize their resource usage, which enhance the flow of external knowledge into the firms and help them sense and seize opportunities associated with OI practices (Agarwal and Selen, 2009; Biesenthal et al., 2019). This can also boost the firm's capacity for external knowledge exploration and exploitation as a means of increasing the innovativeness of the firm through cost and risk reduction.

ORC is expected to positively moderate the impact of OI on innovation outcomes in the context of services because of two reasons: the temporal effects and the closeness to customers. Once an innovative product/service is developed, shorter time to market would give the firms competitive advantages over their competitors (Ritala and Hurmelinna-Laukkanen, 2013). This temporal feature is particular important for services as they tend to have shorter life cycle than tangible goods (Battisti et al., 2015), which implies that the value of the innovation quickly diminish over time. Therefore, ORC is much needed to reconfigure firm's operations that can swiftly integrate external knowledge (inbound OI) and establish external collaborations (coupled OI), which involve incorporating, improving or combining *existing* resources, processes and routines to pursue operational excellence at a satisfactory overall cost (Biesenthal et al., 2019; Jantunen et al., 2018; Kindström et al., 2013; Robertson et al., 2012).

Particular to service innovation, the degree of closeness to customers is especially relevant. Service innovation concerns working closely with customers and customer involvement tends to have positive effects (Lillis et al., 2015; Myhren, 2018). However, being too close to customers carries the risks that firms become deeply entrenched with existing know-how and focus too much on customers. As a result, firms may not actually understand customer needs correctly; blindly depending on customers' demands, personality, and views, parts of customers' insights may be lost in operations (Parida et al., 2012). To avoid this, ORC is a much-needed DC to ensure OI is effectively transformed to innovation outcomes.

Although ORC is argued to moderate the impact of OI on innovation outcomes, the effects are expected to be greater for incremental innovation in comparison to radical innovation. Incremental innovation largely stems from firm's existing resources and knowledge base and aims to meet the needs of existing customers through refinement and improvement (Robertson et al., 2012). ORC is based on existing strategy, resources and knowledge base, but focuses on restructuring operations to facilitate incremental innovation. In contrast, radical innovation is associated with a breakaway from existing technological profiles. Radical innovation departs from existing structural and technological principles and tend to be

conducted separately from the mainstream (Kelley, 2009; O'Reilly and Tushman, 2008). Many times, such innovation has longer time lags to market success compared with incremental innovations (O'Reilly and Tushman, 2008; Parida et al., 2012). The time lags mean that firms can take time to develop and utilise its ORC to explore radical innovation than incremental innovation. In addition, in some instances, ORC might not be enough to facilitate radical innovation; SRC might be required. Hence, we propose the following hypothesis:

H7: *The combinative effects of ORC and inbound OI positively affect (a) radical innovation and (b) incremental innovation; and (c) the effects are stronger for incremental innovation than for radical innovation.*

H8: *The combinative effects of ORC and coupled OI positively affect a) radical innovation and b) incremental innovation; and (c) the effects are stronger for incremental innovation than for radical innovation.*

In parallel to the argument comparing the joint effects of SRC with inbound and coupled OI, we expect stronger moderating effects of ORC on coupled OI than inbound OI. The close partnerships through alliance structure incentivize the focal firm to devote resources in ORC so as to align operations with coupled OI practices (Douma et al., 2000). This helps to achieve operational fit, enabling firms linking strategies to cohesive action plans and effectively performing operations for intended outcomes (Grimaldi et al., 2013; Kindström et al., 2013; O'Reilly and Tushman, 2008). The active strategic management and close exchanges between partners in the context of coupled OI also ensure the effectiveness of the channels of information/knowledge transmission, complementary assets acquisition and organisational learning (Gassmann et al., 2010b). As such, we expect the following hypothesis:

H9: *The combinative effects of ORC and coupled OI are stronger on (a) radical innovation and (b) incremental innovation than those of ORC and inbound OI.*

3. Data and Methods

3.1 The Survey and Sample

The data used in the analysis is drawn from three rounds of UK Community Innovation Survey (CIS7, CIS8 and CIS9). The CIS surveys are based on the core developed by Eurostat and Member States on innovation and are conducted every two years by EU member states and a number of ESS member countries. CIS7, CIS8 and CIS9 took place in 2011, 2013 and 2015 respectively. The CIS datasets have been widely used in studies published in top journals such as Research Policy and Strategic Management Journal, e.g. Cassiman and Valentini (2016); Frenz and Ietto-Gillies (2009); Garriga et al. (2013); Laursen and Salter (2006); and Leiponen and Helfat (2010).

The method and types of questions used in the CIS is described in the Organisation for Economic Co-operation and Development's (OECD) Oslo Manual 2005. The reliability, interpretability and validity of the survey was established through extensive piloting and pre-testing before its implementation across different European countries and in firms from a range of industrial sectors, including manufacturing, construction and services. The questionnaire is developed from a long tradition of research on innovation, including the SPRU innovation database and the Yale survey (Cohen and Levinthal, 1990; Klevorick et al., 1995; Pavitt et al., 1989). The surveys are often described as 'subject-oriented' because they consist of questions relating to individual firm's ability to innovate over a specified period of time, e.g. innovation

related concepts about business strategy and practices, the sources of knowledge for innovation activities, constraints to innovation, strategies for intellectual property, R&D expenditure, and general business and economic information. Firms are also asked performance related questions such as whether the firm has been able to achieve goods, services or process innovation, and what share of their turnover can be ascribed according to the different categories of innovations - new to the market, new to the business and significantly improved.

We used three collective surveys CIS7, CIS8 and CIS9 with a sample size consisting of 3,910 firms drawn from five service sectors namely, business services (46.4%), financial intermediation (11.7%), computer and IT related activities (12.7%), retail trade (12.7%), and hotels and restaurants (16.5%). These sectors were chosen based on their contribution to the economy and interest to government, policy makers and academia. Business services displayed the highest rate of innovation recorded compared to other service sub-sectors. This sector accounted for 12% of UK's 2015 gross value added, and as a result is regarded as an extremely important component of the service economy (BIS, 2015). Mina et al. (2014) stated that OI may be particularly important to business services firms due to the highly relational and interactive nature of their economic activities. Financial intermediation firms are a key component of the contemporary economy as they contribute to employment and economic growth. However, due to the global financial crises, the expectations of customers have become more sophisticated and elaborate, especially with regards to personal finances such as credits, mortgages, insurances, and retirement plans (Schueffel and Vadana, 2015). These changes are pushing financial service firms to adopt innovative strategies such as collaboration with lead users to diversify into new products and new markets (Oliveira and von Hippel, 2011). Computer and IT related activities sector is R&D intensive and highly innovative with the propensity to generate high value, skilled employment and gross value added for any economy (Vence and Trigo, 2009). It is of great importance to businesses, government and academia as it is transforming other sectors by changing the way they deliver their goods and services. BIS (2013) called it the 'information economy sector' and referred to it as a recognisable new dynamic force characterised by the speed of technological advancements. The retail trade sector is another important sector of the economy as it contributes to over 10% of UK's employment and over 5% of gross value added (UK Trade & Investment, 2014). The Hotels and restaurants sector is particularly important due to its significant contribution to the UK's employment rate (BIS, 2015). However, it is one of the least innovation active sectors in the UK according to the UK community innovation survey 2015 (BIS, 2016).

3.2 Variables and Measures

3.2.1 Dependent Variables

Following the extant literature (e.g. Battisti et al., 2015; Berchicci, 2013; Frenz and Ietto-Gillies, 2009; Garriga et al., 2013; Greco et al., 2016; Laursen and Salter, 2006; Tsai and Wang, 2009), we measure innovation performance (***INNO)*** using an output measure, i.e. the proportion of the firm's total turnover comprising goods and services that were new or substantially improved during the period, and differentiate innovation performance into radical and incremental innovation performance to reflect the degree of novelty involved in innovation. Radical innovation performance (***RADINNO***) is measured as the proportion of the firm's turnover related to products and services that are new to the market. Incremental innovation performance (***INCREINNO***) is measured as the proportion of the firm's turnover related to products and services that are new to the business or significantly improved.

3.2.2 Independent Variables

Based on its wide applicability in the literature, this study adopts the OI measures introduced by Laursen and Salter (2006). ***Inbound OI (INBOUNDOI)*** refers to the inflow of external knowledge provided by external sources. To measure this, we used the survey question which asks about the use of various sources of information for innovative activities (breadth) and the level of importance (depth). Laursen and Salter (2006) argued that firms that use greater numbers of sources are more involved in inbound OI than firms that don't. However, the degree of engagement with OI sources differ (Drechsler and Natter, 2012). Some firms may have many sources, but the depth of engagement with these sources are superficial, while some firms may have a small number of sources, but they truly open up their innovation activities to them. 10 external information sources were listed for firms to indicate high, medium or low importance, or not applicable. To create the OI measures that account for both breadth and depth of OI, we assign the value of 1 where the response is high or medium and 0 where the response is low or not applicable. These scores were then summed to generate the variable INBOUNDOI. This approach has been used in recent empirical research in the OI literature (e.g. Drechsler and Natter, 2012; Love et al., 2014).

Coupled OI (COUPLEDOI) refers to collaboration with complementary external partners. The measurement method follows similar approach to that for inbound OI. Firms were asked to indicate whether they had cooperated with a variety of partners for innovative activities within a specified location. Where firms indicate to have cooperated with a partner in any specified location, this was coded as 1, and where there was no cooperation this was coded as 0. These scores were then summed to generate COUPLEDOI.

Operational reconfiguration capabilities (***OPRECON***) involve changes in the firm's operations and ***strategic reconfiguration capabilities*** (***STRECON***) are concerned with changes in the firm's strategy. Adapting the measures by Jantunen et al. (2005), we measured ***OPRECON*** using survey questions that indicate whether there were any major changes in business practices for organising procedures (e.g. supply chain management, business re-engineering, knowledge management, lean production, and quality management), and new methods of organising work responsibilities and decision making (e.g. first use of a new system of employee responsibilities, team work, decentralisation, integration or de-integration of departments, and education/training systems). ***STRECON*** is measured using questions on new methods of organising external relationships with other firms or public institutions (e.g. first use of alliances, partnerships, outsourcing or sub-contracting), and changes to marketing concepts or strategies.

3.2.3 Control Variables

We included the following control measures which have been shown in the literature to have an impact on openness and innovation performance. ***SIZE*** is measured using the log-transformation of the number of employees in the firm (e.g. Battisti et al., 2015; Cassiman and Valentini, 2016; Garriga et al., 2013; Leiponen and Helfat, 2010). ***START-UP*** captures whether the business was established in the sample period (e.g Garriga et al., 2013; Laursen and Salter, 2006). Geographical market (***GEOMRKT***) captures whether the firm operates within the UK and/or outside the UK (e.g. Berchicci, 2013; Laursen and Salter, 2006). R&D intensity (***RDINT***) is measured as the ratio of total R&D expenditures on turnover (e.g Battisti et al., 2015; Garriga et al., 2013; Laursen and Salter, 2006). ***Location*** dummies represent the regional locations of the firms in the UK. ***Year*** is a dummy variable to represent the 3 surveys in the dataset (CIS7, CIS8 and CIS9). We also included ***Sector*** dummies to represent the selected sub-sectors.

3.3 Statistical Methods

Since the innovation performance variables are double censored and highly skewed, ranging from 0 to 100, we follow Laursen and Salter (2006) and take log-transformation with a constant one added to original values, then apply Tobit model on the converted variables. To allow for the likelihood of endogeneity between innovation inputs captured by R&D intensity and innovation outputs (innovation performance), which may rise because of underlying unobserved factors that simultaneously influence both innovation inputs and outputs (Bascle, 2008), we apply instrumental-variables (IV) Tobit approach. Strategic decisions such as investing in R&D are not randomly chosen; instead, they are usually determined by firms based on firm and industry-level factors. Some of these factors may directly affect the performance outcomes. Therefore, we need to test endogeneity. Despite endogeneity being a widely recognised issue in the literature on the relationship between OI and innovation performance (Battisti et al., 2015; Frenz and Ietto-Gillies, 2009; Li-Ying et al., 2016), to the best of our knowledge, there are few studies that employ instrument variable (IV) approach to address the concern with the exception of Garriga et al. (2013). This is largely because of the difficulty in finding a valid set of instruments. To address the endogeneity bias, we choose to use specific innovation impulses and obstacles that affect firm's decision to innovate as instruments (Lachenmaier and Wößmann, 2006), including the importance of new market entry (***NEWMRKT***), quality improvement (***QUALITY***), cost reduction (***COST***), product or process replacement (***REPLACE***), market conditions (***MRKTCON***) and innovation constraint factors (***CONTRAINTS***).

The results of the instrumented stage of the 2SLS which models R&D intensity are reported in Appendix A. As observed, majority of the instrumental variables are significantly associated with the endogenous variable, R&D intensity across three equations. According to Cameron and Trivedi (2010), the 2SLS estimations need to satisfy a set of conditions related to endogeneity, overidentification, and instruments adequacy. We evaluated these conditions by employing several statistical tests. First, Durbin and Wu–Hausman tests were performed for the presence of endogeneity. The statistically significant results would indicate that OLS produce inconsistent results because of endogeneity, thereby justifying the use of the instrumental variable approach. Second, we used Sargan and Basmann tests for overidentifying restrictions (Bascle, 2008). The null hypothesis of both tests is that the instruments are not correlated with the residuals from the main stage regression. They follow a $\chi^2(m)$ distribution with m as the number of overidentifying restrictions. The statistically insignificant results would imply that selected instruments are not correlated with the residuals and thereby can serve as potential instruments. Third, the instrumental variables must be adequate for identifying the instrumented stage equation. We, thus, employed the Montiel-Pflueger's weak-instrument test which is devised for one endogenous variable setting and valid under heteroskedasticity, therefore, is preferred to Stock-Yogo test (Andrews et al., 2019; Olea and Pflueger, 2013). The value of 10 is often used as the rule of thumb cut-off for weak instruments (Andrews et al., 2019). Olea and Pflueger (2013) provide a critical values table and, for 6 instruments at the 5% significance level and 10% bias threshold level, the critical value for F-statistics is 15.62. A test statistic larger than this critical value would indicate the rejection of the weak instruments null hypothesis. Lastly, we applied Clogg's z-test (Clogg et al., 1995) on the coefficient difference between equations for testing H4c, H5c, H7c and H8c.

3.3.1 Common Method Bias

A key issue with this type of survey study is common method bias. The CIS survey is designed in a manner that minimises the potential for common method bias by varying the response type using a mixture of yes/no answers, Likert scale

questions, percentages and absolute numbers. We applied Harman's one factor test and the result showed a number of factors accounting for less than the majority of the variance confirming no indication for common method bias. Also, the use of three collective surveys CIS7, CIS8 and CIS9 in this study helps to limit issues of common method bias (Podsakoff et al., 2003). Table 1 reports summary statistics and variance inflation factor (VIF) scores. The correlation matrix and VIF scores offer some indication on potential multicollinearity problem. None of the reported values are high enough to raise concerns.

4. Results

Table 2 shows the baseline results of both IV Tobit and Tobit estimations for innovation performance at the aggregate level (INNO) and the disaggregate level (radical innovation performance (RADINNO) and incremental innovation performance (INCREINNO)). The endogeneity tests, Durbin and Wu-Hausman, are highly significant. For example, in (2.1), the test statistics are 247.370 and 262.928, respectively. Both indicate the presence of endogeneity. To account for endogeneity, we adopted the IV Tobit model and conducted tests for overidentification and weak instruments. The insignificance test statistics of Sargan and Basmann for overidentifying restrictions indicate that our chosen instruments jointly pass the exogeneity requirement, hence providing evidence for their validity. The Montiel-Pflueger's test produced F statistics of greater than the critical value of 15.62 and the rule-of-thumb value of 10, implying the rejection of the null of weak instruments. Taken together, these test results support our approach of the IV Tobit model. Consequently, we focus the discussion on IV Tobit model results only. Nevertheless, Tobit model results are presented for comparison. It is noticeable that all IV Tobit coefficients are smaller and less significant than their corresponding Tobit coefficients.

In table 2, all the coefficients of inbound OI are positive and statistically significant. But for coupled OI, coefficients in the two disaggregated models of radical and incremental innovation performance are positive and statistically significant and the coefficient of coupled OI is statistically insignificant in the aggregate model of overall innovation. Given the genetic differences between the two types of innovation along the dimension of technological trajectory, uncertainty, development time, complexity of the development process and routes to market success, it is important to estimate their determinants separately. Our interpretation of findings, therefore, will be based on (2.3) and (2.5).

The positive significant coefficients of inbound OI on radical (b = 0.051; s.e. = 0.020) and incremental innovation (b = 0.046; s.e. = 0.010) indicate support for H1a and H1b. Similarly, we find support for H2a and H2b showing the positive effects of coupled OI on radical (b = 0.147; s.e. = 0.032) and incremental innovation (b = 0.030; s.e. = 0.016). For radical innovation, the positive coefficient of coupled OI is statistically significantly larger than that of inbound OI in (2.3), according to t-test (t = 2.544). There is, therefore, evidence to support H3a. However, for incremental innovation, the positive coefficient of coupled OI is smaller than that of inbound OI in (2.5), and this difference is not statistically significant (t = 0.848). Therefore, H3b is not supported. It is worth noting that the degree of impact of inbound OI and coupled OI differs between radical and incremental innovation performance. The difference in the impact of inbound OI on radical and incremental innovation performance is not statistically significant, according to Clogg et al. (1995)'s z-test (z = 0.224). But the impact of coupled OI on radical innovation is statistically significantly larger than that on incremental innovation, as indicated by z-test score of 3.270.

Table 3 reports the moderating effects of SRC and ORC. Specifications (3.1) – (3.2) include SRC as a moderator, while (3.3) – (3.4) include ORC as a moderator and the last two (3.5) and (3.6) include both SRC and ORC as moderators. Tobit

estimation results are presented for comparison in Appendix B, but again our discussion of results focus on IV Tobit models because of the presence of endogeneity, as indicated by Durbin and Wu-Hausman tests.

SRC shows negative moderating effects on inbound OI in both cases of radical (b = -0.036; s.e. = 0.006) and incremental innovation (b = -0.043; s.e. = 0.012) which indicate no support for H4a and H4b, respectively. Its moderating effect on the relationship between coupled OI and radical innovation is positive and statistically significant in (3.1) (b = 0.57; s.e. = 0.025), and directionally significant based on one-tailed test in (3.5) (b = 0.55; s.e. = 0.036), hence H5a is supported. Its effects on the relationship between coupled OI and incremental innovation are statistically insignificant in both (3.2) (b = 0.010; s.e. 0.044) and (3.6) (b= -0.007; s.e. = 0.044), indicating no support for H5b. Comparing the joint effects of SRC and inbound OI on radical innovation in (3.1) and those on incremental innovation in (3.2), z-test indicates statistical insignificance (z = 0.522), showing no support for H4c. However, our finding supports H5c, i.e. the combinative effects of SRC and coupled OI is stronger for radical innovation than incremental innovation. This implies that a change in the firm's strategy complements the collaboration with external partners to facilitate the success of products and services that are new to the market, but SRC's role in moderating the impact of inbound OI and that of coupled OI on incremental innovation is obscure. Furthermore, in (3.1) and (3.5), the positive coefficient of coupled OI for radical innovation is statistically significantly stronger than that of inbound OI (t = 3.617). Hence, we find support for H6a. On the contrary, we do not find support for H6b, i.e. the combinative effects of SRC and coupled OI is no stronger than those of SRC and inbound OI on incremental innovation (t=1.002).

In both (3.3) and (3.5), the results for ORC show no support for H7a, i.e. the inbound OI – radical innovation relationship as the coefficients on (OPRECON X INBOUNDO) are statistically insignificant. Similarly, we find no support for H8a to show the combinative effect of ORC and coupled OI on radical innovation. ORC remains positive in the inbound OI-incremental innovation relationship, but the level of significance differs in (3.4) (b = 0.004; s.e. = 0.013) and (3.6) (b = 0.022; s.e. = 0.012). We find significant positive effects in the full model (3.6) which provides support for H7b. ORC shows positive and significant moderating effects on the relationship between coupled OI and incremental innovation in both (3.4) (b = 0.030; s.e. = 0.014) and (3.6) (b = 0.036; s.e. = 0.008), demonstrating support for H8b. We find no evidence to support H7c because of the presence of insignificant effects of (OPRECON X INBOUNDOI) in both (3.5) and (3.6). The presence of significant positive effects of (OPRECON X COUPLEDOI) for incremental innovation in (3.6) with no significant effect for radical innovation in (3.5) shows support for H8c which expects that the combinative effects of ORC and coupled OI are stronger for incremental than radical innovation. This indicates that changes in firm's operational processes strengthen the effectiveness of using external knowledge and external collaborations to induce incremental innovations. We also examined the differences in the combinative effects of ORC and coupled OI and those of ORC and inbound OI on radical innovation and incremental innovation, respectively. For radical innovation, both the coefficient of (OPRECON X COUPLEDOI) and that of (OPRECON X INBOUNDOI) are statistically insignificant. For incremental innovation, although the positive coefficient of (OPRECON X COUPLEDOI) is larger than that of (OPRECON X INBOUNDOI), this difference is not statistically significant (t = 0.971). Hence, we find neither support for H9a nor for H9b.

5. Discussion

The findings offer support for our expectation that OI has a positive effect on innovation performance. The results indicate that as service firms expand their internal knowledge base to allow the inflow of ideas from external sources and external

collaborations, they widen their pool of innovation opportunities and this leads to an increase in innovation performance. This supports Chesbrough (2003)'s view that knowledge sources required for increasing innovation outcomes can be found outside the boundary of the firm, and firms that are too internally focused may miss the innovation opportunities. Our findings contribute to the existing literature on the advantages of firms adopting OI practices beyond the manufacturing context. In particular, our study responds to the call for empirical studies on OI in the services sector (Gallouj and Djellal, 2018; West and Bogers, 2017).

We find a differential degree of impact of inbound OI and coupled OI on radical and incremental innovation performance, respectively. There is a plausible explanation, relating to the differences between the two types of OI and the two types of innovation outcomes. On the one hand, in comparison to inbound OI, coupled OI's structured engagement with external partners enables firms to better understand, absorb and assimilate the infused new ideas and knowledge and share risks and costs associated with innovation (Bigliardi and Galati, 2016; Greco et al., 2016; Ritala and Hurmelinna-Laukkanen, 2013). On the other hand, the mere inflow of information that inbound OI facilitates, absent the costs associated with coupled OI, seems to suffice for incremental innovation practices. Coupled OI carries higher transaction costs than inbound OI, which would undermine the degree of its positive impact with regards to incremental innovations. The structured approach of knowledge acquisition, utilization and exploration associated with coupled OI, is more effective than mere knowledge access through inbound OI, for radical transformation (Kash and Rycroft, 2002). This is because, to generate radical innovation, firms need to proactively and intensively interact and engage with their external partners. This helps with managing transaction costs and bringing out the maximum benefits of coupled OI. On the other hand, since incremental innovation is about integrating external ideas and knowledge into firm's existing technological trajectory, knowledge access through inbound OI is sufficient. Employing coupled OI for incremental innovation will mean that firms need to balance the benefits and costs associated with coupled OI, which is a costly process. The findings are important because of the following reasons: (a) Few studies have proposed differential effects of inbound and coupled open innovation practices on radical and incremental innovation performance; (b) The finding of differential effects, when identified in the service context, provides actionable, practical suggestion to managers seeking to achieve innovation objectives through radical vs incremental routes. Thus, in documenting the differential effects of inbound and coupled innovation on incremental and radical innovation performance, with specific reference to the service context, the study makes a useful contribution to the OI literature.

After establishing the positive relationship between the two types of OI and the two types of innovation outcomes, we examine the complementary role played by DCs. The positive moderating effects of SRC and ORC are clearly reflected on coupled OI. More specifically, SRC's moderating role is on the relationship between coupled OI and radical innovation performance and ORC's moderating role is on the relationship between coupled OI and incremental innovation performance. Coupled OI involves a formal governance structure that combines internal knowledge and ideas in the firm with external knowledge and ideas from outside the boundary of the firm. This formal, combinative effort can be best utilised by radical innovators with SRC and incremental innovators with ORC.

SRC's role in positively moderating the impact of inbound OI and that of coupled OI on incremental innovation is limited. A tentative explanation is that strategic reconfiguration within an organisation often carries significant costs associated with various changes and its benefits to the organisation may take time to reveal. Therefore, the contemporary effects may not be significant and could even be negative (in the case of inbound OI). But in the longer term, the positive moderating effects of SRC will become evident. Unfortunately, we only have cross-sectional data and are unable to verify

this speculative explanation. Another possible explanation for the negative effects can be linked to the literature on market orientation. Market orientation is concerned with intelligence generation from external market sources which can be associated with inbound OI. Some studies have shown a negative moderating effect of technology turbulence and competitive intensity on the relationship between market orientation and performance (González-benito et al., 2014; Tsai et al., 2008). The rationale is that, in such disruptive environments, listening to external constituents (customers, salespeople who relay market information) could be counterproductive. Therefore, when firms engage in SRC as a result of changes in the environment due to technology turbulence and competitive intensity, this may yield negative innovation outcomes. This is an interesting effect that needs further research exploration. Potentially, it can provide guidance to managers of service firms regarding the use of external knowledge under conditions of strategic restructuring. ORC, on the other hand, exhibits a similar (albeit weaker) moderating effect with inbound OI as it does with coupled OI. That is, the effect of ORC can be leveraged even with relatively straightforward inflow of external ideas (inbound OI), though the effect is accentuated when formal structured arrangements of collaboration (coupled OI) are in place.

The fact that the moderating effects of SRC and ORC on radical and incremental innovation are more pronounced with coupled OI as against inbound OI is in line with the thesis advanced earlier to justify the differential effects of inbound and coupled innovation on incremental and radical innovation. That is, the structured engagement with partners that coupled OI facilitates and the consequent greater assimilation of new ideas as well as sharing of risks (Bigliardi and Galati, 2016; Ritala and Hurmelinna-Laukkanen, 2013), lead to more positive outcomes. Even operational reconfiguration carries a certain amount of risk and demands coordination with partners; hence the moderating effect of ORC too is greater with coupled, compared to inbound OI. In addition, following the argument earlier that the mere inflow of information that inbound OI facilitates, absent the costs associated with coupled OI, seems to suffice for incremental innovation practices, we observe a statistically significant effect even for the moderating effect of ORC on the relationship between inbound OI and incremental innovation. The findings provide support to the notion that dynamic capabilities enhance innovation performance (Agarwal and Selen, 2009; Kindström et al., 2013; Macpherson et al., 2004; Nitzsche et al., 2016; Rothaermel and Hess, 2007; Wilden et al., 2013). Nevertheless, the findings also indicate clear boundary conditions when dynamic capabilities won't be effective (SRC's negative moderating effect on inbound innovation effects). In addition, the findings provide indirect support to the argument advanced by scholars that dynamic capabilities are costly and requires significant managerial involvement (Cassiman and Valentini, 2016; Girod and Whittington, 2017; Jantunen et al., 2018). In this context, coupled open innovation acts as a risk mitigator leading to positive outcomes.

6. Conclusion

6.1 Contributions

This paper examines the relationship between OI practices (inbound and coupled) and innovation performance, and the differential moderating effects of two forms of reconfiguration capabilities, strategic reconfiguration and operational reconfiguration on the focal relationship in the service context. It contributes to the literature in several ways. First, theoretically, in developing the arguments on the moderating roles of SRC and ORC, we provide a logical connection between the two distinct literatures, OI and DCs, which do not have much overlap, but deal with very related questions. For a long time, the extant OI literature have considered the importance of OI to innovation in a dynamic environment and the extant DCs literature has argued that DCs are particularly important for performance in situations of environmental changes (Cheng et al., 2016; Grimaldi et al., 2013; Vanhaverbeke and Cloodt, 2014; West et al., 2014). It therefore seems

natural to consider the complementarity between OI and DCs. Our proposed integrated theoretical framework captures the complexity of the relationships between different dimensions of OI and DCs, and adds to our still scant understanding of the combinative effects of OI and DCs on innovation performance. Based on the current research, we also call for a research agenda to bridge OI and DCs, two mature lines of literature, but are surprisingly, largely separated from each other.

Second, this paper contributes to the burgeoning literature on OI through shedding insights into whether and how managers can influence the relations between OI and innovation outcomes through conscious and targeted managerial efforts. Both inbound and coupled OI are apt for dynamic environments, but they involve costs as well as benefits (Berchicci, 2013; Bigliardi and Galati, 2016; Dahlander and Gann, 2010; Mahdad et al., 2019). We contribute to the debates on the relevance of dynamic capabilities in terms of linking OI to innovation performance. Notably, we demonstrate SRC's relevance to the effects of coupled OI on radical innovation performance and ORC's relevance to the effects of both inbound and coupled OI on incremental innovation in the context of UK service firms. This finding provides support to what Jantunen et al. (2012), among others, have contended that the effects of dynamic capabilities on performance outcomes can be "multiply realizable" (p. 143). The observed differential moderating effects of SRC and ORC suggest that it should be important for managers to focus on different types of dynamic capabilities that address the complexity associated with innovation activities and a major challenge is to manage successful realignment of a firm's resources and capabilities in such a way as to achieve a better fit with OI initiatives.

Our third contribution is to empirically corroborate that the importance of OI to innovation performance is not only relevant to manufacturing but also to services. There are conflicting views on whether OI is relevant to the service sector and the expectation that OI works differently in service firms (Chesbrough, 2011; Mina et al., 2014). This study adds to the OI literature to show that the adoption of inbound and coupled OI by service firms contributes to an increase in both radical and incremental innovation performance. The findings are then subject to the boundary conditions of SRC and ORC. In addition to the service sector, the findings will inform the stream of research on OI in the manufacturing sector which has witnessed the major shift from product-centeredness to a product-and-service orientation (Kindström et al., 2013) and from doing it alone to partnering with service firms (Vendrell-Herrero et al., 2018), particularly in high-velocity industries (e.g. high-tech industries) which emphasise the brisk and discontinuous changes. "Servitisation", a value-creation strategy by blending services into the overall strategies of a firm, has been identified as a strategic research priority (Kindström et al., 2013; Kowalkowski et al., 2017). However, as revealed by Vendrell-Herrero et al. (2018) through their extensive literature review, "only a small number of studies acknowledge the role of external partners in enhancing product-service innovation" (p. 814).

Another empirical contribution of the paper is our findings of the differential effects of inbound and coupled OI. As noted earlier, few papers develop hypotheses referring to the separate impact of inbound OI and coupled OI on radical and incremental innovation, respectively, with the exceptions of Greco et al. (2016) and Parida et al. (2012). These limited research efforts suggest the need for more studies on the efficacy of inbound and coupled OI on radical and incremental innovation, so that firms can focus their limited resources to achieve better innovation performance. Our empirical findings reveal that, in the context of UK's service sector, coupled OI has greater impact than inbound OI on radical innovation, although its positive effects on incremental innovation are no different from those of inbound OI. Inbound OI has similar degree of positive impact on both radical and increment innovation. These findings show that, despite the overall positive effects of both types of OI, different ways of opening firm's boundaries to external inputs have different

degree of effects. For radical innovators, particular attention should be paid to coupled OI that unites both inbound and outbound OI.

6.2 Practical Implications

The findings have implications for policies and managerial practices. Innovation is considered as an important driver of country's economic development and firm's growth (Wu et al., 2021). Bogers et al. (2018) highlight that policies need to embrace OI. Our research suggests that existing OI-related policies should be extended to services and, more importantly, they should be coupled with public policy on the business enterprise with a focus on capability-building activities, e.g. developing value chains and regional clusters (Teece, 2017). OI setting helps organisations with access to external knowledge resources, but is not a guarantee of innovation outcomes (Mahdad et al., 2019). Many factors hinder the adoption of OI (Bigliardi and Galati, 2016). Similarly, despite the recognition of the benefits of reconfiguration as a key dynamic capability for organisational performance, reconfiguration also carries significant costs (Girod and Whittington, 2017). Policy packages to support firms through nurturing capabilities for leveraging open innovation practices may consider a system approach (Grillitsch et al., 2019).

Firms can enhance the way they collaborate and source for external knowledge by making changes to their existing operational processes and strategy. Managers seeking to pursue OI practices to improve their innovation performance need to identify elements in their current operations and strategy that need reconfiguration in order to achieve optimal gains. Both dimensions of reconfiguration capabilities proved to be more beneficial towards coupled OI practices. This study thus suggests to senior managers the need to establish an appropriate alignment between OI practices and firm's reconfiguration capabilities to realise the expected synergistic effects on innovation performance. Second, the results of the study highlight that firms seeking to reconfigure operations or strategy to improve innovation performance should focus on strengthening coupled OI practices and not solely on inbound OI. The distinctively different moderating effects that are accrued from the two types of reconfiguration capabilities may guide managerial choices regarding the emphasis on SRC for utilising coupled OI for radical innovation and on ORC for utilising coupled OI for incremental innovation. The differential direct effects of inbound and coupled OI on radical and incremental innovation provide guidance to managers seeking to achieve radical and incremental innovation outcomes. Finally, the negative moderating effects of SRC on the relationships between inbound OI and radical/incremental innovation alerts managers to be careful while implementing strategic reconfiguration. While our findings are derived from a sample of service sector firms, they are also of relevance to manufacturing firms, particularly firms undergoing the process of servitization (e.g. Xerox and Caterpillar)[3] which often entails a collaborative continuum of internalising, partnering and outsourcing involving customers, suppliers and other collaborators (Mathieu, 2001).

6.3 Limitations and Future Research Opportunities

Despite the extensive consideration and efforts taken towards the research design and selection of the sample, there exist some limitations and opportunities for future research. Due to the limitation of suitable measures in the secondary dataset used, this study only examines strategic and operational reconfiguration dimension of DCs and employs proxy for these

[3] https://www.emeraldgrouppublishing.com/topics/blog/what-servitization-manufacturing-a-quick-introduction

variables. Using primary data collection methods, it would be useful for future research to empirically examine other dimensions of DCs, develop better measures for DCs and examine whether the limited role played by DCs on moderating the relationship between inbound OI and innovation performance is confined to the UK service firms. Second, this study uses pooled cross-sectional data of three surveys at different time period. To answer our research questions, longitudinal data that tract the effects of DCs, particularly SRC, over time would have been better. Additionally, the use of cross-sectional data limits our ability to fully deal with endogeneity issue. An analysis based on panel data would help to better explore dynamic and endogenous characteristics in the OI-DCs-innovation performance relationship. Third, although the sample used in this study is considerably larger and more extensive in terms of sub-sectors covered than those that had been used by majority of the previous studies, the external validity may require further investigation. The results may change in studies outside the UK due to country-specific factors and firm heterogeneity. Therefore, future research is required to examine how the results presented in this study differ across countries to aid in the generalisation of the results. Finally, the study records some unexpected findings which call for further research, such as the negative moderating effects of SRC on the relationship between inbound OI and radical/incremental innovation. While some plausible explanations were provided, these effects have theoretical and managerial significance and need to be explored further.

Acknowledgements

We are grateful to the UK Data Service for access to the UK Innovation Survey data that was used in this paper, and also for providing relevant training and support on the data handling procedure.

References

Agarwal, R., Selen, W., 2009. Dynamic capability building in service value networks for achieving service innovation. *Decision Sciences* 40, 431-475.

Amara, N., Landry, R., Doloreux, D., 2009. Patterns of innovation in knowledge-intensive business services. *Service Industries Journal* 29, 407-430.

Ambrosini, V., Bowman, C., Collier, N., 2009. Dynamic capabilities: An exploration of how firms renew their resource base. *British Journal of Management* 20, S9-S24.

Andrews, I., Stock, J.H., Sun, L., 2019. Weak instruments in instrumental variables regression: Theory and practice. *Annual Review of Economics* 11, 727-753.

Bascle, G., 2008. Controlling for endogeneity with instrumental variables in strategic management research. *Strategic Organization* 6, 285-327.

Battisti, G., Gallego, J., Rubalcaba, L., Windrum, P., 2015. Open innovation in services: knowledge sources, intellectual property rights and internationalization. *Economics of Innovation and New Technology* 24, 223-247.

Bayona-Sáez, C., García-Marco, T., Sanchez-García, M., Cruz-Càzares, C., 2013. The impact of open innovation on innovation performance: The case of Spanish agri-food firms, in: Garcia Martinez, M. (Ed.), *Open Innovation in the Food and Beverage Industry*. Woodhead Publishing, pp. 74-94.

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

Biesenthal, C., Gudergan, S., Ambrosini, V., 2019. The role of ostensive and performative routine aspects in dynamic capability deployment at different organizational levels. *Long Range Planning* 52, 350-365.

Bigliardi, B., Galati, F., 2016. Which factors hinder the adoption of open innovation in SMEs? *Technology Analysis & Strategic Management* 28, 869-885.

Bogers, M., Chesbrough, H., Moedas, C., 2018. Open innovation: Research, practices and policies. *California Management Review* 60, 5-16.

Cameron, A.C., Trivedi, P.K., 2010. *Microeconometrics using Stata*. Stata Press, College Station, Texas.

Cassiman, B., Valentini, G., 2016. Open innovation: Are inbound and outbound knowledge flows really complementary? *Strategic Management Journal* 37, 1034-1046.

Castro, L.M., Montoro-Sanchez, A., Ortiz-De-Urbina-Criado, M., 2011. Innovation in services industries: current and future trends. *Service Industries Journal* 31, 7-20.

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

Chen, K.H., Wang, C.H., Huang, S.Z., Shen, G.C., 2016. Service innovation and new product performance: The influence of market-linking capabilities and market turbulence. *International Journal of Production Economics* 172, 54-64.

Cheng, C.C.J., Huizingh, E.K.R.E., 2014. When is open innovation beneficial? The role of strategic orientation. *Journal of Product Innovation Management* 31, 1235-1253.
Cheng, C.C.J., Yang, C.L., Sheu, C., 2016. Effects of open innovation and knowledge-based dynamic capabilities on radical innovation: An empirical study. *Journal of Engineering and Technology Management* 41, 79-91.
Chesbrough, H., 2003. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Harvard Business School Press, Boston.
Chesbrough, H., 2006. *Open Business Models: How to Thrive in the New Innovation Landscape*. Harvard Business School Press, Boston.
Chesbrough, H., 2010. *Open Service Innovation: Rethinking your Business to Grow and Compete in a New-era*. Jossey-Bass, San Franciso.
Chesbrough, H., 2011. Bringing open innovation to services. *MIT Sloan Management Review* 52, 85-+.
Clogg, C.C., Petkova, E., Haritou, A., 1995. Statistical methods for comparing regression coefficients between models. *American Journal of Sociology* 100, 1261-1293.
Cohen, W.M., Levinthal, D.A., 1990. Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly* 35, 128-152.
Dahlander, L., Gann, D.M., 2010. How open is innovation? *Research Policy* 39, 699-709.
de Brentani, U., 2001. Innovative versus incremental new business services: Different keys for achieving success. *Journal of Product Innovation Management* 18, 169-187.
Douma, M.U., Bilderbeek, J., Idenburg, P.J., Looise, J.K., 2000. Strategic alliances: Managing the dynamics of fit. *Long Range Planning* 33, 579-598.
Drechsler, W., Natter, M., 2012. Understanding a firm's openness decisions in innovation. *Journal of Business Research* 65, 438-445.
Eiteneyer, N., Bendig, D., Brettel, M., 2019. Social capital and the digital crowd: Involving backers to promote new product innovativeness. *Research Policy* 48.
Flynn, B.B., Wu, S.J., Melnyk, S., 2010. Operational capabilities: Hidden in plain view. *Business Horizons* 53, 247-256.
Frenz, M., Ietto-Gillies, G., 2009. The impact on innovation performance of different sources of knowledge: Evidence from the UK Community Innovation Survey. *Research Policy* 38, 1125-1135.
Gallouj, F., Djellal, F., 2018. *A Research Agenda for Service Innovation*. Edward Elgar, Cheltenham, UK and Northampton, MA, USA.
Gallouj, F., Weber, K.M., Stare, M., Rubalcaba, L., 2015. The futures of the service economy in Europe: A foresight analysis. *Technological Forecasting and Social Change* 94, 80-96.
Gallouj, F., Weinstein, O., 1997. Innovation in services. *Research Policy* 26, 537-556.
Gallouj, F., Windrum, P., 2009. Services and services innovation. *Journal of Evolutionary Economics* 19, 141-148.
Garriga, H., von Krogh, G., Spaeth, S., 2013. How constraints and knowledge impact open innovation. *Strategic Management Joumal* 34, 1134-1144.
Gassmann, O., Enkel, E., 2004. Towards a theory of open innovation: three core process archetypes, Proceedings of the R&D Management Conference, Lisbon, Portugal.
Gassmann, O., Enkel, E., Chesbrough, H., 2010a. The future of open innovation. *R&D Management* 40, 213-221.
Gassmann, O., Zeschky, M., Wolff, T., Stahl, M., 2010b. Crossing the industry-line: Breakthrough innovation through cross-industry alliances with 'non-suppliers'. *Long Range Planning* 43, 639-654.
Girod, S.J.G., Whittington, R., 2017. Reconfiguration, restructuring and firm performance: Dynamic capabilities and environmental dynamism. *Strategic Management Journal* 38, 1121-1133.
González - benito, Ó., González - Benito, J., Muñoz - gallego, P.A., 2014. On the consequences of market orientation across varied environmental dynamism and competitive intensity levels. *Journal of Small Business Management* 52, 1-21.
Greco, M., 2015. Open innovation actions and innovation performance. *European Journal of Innovation Management* 18, 150-171.
Greco, M., Grimaldi, M., Cricelli, L., 2016. An analysis of the open innovation effect on firm performance. *European Management Journal* 34, 501-516.
Grillitsch, M., Hansen, T., Coenen, L., Miörner, J., Moodysson, J., 2019. Innovation policy for system-wide transformation: The case of strategic innovation programmes (SIPs) in Sweden. *Research Policy* 48, 1048-1061.
Grimaldi, M., Quinto, I., Rippa, P., 2013. Enabling open innovation in small and medium enterprises: A dynamic capabilities approach. *Knowledge and Process Management* 20, 199-210.
Helfat, C.E., Peteraf, M.A., 2003. The dynamic resource-based view: Capability lifecycles. *Strategic Management Journal* 24, 997-1010.
Helfat, C.E., Winter, S.G., 2011. Untangling dynamic and operational capabilities: Strategy for the (n)ever-changing world. *Strategic Management Journal* 32, 1243-1250.
Huang, F., Rice, J., 2009. The role of absorptive capacity in faciliating "open innovation" outcomes: A study of Australian SMEs in the manufacturing sector. *International Journal of Innovation Management* 13, 201-220.
Huizingh, E.K.R.E., 2011. Open innovation: State of the art and future perspectives. *Technovation* 31, 2-9.
Jantunen, A., Ellonen, H.K., Johansson, A., 2012. Beyond appearances - Do dynamic capabilities of innovative firms actually differ? *European Management Journal* 30, 141-155.

Jantunen, A., Puumalainen, K., Saarenketo, S., Kyläheiko, K., 2005. Entrepreneurial orientation, dynamic capabilities and international performance. *Journal of International Entrepreneurship* 3, 223-243.
Jantunen, A., Tarkiainen, A., Chari, S., Oghazi, P., 2018. Dynamic capabilities, operational changes, and performance outcomes in the media industry. *Journal of Business Research* 89, 251-257.
Jaw, C., Lo, J.-Y., Lin, Y.-H., 2010. The determinants of new service development: Service characteristics, market orientation, and actualizing innovation effort. *Technovation* 30, 265-277.
Kandemir, D., Acur, N., 2012. Examining proactive strategic decision-making flexibility in new product development. *Journal of Product Innovation Management* 29, 608-622.
Kash, D.E., Rycroft, R., 2002. Emerging patterns of complex technological innovation. *Technological Forecasting and Social Change* 69, 581-606.
Kelley, D., 2009. Adaptation and organizational connectedness in corporate radical innovation programs. *Journal of Product Innovation Management* 26, 487-501.
Kindström, D., Kowalkowski, C., Sandberg, E., 2013. Enabling service innovation: A dynamic capabilities approach. *Journal of Business Research* 66, 1063-1073.
Klevorick, A.K., Levin, R.C., Nelson, R.R., Winter, S.G., 1995. On the sources and significance of interindustry differences in technological opportunities. *Research Policy* 24, 185-205.
Kowalkowski, C., Gebauer, H., Oliva, R., 2017. Service growth in product firms: Past, present, and future. *Industrial Marketing Management* 60, 82-88.
Lachenmaier, S., Wößmann, L., 2006. Does innovation cause exports? Evidence from exogenous innovation impulses and obstacles using German micro data. *Oxford economic papers* 58, 317-350.
Laursen, K., Salter, A., 2006. Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal* 27, 131-150.
Leiponen, A., Helfat, C.E., 2010. Innovation objectives, knowledge sources, and the benefits of breadth. *Strategic Management Journal* 31, 224-236.
Li-Ying, J., Wang, Y.D., Ning, L.T., 2016. How do dynamic capabilities transform external technologies into firms' renewed technological resources? - A mediation model. *Asia Pacific Journal of Management* 33, 1009-1036.
Liao, S.Q., Liu, Z.Y., Ma, C.L., 2019. Direct and configurational paths of open innovation and organisational agility to business model innovation in SMEs. *Technology Analysis & Strategic Management* 31, 1213-1228.
Lillis, B., Szwejczewski, M., Goffin, K., 2015. The development of innovation capability in services: research propositions and management implications. *Operations Management Research* 8, 48-68.
Love, J.H., Roper, S., Vahter, P., 2014. Learning from openness: The dynamics of breadth in external innovation linkages. *Strategic Management Journal* 35, 1703-1716.
Lutjen, H., Schultz, C., Tietze, F., Urmetzer, F., 2019. Managing ecosystems for service innovation: A dynamic capability view. *Journal of Business Research* 104, 506-519.
Macpherson, A., Jones, O., Zhang, M., 2004. Evolution or revolution? Dynamic capabilities in a knowledge-dependent firm. *R&D Management* 34, 161-177.
Mahdad, M., De Marco, C.E., Piccaluga, A., Di Minin, A., 2019. Harnessing adaptive capacity to close the pandora's box of open innovation. *Industry and Innovation*.
Mathieu, V., 2001. Service strategies within the manufacturing sector: benefits, costs and partnership. *International Journal of Service Industry Management* 12, 451-475.
Mazzola, E., Bruccoleri, M., Perrone, G., 2012. The effect of inbound, outbound and coupled innovation on performance. *International Journal of Innovation Management* 16, 1240008.
McDermott, C.M., O'Connor, G.C., 2002. Managing radical innovation: an overview of emergent strategy issues. *Journal of Product Innovation Management* 19, 424-438.
McLaughlin, P., Bessant, J., Smart, P., 2008. Developing an organisation culture to facilitate radical innovation. *International Journal of Technology Management* 44, 298-323.
Mina, A., Bascavusoglu-Moreau, E., Hughes, A., 2014. Open service innovation and the firm's search for external knowledge. *Research Policy* 43, 853-866.
Miozzo, M., Desyllas, P., Lee, H.F., Miles, I., 2016. Innovation collaboration and appropriability by knowledge-intensive business services firms. *Research Policy* 45, 1337-1351.
Myhren, P., 2018. Incremental and radical open service innovation. *Journal of Services Marketing* 32, 101-112.
Narula, R., Hagedoorn, J., 1999. Innovating through strategic alliances: moving towards international partnerships and contractual agreements. *Technovation* 19, 283-294.
Newey, L.R., Zahra, S.A., 2009. The evolving firm: How dynamic and operating capabilities interact to enable entrepreneurship. *British Journal of Management* 20, S81-S100.
Nitzsche, P., Wirtz, B.W., Göttel, V., 2016. Innovation success in the context of inbound innovation. *International Journal of Innovation Management* 20, 1650025.
O'Reilly, C.A., Tushman, M.L., 2008. Ambidexterity as a dynamic capability: Resolving the innovator's dilemma. *Research in Organizational Behavior* 28, 185-206.
O'Reilly, C.A., Tushman, M.L., 2013. Organizational ambidexterity: Past, present, and future. *Academy of Management Perspectives* 27, 324-338.
Oerlemans, L.A.G., Knoben, J., Pretorius, M.W., 2013. Alliance portfolio diversity, radical and incremental innovation: The moderating role of technology management. *Technovation* 33, 234-246.

Olea, J.L.M., Pflueger, C., 2013. A robust test for weak instruments. *Journal of Business & Economic Statistics* 31, 358-369.
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, 283-309.
Pavitt, K., Robson, M., Townsend, J., 1989. Technological accumulation, diversification and organisation in UK companies, 1945–1983. 35, 81-99.
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, 879-903.
Randhawa, K., Scerri, M., 2015. Service innovation: A review of the literature, in: Agarwal, R., Selen, W., Roos, G., Green, R. (Eds.), *The Handbook of Service Innovation*. Springer London, London, pp. 27-51.
Ritala, P., Hurmelinna-Laukkanen, P., 2013. Incremental and radical innovation in coopetition — The role of absorptive capacity and appropriability. *Journal of Product Innovation Management* 30, 154-169.
Robertson, P.L., Casali, G.L., Jacobson, D., 2012. Managing open incremental process innovation: Absorptive capacity and distributed learning. *Research Policy* 41, 822-832.
Rothaermel, F.T., Hess, A.M., 2007. Building dynamic capabilities: Innovation driven by individual-, firm-, and network-level effects. *Organization Science* 18, 898-921.
Salunke, S., Weerawardena, J., McColl-Kennedy, J.R., 2011. Towards a model of dynamic capabilities in innovation-based competitive strategy: Insights from project-oriented service firms. *Industrial Marketing Management* 40, 1251-1263.
Schilke, O., 2014. Second-order dynamic capabilities: How do they matter? *Academy of Management Perspectives* 28, 368-380.
Sivusuo, J., Takala, J., 2018. Trust and strategic partnerships: Barriers to developing dynamic capabilities in a public organization, in: B., K., S., M., J., P. (Eds.), *Managing Public Trust*. Palgrave Macmillan, Cham.
Spithoven, A., Vanhaverbeke, W., Roijakkers, N., 2013. Open innovation practices in SMEs and large enterprises. *Small Business Economics* 41, 537-562.
Teece, D.J., 2007. Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal* 28, 1319-1350.
Teece, D.J., 2017. Towards a capability theory of (innovating) firms: implications for management and policy. *Cambridge Journal of Economics* 41, 693-720.
Tidd, J., Bessant, J.R., 2013. *Managing Innovation: Integrating Technological, Market and Organizational Change*, 5th ed. John Wiley & Sons, Chichester.
Tsai, K.-H., Chou, C., Kuo, J.-H., 2008. The curvilinear relationships between responsive and proactive market orientations and new product performance: A contingent link. *Industrial Marketing Management* 37, 884-894.
Tsai, K.-H., Wang, J.-C., 2009. External technology sourcing and innovation performance in LMT sectors: An analysis based on the Taiwanese Technological Innovation Survey. *Research Policy* 38, 518-526.
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, 423-437.
Vanhaverbeke, W., 2017. *Managing Open Innovation in SMEs*. Cambridge University Press, Cambridge.
Vanhaverbeke, W., Cloodt, M., 2014. Theories of the firm and open innovation, in: Chesbrough, H., Vanhaverbeke, W., West, J. (Eds.), *New Frontiers in Open Innovation*. Oxford University Press, Oxford, pp. 256-278.
Vendrell-Herrero, F., Gomes, E., Bustinza, O.F., Mellahi, K., 2018. Uncovering the role of cross-border strategic alliances and expertise decision centralization in enhancing product-service innovation in MMNEs. *International Business Review* 27, 814-825.
Vergori, A.S., 2014. Measuring innovation in services: the role of surveys. *Service Industries Journal* 34, 145-161.
Wang, C.L., Ahmed, P.K., 2007. Dynamic capabilities: A review and research agenda. *International Journal of Management Reviews* 9, 31-51.
Wang, C.L., Senaratne, C., Rafiq, M., 2015. Success traps, dynamic capabilities and firm performance. *British Journal of Management* 26, 26-44.
West, J., Bogers, M., 2017. Open innovation: Current status and research opportunities. *Innovation* 19, 43-50.
West, J., Gallagher, S., 2006. Challenges of open innovation: The paradox of firm investment in open-source software. *R&D Management* 36, 319-331.
West, J., Salter, A., Vanhaverbeke, W., Chesbrough, H., 2014. Open innovation: The next decade. *Research Policy* 43, 805-811.
Wilden, R., Gudergan, S.P., Nielsen, B.B., Lings, I., 2013. Dynamic capabilities and performance: Strategy, structure and environment. *Long Range Planning* 46, 72-96.
Wu, L., Wei, Y., Wang, C., 2021. Disentangling the effects of business groups in the innovation-export relationship. *Research Policy* 50, 104093.
Wu, Q., He, Q., Duan, Y., O'Regan, N., 2012. Implementing dynamic capabilities for corporate strategic change toward sustainability. *Strategic Change* 21, 231-247.
Yen, H.R., Wang, W., Wei, C.-P., Hsu, S.H.-Y., Chiu, H.-C., 2012. Service innovation readiness: Dimensions and performance outcome. *Decision Support Systems* 53, 813-824.

Appendix A: Instrumented stage of the 2SLS - Outcome variable is R&D Intensity

VARIABLES	INNO (1)	RADINNO (2)	INCREINNO (3)
INBOUNOI	-0.814**	-0.945**	-0.764
	(0.114)	(0.100)	(0.610)
COUPLEDOI	0.784	0.735	0.814
	(0.757)	(0.727)	(0.565)
SIZE	-9.042	-8.937	-9.065
	(7.688)	(7.746)	(7.740)
START-UP	-2.822	-2.986	-2.805*
	(1.764)	(1.831)	(1.272)
GEOMRKT	12.235†	11.779	12.443†
	(7.392)	(7.339)	(6.784)
NEWMRKT	2.816**	4.343**	2.373
	(0.355)	(0.828)	(1.704)
QUALITY	3.885**	2.454**	4.066
	(0.146)	(0.823)	(2.790)
COST	0.463	1.250**	0.305
	(0.295)	(0.410)	(0.332)
REPLACE	-0.555*	-0.704	-0.327
	(0.273)	(0.713)	(0.289)
MRKTCON	-3.394**	-2.183	-2.469
	(1.300)	(2.108)	(2.526)
CONSTRAINTS	-4.465*	-3.971	-3.505
	(2.222)	(3.300)	(3.894)
Constant	13.383	13.072	13.230
	(22.036)	(22.024)	(13.843)
Observations (N)	3,910	3,910	3,910

Robust standard errors in parentheses. †, *, **, *** significance at 10%, 5%, 1% and 0.1%, respectively (two-tailed tests).

Appendix B: Tobit results for moderating effect of STRECON and OPRECON on the relationship between open innovation and innovation performance

VARIABLES	RADINNO (1)	INCREINNO (2)	RADINNO (3)	INCREINNO (4)	RADINNO (5)	INCREINNO (6)
INBOUNDOI	0.056***	0.060***	0.054***	0.058***	0.055***	0.059***
	(0.015)	(0.011)	(0.015)	(0.011)	(0.015)	(0.011)
COUPLEDOI	0.211***	0.132***	0.212***	0.127***	0.210***	0.129***
	(0.022)	(0.017)	(0.022)	(0.017)	(0.022)	(0.017)
STRECON X INBOUNDOI	**-0.017**	**-0.019**			**-0.026**	**-0.027^{+}**
	(0.019)	(0.015)			(0.021)	(0.016)
STRECON X COUPLEDOI	**0.056***	**0.003**			**0.046**	**-0.025**
	(0.027)	(0.021)			(0.029)	(0.023)
OPRECON X INBOUNDOI			0.014	0.009	0.024	0.020
			(0.019)	(0.014)	(0.020)	(0.016)
OPRECON X COUPLEDOI			0.042	**0.054****	0.023	**0.066*****
			(0.027)	(0.021)	(0.029)	(0.023)
Chi-square	414.8***	363.4***	415.6***	372.4***	418.4***	379.8***
Observations	3,910	3,910	3,910	3,910	3,910	3,910

Robust standard errors in parentheses. $^{+}$, *, **, *** significance at 10%, 5%, 1% and 0.1%, respectively (two-tailed tests). Control variables, Location, Sector and Year dummies are included, but results are not reported for brevity, but available upon request.

Table 1: Descriptive statistics and correlation matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. INNO	1.000																
2. RADINNO	0.603*	1.000															
3. INCREINNO	0.891*	0.275*	1.000														
4. INBOUNDOI	0.202*	0.167*	0.177*	1.000													
5. COUPLEDOI	0.248*	0.240*	0.199*	0.456*	1.000												
6. OPRECON	0.155*	0.097*	0.162*	0.131*	0.107*	1.000											
7. STRECON	0.236*	0.153*	0.216*	0.188*	0.167*	0.351*	1.000										
8. SIZE	-0.011*	-0.092*	-0.070*	0.054*	0.005	0.022	-0.003	1.000									
9. START-UP	0.056*	0.024	0.041*	-0.006	-0.002	0.059*	0.041*	-0.108*	1.000								
10. GEOMRKT	0.171*	0.177*	0.126*	0.203*	0.169*	0.012	0.067*	0.058*	-0.089*	1.000							
11. RDINT	-0.009	0.000	-0.123	0.011	0.013	0.004	-0.010	-0.020	-0.002	0.024	1.000						
12. NEWMRKT	0.296*	0.227*	0.256*	0.438*	0.279*	0.090*	0.249*	0.001	-0.031	0.265*	0.026	1.000					
13. QUALITY	0.274*	0.135*	0.272*	0.396*	0.229*	0.132*	0.164*	0.056*	-0.049*	0.098*	0.015	0.345*	1.000				
14. COST	0.158*	0.115*	0.146*	0.388*	0.216*	0.181*	0.173*	0.068*	-0.008	0.027	0.011	0.296*	0.419*	1.000			
15. REPLACE	0.090*	0.061*	0.095*	0.315*	0.160*	0.143*	0.077*	0.076*	-0.024	0.026	0.004	0.155*	0.287*	0.354*	1.000		
16. MRKTCON	-0.105*	-0.059*	-0.091*	-0.155*	-0.106*	-0.047*	-0.065*	-0.024	0.033*	-0.116*	-0.006	-0.151*	-0.142*	-0.089*	-0.073*	1.000	
17. CONTRAINTS	-0.075*	-0.044*	-0.065*	-0.032*	-0.061*	-0.006	-0.013	-0.056*	0.002	-0.062*	-0.005*	-0.082*	-0.066*	-0.007	-0.019	0.145*	1.000
Mean	17.409	4.754	12.655	3.599	1.538	0.939	0.672	1.765	0.083	0.421	6.961	2.518	3.106	2.361	2.549	0.068	0.039
Standard deviation	26.679	15.869	24.107	2.641	1.753	0.771	0.743	0.653	0.276	0.494	4.651	0.019	0.018	0.019	0.019	0.004	0.003
VIF	-	-	-	1.37	1.36	1.16	1.22	1.1	1.03	1.2	1.08	1.34	1.33	1.18	1.17	1.03	1.02

N=3910. * Significance at the 5% level

Table 2: Baseline results for open innovation and innovation performance

VARIABLES	INNO IV Tobit (2.1)	INNO Tobit (2.2)	RADINNO IV Tobit (2.3)	RADINNO Tobit (2.4)	INCREINNO IV Tobit (2.5)	INCREINNO Tobit (2.6)
INBOUNDOI	**0.043***	**0.055*****	**0.051***	**0.055*****	**0.046*****	**0.059*****
	(0.018)	(0.010)	(0.020)	(0.015)	(0.010)	(0.011)
COUPLEDOI	**0.058**	**0.149*****	**0.147*****	**0.216*****	**0.030**†	**0.131*****
	(0.055)	(0.015)	(0.032)	(0.022)	(0.016)	(0.017)
SIZE	0.490	-0.248***	0.314	-0.264***	0.632*	-0.188***
	(0.653)	(0.039)	(0.496)	(0.058)	(0.246)	(0.043)
START-UP	0.529**	0.233**	0.353**	0.118	0.487***	0.158†
	(0.171)	(0.087)	(0.136)	(0.129)	(0.145)	(0.096)
GEOMRKT	-0.759	0.344***	-0.284	0.578***	-0.973***	0.245***
	(0.524)	(0.053)	(0.329)	(0.080)	(0.236)	(0.059)
RDINT	0.082***	-0.000	0.064***	-0.000	0.090	-0.001†
	(0.000)	(0.000)	(0.000)	(0.000)	(0.063)	(0.001)
Constant	-2.166	0.037	-3.143*	-1.402***	-2.721***	-0.268*
	(1.975)	(0.112)	(1.580)	(0.171)	(0.788)	(0.123)
Location dummies	Included	Included	Included	Included	Included	Included
Sector dummies	Included	Included	Included	Included	Included	Included
Year dummies	Included	Included	Included	Included	Included	Included
Chi-square		510.0***		410.3***		361.5***
Endogeneity test						
Durbin	247.370***		76.322***		205.413***	
Wu-Hausman	262.928***		77.503***		215.860***	
Over-identification test						
Sargan	0.266		0.059		0.443	
Basmann	0.264		0.058		0.440	
Weak-instruments test						
Montiel-Pflueger	17.84*		17*		17*	
Observations (N)	3,910	3,910	3,910	3,910	3,910	3,910

Robust standard errors in parentheses. †, *, **, *** significance at 10%, 5%, 1% and 0.1%, respectively (two-tailed tests).

Table 3: IV Tobit Results for moderating effect of STRECON and OPRECON on the relationship between open innovation and innovation performance

VARIABLES	RADINNO (3.1)	INCREINNO (3.2)	RADINNO (3.3)	INCREINNO (3.4)	RADINNO (3.5)	INCREINNO (3.6)
INBOUNDOI	0.050*	0.047***	0.049*	0.046***	0.050*	0.046***
	(0.020)	(0.010)	(0.021)	(0.010)	(0.021)	(0.009)
COUPLEDOI	0.143***	0.034*	0.144***	0.027†	0.143***	0.032†
	(0.033)	(0.017)	(0.030)	(0.016)	(0.032)	(0.017)
STRECON X INBOUNDOI	**-0.036*** **	**-0.043*** **			**-0.046*** **	**-0.052*** **
	(0.006)	(0.012)			(0.012)	(0.009)
STRECON X COUPLEDOI	**0.057***	**0.010**			**0.055**$^{\xi}$	**-0.007**
	(0.025)	(0.044)			(0.036)	(0.044)
OPRECON X INBOUNDOI			0.010	0.004	0.026	0.022†
			(0.019)	(0.013)	(0.023)	(0.012)
OPRECON X COUPLEDOI			0.023	**0.030** **	0.003	**0.036*** **
			(0.034)	(0.014)	(0.044)	(0.008)
Chi-square						
Endogeneity test						
Durbin	77.865***	205.750***	74.686***	202.477***	76.410***	201.026***
Wu-Hausman	79.061***	216.123***	75.771***	212.498***	77.514***	210.783***
Over-identification test						
Sargan	0.069	0.443	0.058	0.454	0.065	0.456
Basmann	0.068	0.441	0.057	0.451	0.065	0.454
Observations	3,910	3,910	3,910	3,910	3,910	3,910

Robust standard errors in parentheses. †, *, **, *** significance at 10%, 5%, 1% and 0.1%, respectively (two-tailed tests). $^{\xi}$ $p < 0.15$. Control variables, Location, Sector and Year dummies are included, but results are not reported for brevity, but available upon request.