Process Innovation: Open innovation and the moderating role of the motivation to achieve legitimacy

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Abstract

Global Competition has increased the pressure for firms to develop new and efficient processes in ways that are perceived to be legitimate. At the same time, there has been a realization that engaging with open innovation can improve competitiveness. Our study aims to address two research questions: a) How does engaging with open innovation support an organization's process innovation? and b) How does the motivation to achieve legitimacy affect the relationship between engaging with open innovation and process innovation? We use arguments from the resource-based view to explain how open innovation influences an organization's likelihood of introducing new processes. We then use arguments from institutional theory to explain how the motivation to achieve legitimacy moderates this relationship. We test our conceptual model using data from the European Community Innovation Survey administered by the UK government. Our findings and theoretical development support the notion that engagement with open innovation will increase the likelihood of introducing new processes and that the motivation to achieve legitimacy will affect this relationship. However, this moderating effect will be different depending on how engagement takes place. It will be positive on cooperation with external parties, and negative on the use of information. Therefore, when organizations cooperate with external parties and are motivated to achieve legitimacy, the likelihood of introducing a new process will increase. However, the effect is opposite in the case of use of external information. These findings contribute to the understanding of the relationship between open and process innovation.

Practitioner's points

- Engaging with open innovation via a) cooperation with external parties, b) the use of external information, and c) the acquisition of external R&D will support the introduction of new processes.
- When there is motivation to adhere to regulations and implement standards of good practice, close cooperation with external parties will boost learning and support the introduction of new processes.
- When the same motivation is present but managers only passively use information from external sources (without cooperation) present norms will be reinforced and the introduction of new processes will be resisted.

Keywords: Process Innovation, Open Innovation, Motivation to Achieve Legitimacy, Resource Based View, Institutional Theory

Introduction

Given the need to systematically improve the efficiency of modern operations (Schroeder et al., 2008), there has been a notable increase in the efforts to develop theoretical frameworks for understanding process innovation (Piening and Salge, 2015; Un and Asakawa, 2015). In this context, research on open innovation, which explores how engagement with external parties can support an organization's innovative ability, has focused mainly on the development of new products, largely ignoring the introduction of new processes. This is despite evidence that open innovation is very common in the development of processes (e.g. on process technology) (Robertson et al., 2012). As a result, there is a need for more theoretical and empirical work on the interplay between open and process innovation (Du et al., 2014) on one hand, and on the extension of product to process innovation theory (Piening and Salge, 2015) on the other.

Research on open innovation has been aiming to explain why and how external parties share ideas and expertise, and how these are then combined with an organization's internal knowledge to help improve its products (Chesbrough, 2003b). The general consensus is that engaging with open innovation does improve an organization's innovative ability, because it triggers a process where new ideas are being developed, and current thinking is challenged by external parties (West and Bogers, 2014). When a new product is introduced, or when older equipment needs to be upgraded, organizations work with their partners to identify new ways of doing things (Robertson et al., 2012). In such cases an organization's competence does not lie only in its in-depth understanding of how its processes work, but also on its ability to communicate with its partners and understand how their competences can be used effectively to improve what they do and how they do it. Developing relationships with external parties, however, is highly context- specific, requires a degree of openness (Laursen and Salter, 2014) and, thus, is difficult to achieve. For instance, the decision of multinational firms to maintain their operations in some European locations, where costs are comparatively high, often depends on their ability to work with external

partners (Allred and Swan, 2014), and increasingly depends on their ability to engage with open innovation for introducing new processes as opposed to new products. When properly achieved, this ability becomes a rare and difficult-to-imitate capability which helps in differentiating one organization from its competition (Rosenzweig et al., 2003). Therefore, one question that remains unanswered is: How does engaging with open innovation support an organization's process innovation?

In product development, the iterative process of engaging with open innovation can be strengthened by the customers' intrinsic motivations to improve the product they use (Schreier and Prügl, 2008), the suppliers' economic motivations for increased business (Al-Zu'bi and Tsinopoulos, 2012), and the focal organization's motivation for improving its own products. The introduction of a new process, however, is an intermediary outcome rather than an end in itself (Piening and Salge, 2015) and as such the motivations that may affect whether and how open innovation leads to it, are likely to be different from the ones that drive the development of the product that the customer is actually going to buy.

Two motivations for process innovation, which have been explored by previous researchers, are the need to achieve a financial benefit (Katz and Shapiro, 1987), and the desire to appear legitimate to external stakeholders (DiMaggio and Powell, 1983). Achieving a financial benefit is a relatively well-understood motivation. Organizations, aiming to reduce costs, engage in open innovation to find more efficient ways of doing things through the acquisition of new process technology (Robertson et al., 2012). When the motivation is the desire to be seen as legitimate, however, the aim is not to develop a process that achieves an immediate cost saving, but to find a way of doing things which adheres to regulatory requirements on the one hand and meets standards of best practice on the other (Sherer and Lee, 2002), as explained by Kennedy and Fiss (2009, p. 914) who note that "wanting to look good does not preclude wanting to do well". For instance, the pursuing of ISO standards or the implementation of six sigma methodologies also aims to signal to external parties that the organization adheres to regulatory requirements and implements standards of good practice (Khazanchi et al., 2007; Stadler, 2011). That is, it aims to signal that it fosters an organized environment and a culture of continuous improvement. The

way the desire to appear legitimate affects the relationship between engaging with open innovation and introducing new processes is not well understood (Jean et al., 2014). This gives rise to a second question: How does the motivation to achieve legitimacy affect the relationship between engaging with open innovation and process innovation?

Our Contribution

In this article we aim to address the above two questions both theoretically and empirically. Drawing on the resource based view (RBV) and institutional theory, we provide a framework to explain how engaging with open innovation leads to process innovation and then how this relationship is affected by the motivation to achieve legitimacy. We, therefore, address the need for more theoretical and empirical work on the interplay between open and process innovation, and extend product to process innovation theory. Furthermore, by focusing on the motivation to achieve legitimacy, we respond to calls for integrating institutional theory as a contextual variable in the innovation literature (Jean et al., 2014) and for more quantitative studies to explore the responses to legitimation issues (Boiral, 2007; Ketokivi and Schroeder, 2004; Lo et al., 2014).

Our main argument and contribution consists of two parts. In the first, we extend product to process innovation theory and explain how efforts to engage with open innovation will have a positive effect on the ability to introduce new processes. At one level, engaging with open innovation provides ideas for improving existing routines. At another, it enables the cooperation with external parties, the use of external information, and acquisition of R&D, thereby generating higher levels of intra-organizational learning which eventually diffuse to generate new processes.

In the second, we combine arguments from the RBV and institutional theory to explain that when these efforts are combined with the motivation to be seen as legitimate, the overall incentive for introducing a new process would be affected. As resource-based advantages depend on the institutional context (Oliver,

1997; Brouthers, et al., 2008), the integration of the two theoretical approaches provides a more comprehensive understanding of the organizational motivations behind certain actions. .

The article is structured as follows. In the following section we review the literature on open innovation and identify three dimensions that indicate the degree to which an organization engages with open innovation, namely, co-operation with external parties, use of external information, and acquisition of external R&D. We then review the RBV and institutional theory to explain how the interplay between the two can explain how engaging with open innovation can lead to process innovation and the role which the motivation to achieve legitimacy can play. Next we develop six hypotheses, which we test by using data from the European Community Innovation Survey administered by the government of the UK covering the period from 2004 to 2010. Finally, we explain the conclusions and implications of our findings for innovation management scholars and practitioners.

Theoretical Background

Open Innovation

Open innovation initiatives aim to facilitate the use of external sources of ideas as an organization looks to advance its technological and knowledge capabilities (Chesbrough, 2003b). Such initiatives, share a common aim to enable the acquisition and integration of innovations from external sources, by sharing resources and innovation processes with their partners (West and Bogers, 2014). Exploring, and subsequently measuring the degree to which an organization engages with open innovation, would therefore require analyzing the degree to which it interacts with processes and activities that support co-operation with external partners on the one hand, and acquisition of information and R&D on the other. To put this differently, when an organization cooperates with external sources and acquires information and R&D in order to commercialize its innovations (West and Bogers, 2014), it is reasonable to presume that it engages in open innovation.

In line with the above argument, we develop our theoretical arguments and hypotheses by focusing on three dimensions of open innovation. The first is cooperation with external parties, which refers to the extent to which an organization works with an external party on any activities and processes associated with innovation (Petersen et al., 2005; West and Bogers, 2014). Working with external parties, such as suppliers, users, competitors, research organizations and universities (Laursen and Salter, 2014), enables an organization to search and subsequently integrate external innovations (Dodgson et al., 2006; Laursen et al., 2010). Although in itself, a partnership does not lead to commercialization, it does enable interaction and the development of feedback loops which allow learning and even co-creation (Lynn et al., 1996).

The second dimension of open innovation on which we focus is the information acquired from external sources. It refers to the extent to which an organization is using information from external sources in its innovation efforts (Tsang, 2002). While some pieces of information can be obtained via the co-operation with external parties, this dimension differs from the co-operation with external parties as it includes relatively passive information (e.g. facts and figures about a new market or the location of a technology; information from scientific journals and trade publications). The increasing presence of information technology and the internet has improved the availability of such information. Yet, scouting for up-to-date hard-to-find technologies is becoming increasingly popular (Rohrbeck, 2010), making the acquisition of information a significant enabler in facilitating open innovation (West and Bogers, 2014).

The third dimension is the acquisition of external R&D which is not necessarily co-developed with other parties and, thus, is not the result of cooperation. It refers to the extent to which a firm obtains knowledge developed via research purposes by a third party (Buss and Peukert, 2015; Un et al., 2010). Contrary to the acquisition of information, which is relatively uninvolved, acquiring R&D requires a more detailed understanding of how knowledge developed externally can be combined with that developed internally (Laursen and Salter, 2014). Acquiring R&D, therefore, is the result of a relatively more complex process

which is driven by a combination of formal and informal methods for integrating what is being developed externally (Laursen and Salter, 2014).

Taken together, these three dimensions can indicate whether an organization engages with open innovation activities. For instance, organizations such as P&G cooperate with suppliers, and customers, they have a proactive process for acquiring external information through their "connect and develop" scheme, and actively acquire R&D from research institutions (Huston and Sakkab, 2006). We use these three dimensions to explain how we expect engaging with open innovation can influence an organization's likelihood to introduce new processes.

RBV and Institutional Theory

The Resource Based View (RBV) can help explain how engaging with open innovation supports the development of rare, inimitable and non-substitutable resources in order to acquire a competitive advantage (Barney, 1991). Scholars who have extended this theory to dynamic markets (Teece et al., 1997) argue that behavior can be explained by an organization's efforts to build dynamic capabilities, which allow it to integrate, build, and reconfigure external resources and competencies to address the rapidly changing environments. Institutional arguments, however, argue that individual and organizational behavior is not explained only by competition terms, but by a process of comparison where people are looking at what others have done in circumstances similar to theirs (McFarland et al., 2008). This process leads to convergence, and subsequently to legitimacy (Ketokivi and Schroeder, 2004). A state where external stakeholders perceive the organization to be compliant with standards of acceptable behavior (DiMaggio and Powell, 1983). Therefore, although RBV arguments can explain how engaging with open innovation can lead to the introduction of new processes, institutional theory can explain how a process of comparison with external norms affects this relationship. Integrating the two theoretical

approaches (RBV and institutional theory) could, thus, help explain more comprehensively, organizational motivations behind certain actions (Auh and Menguc, 2009).

Dynamic capabilities indicate the ability the firm has to combine and coordinate external resources in order to gain and internalize new knowledge from other organizations within new processes (Wu, 2007). Research that uses the RBV to consider how the process of engaging with open innovation becomes a dynamic capability is still relatively limited. Yet, the innovation body of literature (Koufteros et al., 2005) argues that engaging with external partners who have knowledge to share allows organizations to find opportunities for improving what they do, which helps them address specific problems. As such it becomes a difficult-to-imitate capability (Mishra and Shah, 2009).

Institutional theory on the other hand, which examines the role of social influence in shaping firms' actions (DiMaggio and Powell, 1983; Oliver, 1991) argues that a firm's behaviors are also motivated by the desire to conform with established cognitive structures in society (e.g. rules, and norms) (Baum and Oliver, 1991; Oliver, 1997), in order to be legitimate (Kostova and Zaheer, 1999). Organizational legitimacy is shaped by the characteristics of the organization and its environment, and the processes by which perceptions are built. Although the way this will be conducted will depend on the type of legitimacy that is being sought, organizations aim to change their processes to position themselves within accepted institutional regimes and then to signal that they have been successful in doing so (Suchman, 1995; Zucker, 1983). For instance, firms are motivated to implement ISO14001, by the desire to signal to external partners that they have a credible way of managing their environmental systems (Bansal and Hunter, 2003). Customers are looking for evidence of the existence of management systems and control mechanisms as a way of ensuring that the potential supplier is able to consistently provide the products and services they have promised (Anderson et al., 1999; Matias and Coelho, 2002). As a result, suppliers openly publicize their external accreditations to indicate that they have robust and effective control mechanisms in place and are, thus, legitimate organizations with which to do business.

Combining the RBV with Institutional arguments

Process innovation is the result not only of combining and coordinating external resources in order to gain and internalize new knowledge, but also of legitimizing and conforming to normative standards and pressures. The fundamental premise of institutional theory is that organizational behavior is influenced by societal influences and pressures to conform (Auh and Menguc, 2009), and thus, underscores how important it is for organizations to enhance their legitimacy (Berrone et al., 2013). As a result, organizations strive for both economic fitness, which emphasizes the importance of resources, and social fitness, which stresses the pursuit of legitimacy in the eyes of the stakeholders thereby accentuating the significance of the institutional environment (Grewal and Dharwadkar, 2002).

Unlike the RBV, institutional theory incorporates the broader social context in which resource adoption and deployment occurs (Auh and Menguc, 2009). Oliver (1997) argues that institutional environments (e.g. laws and regulations) profoundly influence firms' strategic decisions arising from resources. Firms using their resources make strategic choices within the constraints of the institutional environments (Peng, 2003; Su et al., 2009). Failure to incorporate the institutional environment into the RBV encourages the flawed perspective that resource-based advantages are independent of the institutional constraints in which they are employed (Brouthers et al., 2008; Priem and Butler, 2001). As such, an organization's desire to enhance social fitness provides the boundary condition for the effectiveness of economic fitness (Menguc et al., 2010). That is, combining the RBV with institutional theory supports the idea that the motivation to achieve legitimacy in the eyes of stakeholders can moderate the impact of the use of external resources on developing new processes. For instance, the effectiveness of a manufacturer's collaboration with a University when working on the development of a new process technology would improve when motivated by the desire to be seen as legitimate (e.g. seeking external accreditation).

Within the context of open innovation, the motivation to achieve legitimacy may reduce the uncertainty associated with the introduction of new processes which have been the result of engaging with external

sources. Increased levels of motivation to achieve legitimacy would encourage the implementation of systems and controls which adhere to regulatory requirements and externally-accredited standards (e.g. ISO). Regulation, and management systems, may differ from one industrial sector to another, but typically, they share commitment to systematization, documentation, and continuous improvement (Matias and Coelho, 2002). These initiatives would reduce the perceived uncertainty of decision-making (Bello and Gilliland, 1997), and help in the implementation of developing new processes. As such, the implementation of externally-sourced ideas for the introduction of new processes would be seen as less risky and would facilitate that development. Therefore, the motivation to achieve legitimacy could moderate the effect of using external ideas on developing new processes.

Finally, the motivation to adhere to regulation and standards of good practice implies that the organization is open to external ideas and is willing, at least to a degree, to experiment and learn from mistakes (Westphal et al., 1997). Although the actual reasons why standards of good practice may be implemented vary (Martínez-Costa et al., 2009), the motivation to achieve legitimacy could foster a fertile environment for learning and experimentation in which ideas originating from outside an organization are more likely to lead to change (i.e., development of new processes).

From the previous arguments, it would be reasonable to conclude that the motivation to achieve legitimacy can strengthen the change of routines and the management of daily operations, and hence, there are good theoretical reasons to expect that it could moderate the relationship between open innovation and the likelihood of introducing new processes. In the next sections we develop our hypotheses, aiming to explain how engaging with open innovation and the motivation to achieve legitimacy will influence an organization's ability to introduce new processes.

Hypotheses Development

We start our hypotheses development by exploring how the three dimensions of open innovation directly influence an organization's process innovation. To make sure that our arguments are closely aligned with our operationalization of process innovation, we focus on the likelihood of introducing a new process. That is, we argue that the likelihood of an organization introducing a new process will be higher when its process innovation ability is also higher (Piening and Salge, 2015).

Relational resources such as the ability to cooperate or establish partnerships with other organizations, enable a firm to access additional resources more easily (Luo et al., 2004; Srivastava and Gnyawali, 2011). Cooperation with external parties can provide firms with access to valuable knowledge (Dyer and Singh, 1998) that can be used to increase the likelihood of introducing a new process (Un and Asakawa, 2015). For instance, suppliers can provide an organization with the technology, investment and know-how (Potter and Lawson, 2013) to advance their development projects. Cooperation with external parties therefore, helps in understanding the capabilities of the partners and how they complement each other's processes and products (Stock, 2014). Working with them would strengthen the focal organization's awareness of the available process technology, both at the supplier and the more general market levels, and will expose them to different ways of managing their processes (Stadler, 2011).

External parties are different organizations, and as such, they will have developed different routines and processes which make them unique, and potentially provide them with sustainable competitive advantage (Coates and McDermott, 2002). As an organization is cooperating with a supplier, customer, or competitor, it will need to learn how to make efficient use of its partners' routines. Increased levels of cooperation would, therefore, require increased levels of intra-organizational learning (Kessler and Bierly, 2000) which leads to a greater emphasis on the development of new procedures and routines.

Although many external suggestions do not necessarily lead to new direct developments (Dahlander and Piezunka, 2014), cooperation, requires the sharing of potentially-valuable information and tacit

knowledge which could be integrated into the way it organizes its activities (Siguaw et al., 2006). Adapting processes as a result of open innovation requires the understanding of the way people use equipment to solve problems to meet their organizational objectives (Robertson et al., 2012). For instance, the emergence of 3D printing has provided new opportunities for cooperating with suppliers in developing new and improved manufacturing processes (Economist, 2012). The above arguments lead us to the first hypothesis:

H1: Cooperation with external parties increases the likelihood of an organization introducing a new process.

For the second hypothesis we explore how the use of external information affects the introduction of new processes. Contributions inspired by the RBV and the dynamic capabilities frameworks (e.g. Barney, 1991; Teece et al., 1997) stress the importance of acquiring external information to complement existing resources and capabilities, thereby enabling the firm to enhance its innovative skills. However, contrary to cooperation efforts we view the use of information as a relatively more passive activity where an organization is using information from an external source (e.g. on the changes of market trends) without necessarily cooperating with the party that is developing it or information collected from scientific journals and trade publications. For instance, the monitoring of a blog where individuals share their views can be monitored by an innovation manager to identify flaws or ideas for improving existing processes (Droge et al., 2010). Such information can be used to both develop new products and processes, and adjust an organization's strategy (Benner and Tushman, 2003) without necessarily closely cooperating with the person or organization that sources the relevant information.

The use of information from external sources would lead to suggestions for improvement of the existing processes. Market information, for instance, which is critical for recognizing new trends and initiating creative output (Slater and Narver, 1995; Troy et al., 2001), may indicate a new opportunity for which a

new process would need to be developed (Kotler et al., 2009). In such cases the use of information is expected to have a direct and positive impact on the development of new processes. The above arguments would lead us to the second hypothesis:

H2: Using information acquired from external sources increases the likelihood of an organization introducing a new process.

For the third hypothesis we explore how the acquisition of external R&D (i.e. knowledge developed via research purposes by a third party) affects the introduction of new processes. According to the RBV, external R&D serves as an instrument to acquire knowledge resources that may subsequently be redeployed with existing resources in a way superior to a competitor's deployment (Barthélemy and Quélin, 2006; Desarbo et al., 2005). Innovation literature, which has also used RBV arguments to explore the relationship between the acquisition of external R&D and the way new products are developed (Koufteros et al., 2005; Petersen et al., 2003, 2005), argues that it improves an organization's ability to innovate (Ebers and Maurer, 2014). Knowledge developed and owned by a supplier or a customer can be used by the focal organization to develop or improve a new product or process (Koufteros et al., 2007).

The increased innovation capability which accrues from the use of external R&D has been supported by work on absorptive capacity, which refers to the firm's ability to identify, assimilate and exploit knowledge from the environment (Lane et al., 2006). It encompasses a firm's ability to imitate new process or product innovations and exploit outside knowledge which is critical to that firm's innovative capabilities (Cohen and Levinthal, 1990). Some authors have defined it as a dynamic capability that refocuses a firm's knowledge base through iterative learning processes (Szulanski, 1996; Zahra and George, 2002). This work has demonstrated that certain organizations are better able to exploit externally-acquired knowledge than others (Wales et al., 2013). The development of such 'relational' capabilities is difficult to imitate and can lead to a unique combination of knowledge and technology

which could help improve organizational processes (Lenox and King, 2004; Yli-Renko et al., 2001). Therefore, acquiring externally-developed R&D will strengthen an organization's knowledge assets and support it in the development of its innovation projects.

The reasons that lead an organization to acquire R&D from an external source may vary. One is that it does not own the capability to develop aspects of a product or a process, as for instance in the case of new firms (Yli-Renko et al., 2001). From an RBV perspective, the acquisition of external R&D helps firms to access resources which are not available internally (Weigelt, 2009). Another reason is that it may be too expensive or too risky to develop it internally (Veugelers and Cassiman, 1999). In both cases, R&D acquired from external sources helps to improve aspects of the process which the focal organization is not able to change. Acquisition of external R&D can, therefore, increase the number of improvement ideas that can be pursued. For instance, acquiring knowledge from a University on the testing of process technology can help an organization to better understand the capabilities of its own operations (Khazanchi et al., 2007). As a result, the acquisition of external R&D should lead to an increased likelihood of introducing new processes. From the above arguments our third hypothesis is:

H3: Acquisition of external R&D increases the likelihood of an organization introducing a new process.

Moderation of the motivation to achieve legitimacy

As we explained earlier, there are good theoretical reasons to expect that the motivation to achieve legitimacy may affect the way open innovation leads to the introduction of new processes. To be legitimate, organizations have to conform with established cognitive structures in society (Kostova and Zaheer, 1999) whereby they have to adhere to regulatory requirements and standards. The motivation to achieve legitimacy could, therefore, affect how the cooperation with external parties is managed and how external information and R&D are used. We explain each in turn.

Cooperation with external parties can give an organization access to valuable knowledge and ideas, and support its learning. This is clearly important, and much of the literature on innovation management has long argued for the benefits of this approach (i.e. a direct relationship between higher levels of cooperation and higher levels of innovation). As the level of the motivation to achieve legitimacy increases, the effectiveness of the cooperation with external parties is also likely to increase as we explain in this section.

One reason is the fertile environment for learning that would result from the combination of being motivated to achieve legitimacy and cooperate with external parties. Martínez-Costa et al. (2008) studied the motivation of the implementation of the ISO 9000 standard as a moderator. They found that, the internal motivation to implement the standard results in positive changes in the technical core of the business, and, subsequently, contributes to the organization's capability and its competitive advantage. Furthermore, Westphal et al. (1997), argued that the motivation to adhere to legislation and standards of good practice implies that the organization is open to external ideas and is willing, at least to a degree, to experiment and learn from mistakes. Therefore, the motivation to achieve legitimacy contributes to the development of a fertile environment of learning and experimentation. As we explained in the development of the first hypothesis, cooperation with external parties also contributes to a learning environment as the organization will need to learn how to make efficient use of its partner's routines. Therefore, we would expect that the efforts to cooperate with external parties become more effective when the motivation to achieve legitimacy increases.

Moreover, the motivation to achieve legitimacy would encourage the comparison of the ideas that emerge from collaboration with those that emerge from accepted best practice, and would thus reduce the perceived risk of change. Meeting regulatory requirements, legislation, and achieving standards of good practice requires a systematic engagement with external parties (e.g. accrediting bodies and consultants) (Martínez-Costa et al., 2009). Such engagement may increase both the frequency and effectiveness of the interaction among the members of the network (Grewal and Dharwadkar, 2002). The process of

comparison reduces the perceived risk and increases the perceived opportunity of change. When an organization perceives a situation as risky, it would be more likely to fall back on previous familiar routines (Kennedy and Fiss, 2009). However, when innovation is also motivated by the desire to achieve standards of accepted practice and adhere to legislation, the opportunities arising from change will be easier to justify. In their study of the diffusion of TQM among US hospitals, Kennedy and Fiss (2009) found that when motivated by achieving performance improvements, organizations are more likely to work harder towards the introduction of a new process perceived to be beneficial, both socially and technically. As a result, combining efforts to cooperate with external parties with the motivation to achieve legitimacy will reduce barriers to change and support the introduction of new processes. From the above arguments our fourth hypothesis is:

H4: The motivation to achieve legitimacy moderates the relationship between the cooperation with external parties and an organization's likelihood of introducing a new process in such a way that increased levels of motivation encourage organizations to introduce more new processes.

Following on from the arguments for the development of the fourth hypothesis, we explain how the use of information, from external sources, such as trade fairs, technical publications, and exhibitions, is also likely to be affected by the motivation to achieve legitimacy. Such information can provide several ideas for improvement, which can result in the introduction of a new process. The motivation to achieve legitimacy, however, will encourage a proactive comparison of these ideas with regulations and accepted good practice. As with our earlier argument such a comparison will reduce the perceived risk of implementation and as a result increase the likelihood of take-up (Kennedy and Fiss, 2009). Taking our earlier example further, information on the potential application and benefits of 3D printing can provide an organization with ideas on how to improve its existing processes. However, this may be perceived as risky when done in isolation. When efforts to use such information are combined with the motivation to

achieve standards (e.g. on the application of rapid technologies) (ISO-Staff, 2015), the perceived risk associated with the application of the new technology will be reduced. That is, when the effort to achieve a competitive advantage, via the effective use of some relevant information, is combined with the motivation to implement an associated standard, the perceived risk of failure will be reduced which should encourage organizations to introduce more new processes. The above arguments lead us to the fifth hypothesis:

H5: The motivation to achieve legitimacy moderates the relationship between the use of external information and an organization's likelihood of introducing a new process in such a way that increased levels of motivation encourage organizations to introduce more new processes.

The motivation to be seen as legitimate would also moderate the relationship between the third dimension of open innovation, the acquisition of external R&D, and process introduction for two related reasons. As we explained in the development of the previous hypotheses, increased levels of motivation to achieve legitimacy, encourage the implementation of a culture of learning which could lead to a reduction in the perceived risk of the implementation of a new process. Yet, such a culture also fosters an organization's ability to effectively identify, assimilate, and exploit knowledge from the environment (Escribano et al., 2009), thereby increasing the organization's absorptive capacity (Lane et al., 2006). Increased levels of motivation will, therefore, lead to increased levels of absorptive capacity, and this will strengthen the relationship between the acquisition of external R&D and the likelihood of introducing new processes.

Furthermore, the motivation to achieve legitimacy will encourage firms to consider the implementation structures and policies which will be recognized by external stakeholders as explained earlier. Yet, such structures and policies may lead to empowerment and improvisation because they provide a framework for brainstorming and experimentation (Lewis and Boyer, 2002). Therefore, when efforts to acquire externally- developed R&D are combined with the motivation to achieve legitimacy, it will be more likely

that there will be a structure in place to explore how the new knowledge can be integrated with the existing processes, thereby encouraging the introduction of new processes. The above arguments lead us to the sixth hypothesis:

H6: The motivation to achieve legitimacy moderates the relationship between the acquisition of external R&D and an organization's likelihood of introducing a new process in such a way that increased levels of motivation encourage organizations to introduce more new processes.

The six hypotheses are summarized graphically in Figure 1.

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Data and Measures

Data Collection and Sample

To accomplish the objectives of this research, we use data from the European Community Innovation Survey (CIS4, CIS5, CIS6 and CIS7) administered by UK Office of National Statistics. The purpose of this survey was to collect information about firm-level innovation capacities and innovation outputs. The sample was drawn from the ONS Inter-Departmental Business Register (IDBR). The survey was conducted every other year from 2004-2010 from the stratified random sample of IDBR. A mail survey was sent first and, when no response was received, it was followed by telephone call. It was typically answered by the R&D manager, the Chief Financial Officer or the Managing Director. The response rate is 51.1%, which is high, given that in the UK the survey was voluntary. Each stratum was weighted back

to the population using the inverse sampling proportion based on industry sectors as provided by CIS. More detail about the data and the sampling procedures can be found in the report of the UK's Department for Business Innovation & Skills (Robson and Achur, 2013). Therefore, the sampling process can ensure representativeness of the populations of UK establishments.

Measures

Table 1 provides information about the definition and measurement of the variables used in our study, along with the set of models.

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To measure the likelihood of introducing a new process we used a binary variable, which took the value of 1 when the firm reports that it has introduced any new or significantly improved process for producing or supplying goods or services, and 0 when it does not. The acquisition of external R&D was measured in a similar fashion (i.e. a binary variable which took the value of 1 when the firm reports that it has acquired external R&D, and 0 when it does not). Similar measures have been used in the literature to operationalize these constructs (e.g. Freel, 2003; Leiponen and Byma, 2009; Roper et al., 2008; Schmiedeberg, 2008). *Cooperation with external parties* and *use of external information* were also operationalized based on previously-used measures (e.g. Lee et al., 2010; Leiponen and Byma, 2009). *External Cooperation* was measured by adding up the number of external parties with which the firm reports it cooperates. In the questionnaire, respondents were asked to select the parties with which they collaborated during their innovation activities. The actual wording was: *Did your business co-operate on any innovation activities with any of the following?* (the parties are listed in Table 1). A higher number of

selections indicates that the organization works on more activities and processes with its external parties and thus the level of collaboration would be higher. *External information* was measured by the perceived importance (high, medium, low) placed on using information from the external parties shown in Table 1. To measure the *motivation to achieve legitimacy* we used one item which asked respondents to indicate the importance of meeting regulatory requirements (including standards) in the decision to innovate in goods or services and/or processes (high, medium, low).

To empirically examine the effects of external R&D, external cooperation, external information, and legitimation motivation on process innovation, we included the following control variables: *firm size, turnover, labor productivity, innovativeness, industry, and geographical location*. We controlled for firm size because it may influence how firms engage with innovation activities (Chudnovsky et al., 2006; Jiang and Li, 2009). Based on a similar argument, we also included turnover as a control variable. Furthermore, to capture the efficiency of production, which may also have an impact on process innovation, we included labor productivity, measured as the total annual turnover divided by the number of employees. Moreover, different levels of innovativeness may affect the motivations and propensity of a firm to acquire R&D (Wales et al., 2013; Wang and Libaers, 2016). To control for that we used four variables to represent the percentage of the total annual turnover of a business from goods or services that were new to the market (INNOV1), that were familiar to this business (INNOV2), that were significantly improved (INNOV3), and that were unchanged or only marginally modified (INNOV4).

Furthermore, we controlled for the industrial sector as both the response to legitimation and the impact of process innovation could be different for different sectors. This was captured by a categorical variable representing seven main sectors including manufacture, mining, electricity & water supply, construction, hotel & accommodation, transportation and others. Finally, we controlled for geographical location as there may be regional effects that influence the innovation activities of firms located in each region. This was captured by a dummy variable representing 12 regions in the UK, classified according to the EUROSTAT classification (2008).

Analysis

Model selection and descriptive statistics

In order to understand the role of the acquisition of external R&D, cooperation with external parties, use of external information, and legitimation motivation in determining the probability of an organization to introduce a new process, we used a firm-year unit of analysis to form our estimator. We employed a set of logit models to test our hypotheses. The independent, moderating and control variables were entered into regression step by step in order to show the robustness of estimates. We adopted logistic regressions for two reasons. The first is the ability of this method to estimate the probability of a binary response based on one or more predictors. We remind the reader that our dependent variable is the likelihood of introducing a new process. Therefore, logistic regression is well-suited for estimating how factors such as external cooperation change the probability that a firm will introduce a new process (Greene, 2012). The second is that logistic regression is "formulated to predict and explain a binary (two-group) categorical variable rather than a metric dependent measure" (Hair et al., 2014 p. 313), which fits the nature of our dependent variable.

We also employed Hausman (1978) tests to decide whether to use the random effect or the fixed effects models (Arellano, 2003; Boulding, 1990; Boulding and Christen, 2003). An insignificant *p* value of this test would indicate that the random effects model outperforms the fixed effects one, and a significant *p* value suggests that a fixed effects model outperforms a random effects one. The Hausman test result from Model 5 was not significant ($\chi^2_{diff(model6)}$=0.58, p>0.1), thus favoring the specified random effects model in Model 5. This test was also performed on models 1-4 to compare the random effect and fixed effects models. The results of the Hausman test showed that χ^2 ranges from 0.41 to 18.30 and all *p*-value >0.05, suggesting that random effects models were more appropriate than fixed effects models. Therefore, we specified random logit models (Gönül and Srinivasan, 1993) in order to test our hypotheses.

We then tested whether the specified models had any multicollinearity effects as they could seriously bias the coefficient estimates. Table 2 presents descriptive statistics and a correlation matrix for all variables. We examined the effect of multicollinearity by using variance inflation factors (VIFs), which are reported in Table 2. The VIF values relating to the independent variables range from 1 to 4.08, indicating no need for concern regarding multicollinearity effects.

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Finally, in order to facilitate causal inference we tested our hypotheses using a time-lag effect. The time it takes for innovation initiatives to be implemented differs between industrial sectors (Schramm and Hu, 2013; van der Duin et al., 2014). A frequent and accepted period used in surveys that have also employed time-lag effects, which have mainly focused on product innovation, has been 2-5 years (Cheng and Huizingh, 2014; Xu, 2015). We would expect the period taken for the introduction of a new process to take effect to be relatively shorter for the following two reasons. The first relates to the time it takes to evaluate a process relative to a product. A new product requires feedback from a customer, whereas a new process is more likely to be evaluated internally (Un and Asakawa, 2015). The second relates to the objective of the innovation, which focuses more on efficiency rather than product differentiation (Piening and Salge, 2015; Un and Asakawa, 2015) and as result it is more likely to result in incremental improvements (Robertson et al., 2012). Therefore, all else being equal, we would expect the time it takes to introduce a new process to be shorter than that it takes to introduce a new product.

CIS is conducted every other year, which, given the above argument, on average should be sufficiently long to capture the impact of open on process innovation. We therefore lagged the measures of independent and moderating variables to those of the dependent variable by one survey period (two years). The independent and moderating variables were in the questionnaires a firm answered in period

t-1, and the dependent variable was in the questionnaire the same firm answered in period t (two years later). This resulted in 7,645 firm observations because: a) firms had to participate in the survey at least in two consecutive years, and, b) their submissions needed to have no missing variables.

Hypotheses testing

Table 3 shows the regression summary statistics for Models 1-5. Process innovation is the dependent variable.

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The χ^2 in Models 1-5 range from 246.9 to 285.1, and all Wald Chi tests were significant at the 0.001 level. Moreover, log-likelihood ratio tests were also highly significant. The computed statistical measures indicate that the different combination of variables included in the models impact on process innovation at the 0.001 level. Models 1-5, therefore, had satisfactory explanatory power and fit the data well. The intra-class latent correlation ρ for Models 1-5 ranges from 0.585 to 0.768, indicating a high level of correlation between a firm's propensity to increase its process innovation in different years, after controlling for its firm size, turnover, labor productivity, innovativeness, industry type and regions. The estimate of σ_u can be interpreted as an ordinary logit coefficient. For example, σ_u in Model 5 indicates that the odds of developing new processes in a given year for a firm that has unobserved propensity one standard deviation above the mean are about twenty-four times (exp(3.284)=26.68) the corresponding odds for a firm with average unobserved propensity and the same observed characteristics.

The estimated coefficients from the logit regression models do not provide any straightforward interpretations *per se* except to represent potential change in the probability of observing the dependent variable. This means that the estimated coefficients can only indicate whether they are positively or

negatively associated with the probability that process innovation will be developed due to a unit change in a particular explanatory variable. A clearer approach is to compute the marginal effects or average marginal probabilities. Marginal effects measure the change in probability of developing new processes with respect to a change in each explanatory variable. Our dependent variable is binary, but probability derivatives for binary variables do not exist. Hence, we calculated the marginal effect for process innovation by taking the difference between the *Pr (Y|X=1)* and *Pr(Y|X=0)*, while all other variables are held constant at the weighted sample means. The estimated marginal probabilities and their corresponding *p-value* are presented in Table 4. The interaction terms in Models 3-5 are computed based on the methods introduced by Ai and Norton (2003).

In Tables 3 and 4, Model 1 is the model that includes the key independent variables and the control variables, which is used to test Hypotheses 1-3. Our results show that key predictors and all control variables have a significant joint impact on process innovation at the 0.001 level (χ^2 =267.68, p<0.001). Hypothesis 1 (H1) predicts that cooperation with external parties has a positive impact on process innovation development. In Model 1, cooperation with external parties shows a positive sign and significance at the 0.01 level. The results indicate that firms cooperating with external parties are more likely to develop new processes. Hence, H1 is supported. The marginal coefficient of the perceived importance of using information acquired from external sources is positive and significant at the 0.01 level. The results support Hypothesis 2 (H2), indicating that as the perceived importance of external information increases by one unit, firms are more likely to develop new processes. Hypothesis 3 (H3), which predicts that the acquisition of external R&D has a positive impact on process innovation, shows external R&D to be positively signed and significant at the 0.01 level. The results indicate that as firms acquire R&D from external resources, they are more likely to develop new processes. Hence, H3 is supported.

Model 3 is used to test Hypothesis 4 (H4), which predicts that the motivation to be legitimate moderates the relationship between the cooperation of external parties and process innovation. In Model 3, the

interaction term of the motivation to be legitimate and external cooperation, is positive and significant at the 0.05 level. The results indicate that as motivation is enhanced, the positive impact of external cooperation on process innovation will be strengthened, thereby supporting H4. Model 4 tests Hypothesis 5 (H5), predicting that the motivation to be legitimate moderates the relationship between the external information usage and process innovation. In Model 4, the interaction term of the motivation to be legitimate and external information usage is negative and significant at the 0.05 level. The results indicate that as motivation is enhanced, the positive impact of external information usage on process innovation will be weakened. Hence, the results are contrary to our expectations and, therefore, H5 is refuted. The results from Model 5 are used to test Hypothesis 6 (H6), which predicts that the motivation to be legitimate moderates the relationship between the acquisition of external R&D and process innovation. In Model 5, the interaction term of the motivation to be legitimate and external R&D is not significant. The results indicate that the positive impact of external R&D on process innovation will not be strengthened or weakened by enhanced legitimate motivation. Hence, H6 is not supported. Moreover, the marginal probability coefficients of all independent variables are almost the same across different models in terms of magnitude, sign and significance level, indicating that our results are robust in different model settings.

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Additional analysis

Although the focus of this study is on process innovation, we decided to also test the impact on firm performance considering lagged effects. We conducted an additional analysis to assess the influence of process innovation at period *t-1* on firm performance at period *t*. Firm performance was measured by logarithms of a firm's annual total turnover. We adopt both structure equation modeling (SEM) methods and a random effects model to assess the effect of process innovation on firm performance. The results of

both estimates show that the coefficient of process innovation is positive and has a significant impact (at the 0.01 level) on the firm's performance. Thus, the results suggest that firms that introduce more new processes are likely to achieve higher levels of performance (see Table 5).

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Discussion and Implications

We explored the relationship between engaging with open innovation and an organization's ability to introduce new processes. In addition, we explained and empirically validated, using a time-lagged effect, the moderating role of the motivation to achieve legitimacy.

Higher levels of cooperation with external parties (H1), increased use of external information (H2), and acquisition of R&D (H3) will all increase the ability of an organization to introduce new processes. Open innovation requires sharing of potentially-valuable information and tacit knowledge which then needs to be integrated into existing activities (Siguaw et al., 2006). Engaging with open innovation, at least within the scope of these three dimensions, will generate higher levels of intra-organizational learning (Kessler and Bierly, 2000). As our results indicate, such learning will not only enable two organizations to work with each other, but will eventually diffuse to the generation of new processes.

The motivation to achieve legitimacy positively moderates the relationship between cooperation with external parties and the ability of an organization to introduce more new processes (H4). Perhaps more surprisingly, and contrary to our hypothesized relationship (H5), the motivation to achieve legitimacy negatively moderated the relationship between the use of external information and process innovation. Increased levels of motivation will weaken the relationship between the use of external information and

process innovation. Further, our hypothesized moderation between the acquisition of external R&D and process innovation (H6) did not reach statistical significance.

Firstly, the positive moderation explains the effect of the motivation to achieve legitimacy on an organization's ability to innovate. Previous work has argued that early adopters of popular improvement initiatives (e.g. TQM) customize their processes in ways that lead to efficiency gains, while later adopters do so to gain legitimacy (Westphal et al., 1997). This view has been backed by studies on the processes and motivations to adopt ISO standards which have argued that these are driven by a ceremonial approach to implementation (Boiral, 2007) and do not necessarily lead to performance improvements (Martínez-Costa et al., 2009). Although our aim was not to focus on performance directly, we did find that when the motivation to innovate is linked with such practices (regulations and standards) the organization makes better use of its cooperation efforts. Such a motivation, therefore, helps the organization make more efficient use of its relational assets, at least in terms of the likelihood of introducing a new process.

Secondly, contrary to our hypothesis (H5), the motivation to achieve legitimacy negatively moderated the relationship between the use of external information and process innovation. Increased levels of motivation will weaken the positive relationship between external information and process innovation. An important methodological observation relevant to this result is that acquiring seemingly passive information (e.g. through fairs and industrial publications) does not have the same effect as that of cooperation with external parties. This suggests that the two dimensions are independent.

Our main argument in support of a positive moderation was that the motivation to achieve legitimacy will encourage a proactive comparison of the ideas generated from the use of external information and that this will reduce the perceived risk of implementation. One explanation for the negative moderation relates to the power balance between customers and suppliers. Power is one of the mechanisms that supports institutionalization, and depends on different dimensions that may have different effects on how legitimacy is achieved and sustained (Lawrence et al., 2001). Powerful actors within a supply network

can force an organization to implement different practices (Ireland and Webb, 2007). As the motivation to achieve legitimacy increases, a powerful external actor can enforce a certain way of operating (Emerson, 1962). For instance, suppliers who aimed at doing business with one of the big three US automotive manufacturers had to adhere to additional requirements (originally referred to as QS9000). In such contexts, legitimacy was judged by a more powerful customer, rather than society or a network. When this is the case, information acquired from external sources would still lead to process innovation. Yet, its effectiveness would be reduced because only the improvements guided by the external actor would lead to new processes. Our measures, which focused on internal motivation to achieve legitimacy, do not allow us to test this proposition, but could be explored in a future study.

A second related explanation for the negative moderation is the way the information is used when the motivation to innovate is to achieve legitimacy. As we argued in the development of the fifth hypothesis, one way of using external information is to develop and introduce new processes which are perceived to be legitimate. However, inertial forces and risk aversion could limit an organization's ability and willingness to change (Hannan and Freeman, 1984) making it difficult to implement new processes. Furthermore, internal processes may be perceived to be superior to those recommended by external information-givers. When this is the case, external information could be used to explain how existing processes are legitimate to reinforce present norms and resist the introduction of new processes. For instance, as argued by Bansal and Hunter (2003), when an organization has systems in place which are already perceived as legitimate, it is more likely to implement ISO14001 early, because certification will simply reinforce a strategy that is already implemented. As was explained by a health and safety manager of a copper pipe manufacturing company:

"Often the processes we have in place are ahead of the legislation mainly due to our internal risk assessments. When a new legislation or guideline is published, we first try to see whether our processes are already compliant and in many cases they are. So, compliance then makes us focus more on developing the right documentation and less on the introduction of new processes."

From our results it becomes apparent that this explanation is more likely to be the case. Therefore, the effect of the use of external information is different to that of the cooperation with external parties. Whereas cooperation requires the sharing of processes associated with innovation (Petersen et al., 2005; West and Bogers, 2014), using external information is relatively simpler, and would not necessarily prompt the initiation of significant changes. It can, for instance, be used to help develop supporting documentation which explains how existing processes are legitimate, thus avoiding the potentially expensive and risky introduction of new ones. This explanation is in line with that of Boiral (2007), who argued that the preparation of audits of the implementation of the ISO14001 standard often led to a superficial demonstration of conformity. It also extends it by exploring the moderating role of the motivation to achieve legitimacy. Taken together, the motivation to achieve legitimacy is a factor that expands beyond the management of internal operations as it influences how external information and cooperation with external parties leads to the introduction of new processes.

Finally, our results indicate that the motivation to achieve legitimacy does not influence the relationship between the acquisition of external R&D and an organization's likelihood of introducing a new process. Although the acquisition of external R&D, as expected, has a positive impact on process innovation, this seems to happen irrespective of the motivation to achieve legitimacy. In the development of H3 we explained that the acquisition and successful implementation of externally-developed R&D, and its subsequent contribution to process innovation, requires the development of relational capabilities. These capabilities are the result of investment in exchange relationships (Hannan and Freeman, 1984) and are embedded into the organizational routines. These may encourage an efficient way of operating which is associated more with exploitation and less with exploration (Benner and Tushman, 2003) supporting small incremental innovations. Therefore, as expressed by Hannan and Freeman (1977), they generate organizational inertia. As a result, a potential explanation for the lack of moderation is that the routines generated when external R&D is acquired are too resistant to be affected by the motivation to achieve

legitimacy. While we provide a possible explanation for this non-significant result, this is an issue that should be explored further in future studies.

Theoretical Implications

We aimed to address two research questions: a) How does engaging with open innovation support an organization's process innovation? and b) How does the motivation to achieve legitimacy affect the relationship between engaging with open innovation and process innovation?.

To answer our first research question we explored the implications of our findings for the innovation literature. Our results clearly indicate that cooperation with external parties, use of external information, and the acquisition of external R&D improve an organization's ability to introduce a new process. By conducting this investigation, we responded to calls for more research on the link between open and process innovation (Robertson et al., 2012). At a broad level our results are consistent with those of the RBV and product innovation literature. Organizations that focus on developing relational capabilities (e.g. via cooperating with suppliers and customers) improve their ability to introduce new processes. Yet, our work extends this thinking by explaining how the use of information and acquisition of R&D contribute to an environment of learning which benefits an intermediary outcome (Piening and Salge, 2015) such as the development of a process.

To answer our second question we explored the moderating effect of the motivation to achieve legitimacy by combining arguments from the RBV and institutional theory. By doing so we responded to calls for integrating institutional theory as a contextual variable in the innovation literature (Jean et al., 2014) and for more quantitative studies to explore the responses to legitimation issues (Boiral, 2007; Ketokivi and Schroeder, 2004; Lo et al., 2014). The implications of our contribution here are more complex. When efforts to cooperate with external parties are combined with the motivation to achieve legitimacy, the

impact on process innovation is positive. We therefore support the view that the motivation to be legitimate, can coexist with efforts to achieve technical gains (Kennedy and Fiss, 2009) and extend it by explaining how it can lead to the introduction of a new process. Yet the effect will be opposite when the focus is on the use of external information. This, potentially counter-intuitive, result indicates how information which is seemingly uninvolved will be used to, most probably, justify the existing state of affairs rather than inspire change. Thus, our study suggests that integrating institutional theory in the innovation literature is warranted as institutional factors are deeply involved in the development of new processes by explaining how the motivation to achieve legitimacy will affect different dimensions of open innovation.

Practical Implications

Our first recommendation relates to the direct relationship between engaging with open innovation and an organization's ability to introduce a new process. In line with the open innovation paradigm (Chesbrough, 2003a), our results support the notion that greater levels of the use of cooperation with external parties, use of information, and acquisition of R&D will improve the development of new processes. So, in line with the growing open innovation literature, our advice to managers who are aiming to improve existing processes and introduce new ones would be to look externally and to cooperate with customers and suppliers.

Our second set of recommendations relates to the effect that the motivation to achieve legitimacy can have on the ability to introduce a new process. The impact of cooperation with external parties, such as customers and suppliers, on the ability to introduce new processes is strengthened when combined with the motivation to achieve legitimacy. Yet the effect is different when the external information is being used relatively passively. Our advice to managers looking at open innovation as a means of boosting their ability to introduce new processes would be to focus more on developing partnerships with external parties that allow effective cooperation rather than simply to acquire information. Given the continuous

motivation to adhere to regulations and implement standards of good practice, close cooperation rather than acquisition of information, and even R&D, is likely to boost learning and support a competitive advantage.

Limitations and Directions for Further Research

There are some limitations within the context of which our results and contributions would need to be interpreted. The first relates to our measure of legitimation. Our arguments focused mainly on legislation and standards. Although they do cover the definition we provided in this article and are in line with the legitimation literature, we cannot argue that the article captures all aspects of legitimacy. For instance, professional association membership and winning awards have also been used to capture the degree to which an organization and its practices are seen as legitimate by external stakeholders. The second relates to the nature of the dataset. As this data has been collected from UK businesses, caution should be exercised in generalizing the findings to other countries. In the development of our empirical model we did control for geographical location within the UK. However, future studies could test whether our results hold in other geographical settings as well. The third relates to the time lag effect. The survey is conducted every two years and, as a result, we are only able to test the effect of the independent and moderating variables on process innovation over this period. Although this is a significant departure from many studies that do not use such effects, a wider range would have been more desirable. However, given that not all firms answer the questionnaire in every period, a wider period would have resulted in a significant drop in sample size, limiting our ability to draw more generalizable conclusions.

We should note here that these three dimensions are not exhaustive of all open innovation initiatives while some aspects of these may overlap. For instance, an organization that works with suppliers and customers will also exchange information and most probably will come to some agreement about the acquisition of R&D. Although we make a distinction between what has been developed cooperatively

and what has been obtained and subsequently integrated from an external source, there is scope for some of these dimensions to be capturing similar concepts. However, our argument is that an organization that reports that it engages with aspects of the three dimensions, whether by desire or by inertia, will also be engaging with open innovation.

We need to note here, that although much of the open innovation literature has assumed its effects to be beneficial to the organization, it may also run some risks. An apparent one is the risk to intellectual property (Berthon et al., 2015). Exchanges of information and R&D are more effective when they are based on trust (Johnston et al., 2004), but are also at risk of breaching contractual relationships with other parties (Belderbos et al., 2014). Furthermore, acquiring knowledge consistently from one external source may run the risk of lack of longer term innovation capabilities as individuals may be locked in the relationship and stop thinking creatively (Petersen et al., 2005). So, although we take a positive view on the application of open innovation, special care should also be taken in avoiding any of the potentially-negative implications.

Our findings also provide avenues for future research. Our theoretical development and measures focused on process innovation as a relatively general notion not necessarily linked to performance improvements. Although not within the scope of our article, process innovation and organizational change more generally are driven by the wider need to improve efficiencies and performance more generally. As a result, we provided some additional analysis where we tested the impact of process innovation on the firm performance. While the results suggest that process innovation has a positive influence on performance, future studies are encouraged to explore this link further. We would recommend the exploration of the role of external collaborators (e.g. customers or suppliers) (Un and Asakawa, 2015), and the impact of the supply chain integration context (Tsinopoulos and Mena, 2015) on the theoretical framework and performance.

An additional avenue for future research stems from the result of Hypotheses 5 and 6. Given the reverse direction of the former and the lack of support for the latter, future research could explore some of the reasons that might have affected the results. We recommend that such studies explore first how different types of process innovation (e.g. radical versus incremental) (Benner and Tushman, 2003), and then how different types of motivation (e.g. internal versus external) (Mart ńez-Costa et al., 2008) affect the results. This would help support some of the findings we propose in the discussion of the article. For instance, if the acquisition of external R&D is associated more with exploitation, then one would expect that the motivation to achieve legitimacy would moderate the relationship between R&D acquisition and the likelihood of introducing radical new processes. Similarly, if there are differences between internal and external motivations to achieve legitimacy then the explanation of how engaging with open innovation can be combined with efforts to be seen as legitimate will vary. Such a study would require a more finely grained data set to ours, but would help further advance our understanding of the factors that support the development of new processes.

A final motivation for future research relates to the potentially-negative effect of open innovation. Although many studies have emphasized the mainly positive contribution of open innovation, there are several reasons to believe that there may be negative implications as well. For instance, recent research on supply chain integration has argued that there may be a 'dark side' to supply chain integration, whereby after a while, the benefits accrued from working with customers and suppliers diminish (Villena et al., 2011). Future studies could therefore, explore a potentially-inverted U shaped relationship, where, after a certain time, the effect of open innovation on the likelihood of an organization to introduce a new process turns negative.

References

Ai, C., Norton, E.C., 2003. Interaction Terms in Logit and Probit Models. Economic Letters 80

Al-Zu'bi, Z.b.M.F., Tsinopoulos, C., 2012. Suppliers versus Lead Users: Examining Their Relative Impact on Product Variety. Journal of Product Innovation Management 29, 667-680

Allred, B.B., Swan, K.S., 2014. Process Technology Sourcing and the Innovation Context. Journal of Product Innovation Management 31, 1146-1166

Anderson, S.W., Daly, J.D., Johnson, M.F., 1999. Why firms seek ISO 9000 certification: regulatory compliance or cometitive advantage. Production and Operations Management 8, 28-43

Arellano, M., 2003. Panel data econometrics. Oxford University Press, London

Auh, S., Menguc, B., 2009. Broadening the scope of the resource-based view in marketing: The contingency role of institutional factors. Industrial Marketing Management 38, 757-768

Bansal, P., Hunter, T., 2003. Strategic Explanations for the Early Adoption of ISO 14001. Journal of Business Ethics 46, 289-299

Barney, J., 1991. Firm Resources and Sustained Competitive Advantage. Journal of Management 17, 99-120

Barthélemy, J., Quélin, B.V., 2006. Complexity of Outsourcing Contracts and Ex Post Transaction Costs: An Empirical Investigation. Journal of Management Studies 43, 1775-1797

Baum, J.A.C., Oliver, C., 1991. Institutional linkages and organizational mortality. Administrative Science Quarterly 36, 187-218

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

Bello, D.C., Gilliland, D.I., 1997. The Effect of Output Controls, Process Controls, and Flexibility on Export Channel Performance. Journal of Marketing 61, 22-38

Benner, M.J., Tushman, M.L., 2003. Exploitation, Exploration, And Process Management: The Productivity Dilemma Revisited. Academy of Management Review 28, 238-256

Berrone, P., Fosfuri, A., Gelabert, L., Gomez-Mejia, L.R., 2013. Necessity as the mother of 'green' inventions: Institutional pressures and environmental innovations. Strategic Management Journal 34, 891-909

Berthon, P., Pitt, L., Kietzmann, J., McCarthy, I.P., 2015. CGIP: Managing consumer-generated intellectual property. California Management Review 57, 43-62

Boiral, O., 2007. Corporate Greening Through ISO 14001: A Rational Myth? Organization Science 18, 127-146

Boulding, W., 1990. Commentary on "Unobservable Effects and Business Performance: Do Fixed Effects Matter?". Marketing Science 9, 88-91

Boulding, W., Christen, M., 2003. Sustainable pioneering advantage? Profit implications of market entry order. Marketing Science 22, 371-392

Brouthers, K.D., Brouthers, L.E., Werner, S., 2008. Resource-Based Advantages in an International Context. Journal of Management 34, 189-217

Buss, P., Peukert, C., 2015. R&D outsourcing and intellectual property infringement. Research Policy 44, 977-989

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

Chesbrough, H.W., 2003a. The Era of Open Innovation. MIT Sloan Management Review 44, 35-41

Chesbrough, H.W., 2003b. Open Innovation: The New Imperative for Creating and Profiting from Technology. Harvard Business School Press

Chudnovsky, D., López, A., Pupato, G., 2006. Innovation and productivity in developing countries: A study of Argentine manufacturing firms' behavior (1992–2001). Research Policy 35, 266-288

Coates, T.T., McDermott, C.M., 2002. An exploratory analysis of new competencies: a resource based view perspective. Journal of Operations Management 20, 435-450

Cohen, W.M., Levinthal, D.A., 1990. Absorptive Capacity: A New Perspective on Learning and Innovation. Administrative Science Quarterly 35, 128-152

Dahlander, L., Piezunka, H., 2014. Open to suggestions: How organizations elicit suggestions through proactive and reactive attention. Research Policy 43, 812-827

Desarbo, W.S., Benedetto, C.A.D., Song, M., Sinha, I., 2005. Revisiting the miles and snow strategic framework: uncovering interrelationships between strategic types, capabilities, environmental uncertainty, and firm performance. Strategic Management Journal 26, 47-74

DiMaggio, P.J., Powell, W., 1983. The iron cage revisited: institutional isomorphism and collective rationality in organizational fields. American Sociological Review 48, 147-160

Dodgson, M., Gann, D., Salter, A., 2006. The role of technology in the shift towards open innovation: the case of Procter & Gamble. R&D Management 36, 333-346

Droge, C., Stanko, M.A., Pollitte, W.A., 2010. Lead Users and Early Adopters on the Web: The Role of New Technology Product Blogs*. Journal of Product Innovation Management 27, 66-82

Du, J., Leten, B., Vanhaverbeke, W., 2014. Managing open innovation projects with science-based and market-based partners. Research Policy 43, 828-840

Dyer, J.H., Singh, H., 1998. The relational view: Cooperative strategy and sources of interorganizational competitive advantage. Academy of Management Review 23, 660-679

Ebers, M., Maurer, I., 2014. Connections count: How relational embeddedness and relational empowerment foster absorptive capacity. Research Policy 43, 318-332

Economist, T., 2012. The third industrial revolution, The Economist, London

Emerson, R.M., 1962. Power-Dependence Relations. American Sociological Review 27, 31-41

Escribano, A., Fosfuri, A., Tribó, J.A., 2009. Managing external knowledge flows: The moderating role of absorptive capacity. Research Policy 38, 96-105

Freel, M.S., 2003. Sectoral patterns of small firm innovation, networking and proximity. Research Policy 32, 751-770

Gönül, F., Srinivasan, K., 1993. Modeling multiple sources of heterogeneity in multinomial logit models: Methodological and managerial issues. Marketing Science 12, 213-229

Greene, W.H., 2012. Econometric Analysis, 7th Edition ed. Pearson, London

Grewal, R., Dharwadkar, R., 2002. The Role of the Institutional Environment in Marketing Channels. Journal of Marketing 66, 82-97

Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E., 2014. Multivariate Data Analysis, 7th ed. Pearson Education, Edinburgh

Hannan, M.T., Freeman, J., 1977. The Population Ecology of Organizations. The American Journal of Sociology 82, 929-964

Hannan, M.T., Freeman, J., 1984. Structural Inertia and Organizational Change. American Sociological Review 49, 149-164

Hausman, J.A., 1978. Specification tests in econometrics. Econometrica 46, 1251-1271

Huston, L., Sakkab, N., 2006. Connect and Develop: Inside Procter & Gamble's New Model for Innovation. Harvard Business Review 84, 58-66

Ireland, R.D., Webb, J.W., 2007. A multi-theoretic perspective on trust and power in strategic supply chains. Journal of Operations Management 25, 482-497

ISO-Staff, 2015. Who will set the standards for the 3D printing industry? FESPA

Jean, R.-J.B., Sinkovics, R.R., Hiebaum, T.P., 2014. The Effects of Supplier Involvement and Knowledge Protection on Product Innovation in Customer–Supplier Relationships: A Study of Global Automotive Suppliers in China. Journal of Product Innovation Management 31, 98-113

Jiang, X., Li, Y., 2009. An empirical investigation of knowledge management and innovative performance: The case of alliances. Research Policy 38, 358-368

Johnston, D.A., McCutcheon, D.M., Stuart, F.I., Kerwood, H., 2004. Effects of supplier trust on performance of cooperative supplier relationships. Journal of Operations Management 22, 23-38

Katz, M.L., Shapiro, C., 1987. R&D Rivalry with Licensing or Imitation. American Economic Review 77, 402

Kennedy, M.T., Fiss, P.C., 2009. Institutionalization, framing, and diffusion: the logic of tqm adoption and implementation decisions among U.S. hospitals. Academy of Management Journal 52, 897-918

Kessler, E.H., Bierly, P.E., 2000. Internal vs. external learning in new product development: effects on speed, costs and competitive advantage. R&D Management 30, 213-223

Ketokivi, M.A., Schroeder, R.G., 2004. Strategic, structural contingency and institutional explanations in the adoption of innovative manufacturing practices. Journal of Operations Management 22, 63-89

Khazanchi, S., Lewis, M.W., Boyer, K.K., 2007. Innovation-supportive culture: The impact of organizational values on process innovation. Journal of Operations Management 25, 871-884

Kostova, T., Zaheer, S., 1999. Organizational legitimacy under conditions of complexity: The case of the multinational enterprise. Academy of Management Review 24, 64-81

Kotler, P., Keller, K., Brady, M., Goodman, M., Hansen, T., 2009. Marketing Management. Prentice Hall, London

Koufteros, X., Vonderembse, M., Jayaram, J., 2005. Internal and External Integration for Product Development: The Contingency Effects of Uncertainty, Equivocality, and Platform Strategy. Decision Sciences 36, 97-133

Koufteros, X.A., Cheng, T.C.E., Lai, K.H., 2007. "Black-box" and "gray-box" supplier integration in product development: Antecedents, consequences and the moderating role of firm size. Journal of Operations Management 25, 847-870

Lane, P.J., Koka, B.R., Pathak, S., 2006. The reification of absorptive capacity: a critical review and rejuvenation of the construct. Academy of Management Review 31, 833-863

Laursen, K., Leone, M.I., Torrisi, S., 2010. Technological exploration through licensing: new insights from the licensee's point of view. Industrial & Corporate Change 19, 871-897

Laursen, K., Salter, A.J., 2014. The paradox of openness: Appropriability, external search and collaboration. Research Policy 43, 867-878

Lawrence, T.B., Winn, M.I., Jennings, P.D., 2001. The temporal dynamics of institutionalization. Academy of Management Review 26, 624-644

Lee, S., Park, G., Yoon, B., Park, J., 2010. Open innovation in SMEs-An intermediated network model. Research Policy 39, 290-300

Leiponen, A., Byma, J., 2009. If you cannot block, you better run: Small firms, cooperative innovation, and appropriation strategies. Research Policy 38, 1478-1488

Lenox, M., King, A., 2004. Prospects for developing absorptive capacity through internal information provision. Strategic Management Journal 25, 331-345

Lewis, M.W., Boyer, K.K., 2002. Factors impacting AMT implementation: an integrative and controlled study. Journal of Engineering and Technology Management 19, 111-130

Lo, C.K.Y., Pagell, M., Fan, D., Wiengarten, F., Yeung, A.C.L., 2014. OHSAS 18001 certification and operating performance: The role of complexity and coupling. Journal of Operations Management 32, 268-280

Luo, X., Griffith, D.A., Liu, S.S., Yi-Zheng, S., 2004. The Effects of Customer Relationships and Social Capital on Firm Performance: A Chinese Business Illustration. Journal of International Marketing 12, 25-45

Lynn, G.S., Morone, J.G., Paulson, A.S., 1996. Marketing and Discontinuous Innovation: The probe and learn process. California Management Review 38, 8-37

Mart ńez-Costa, M., Choi, T.Y., Mart ńez, J.A., Mart ńez-Lorente, A.R., 2009. ISO 9000/1994, ISO 9001/2000 and TQM: The performance debate revisited. Journal of Operations Management 27, 495-511

Mart ńez-Costa, M., Mart ńez-Lorente, A.R., Choi, T.Y., 2008. Simultaneous consideration of TQM and ISO 9000 on performance and motivation: An empirical study of Spanish companies. International Journal of Production Economics 113, 23-39

Matias, J.C.D.O., Coelho, D.A., 2002. The integration of the standards systems of quality management, environmental management and occupational health and safety management. International Journal of Production Research 40, 3857-3866

McFarland, R.G., Bloodgood, J.M., Payan, J.M., 2008. Supply Chain Contagion. Journal of Marketing 72, 63-79

Menguc, B., Auh, S., Ozanne, L., 2010. The Interactive Effect of Internal and External Factors on a Proactive Environmental Strategy and its Influence on a Firm's Performance. Journal of Business Ethics 94, 279-298

Mishra, A.A., Shah, R., 2009. In union lies strength: Collaborative competence in new product development and its performance effects. Journal of Operations Management 27, 324-338

Oliver, C., 1991. Strategic responses to institutional processes. Academy of Management Review 16, 145-179

Oliver, C., 1997. Sustainable competitive advantage: Combining institutional and resource-based views. Strategic Management Journal 18, 697-713

Peng, M.W., 2003. Institutional transitions and strategic choices. Academy of Management Review 28, 275-296

Petersen, K.J., Handfield, R.B., Ragatz, G.L., 2003. A Model of Supplier Integration into New Product Development. Journal of Product Innovation Management 20, 284-299

Petersen, K.J., Handfield, R.B., Ragatz, G.L., 2005. Supplier integration into new product development: coordinating product, process and supply chain design. Journal of Operations Management 23, 371-388

Piening, E.P., Salge, T.O., 2015. Understanding the Antecedents, Contingencies, and Performance Implications of Process Innovation: A Dynamic Capabilities Perspective. Journal of Product Innovation Management 32, 80-97

Potter, A., Lawson, B., 2013. Help or Hindrance? Causal Ambiguity and Supplier Involvement in New Product Development Teams. Journal of Product Innovation Management 30, 794-808

Priem, R.L., Butler, J.E., 2001. Is the resource-based "view" a useful perspective for strategic management research? Academy of Management Review 26, 22-40

Robertson, P.L., Casali, G.L., Jacobson, D., 2012. Managing open incremental process innovation: Absorptive Capacity and distributed learning. Research Policy 41, 822-832

Robson, S., Achur, J., 2013. First findings from the UK innovation survey 2011 (revised). Department for Businesss Innovation & Skills, London

Rohrbeck, R., 2010. Harnessing a network of experts for competitive advantage: technology scouting in the ICT industry. R&D Management 40, 169-180

Roper, S., Du, J., Love, J., 2008. Modelling the innovation value chain. Research Policy 37 961-977

Rosenzweig, E.D., Roth, A.V., Dean, J.W., 2003. The influence of an integration strategy on competitive capabilities and business performance: An exploratory study of consumer products manufacturers. Journal of Operations Management 21, 437-456

Schmiedeberg, C., 2008. Complementarities of innovation activities: An empirical analysis of the German manufacturing sector. Research Policy 37, 1492-1503

Schramm, M.E., Hu, M.Y., 2013. Perspective: The Evolution of R&D Conduct in the Pharmaceutical Industry. Journal of Product Innovation Management 30, 203-213

Schreier, M., Prügl, R., 2008. Extending Lead-User Theory: Antecedents and Consequences of Consumers' Lead Userness. Journal of Product Innovation Management 25, 331-346

Schroeder, R.G., Linderman, K., Liedtke, C., Choo, A.S., 2008. Six Sigma: Definition and underlying theory. Journal of Operations Management 26, 536-554

Sherer, P.D., Lee, K., 2002. Institutional change in large law firms: a resource dependency and institutional perspective. Academy of Management Journal 45, 102-119

Siguaw, J.A., Simpson, P.M., Enz, C.A., 2006. Conceptualizing Innovation Orientation: A Framework for Study and Integration of Innovation Research. Journal of Product Innovation Management 23, 556-574

Slater, S.F., Narver, J.C., 1995. Market Orientation and the Learning Organization. Journal of Marketing 59, 63-74

Srivastava, M.K., Gnyawali, D.R., 2011. When do relational resources matter? Leveraging portfolio technological resources for breakthrough innovation. Academy of Management Journal 54, 797-810

Stadler, C., 2011. Process Innovation and Integration in Process-Oriented Settings: The Case of the Oil Industry. Journal of Product Innovation Management, 44-62

Stock, R.M., 2014. How Should Customers Be Integrated for Effective Interorganizational NPD Teams? An Input–Process–Output Perspective. Journal of Product Innovation Management 31, 535-551

Su, Z., Xie, E., Li, Y., 2009. Organizational slack and firm performance during institutional transitions. Asia Pacific Journal of Management 26, 75-91

Suchman, M.C., 1995. Managing legitimacy: Strategic and institutional approaches. Academy of Management Review 20, 571-610

Szulanski, G., 1996. Exploring internal stickiness: Impediments to the transfer of best practice within the firm. Strategic Management Journal 17, 27-43

Teece, D.J., Pisano, G., Shuen, A., 1997. Dynamic capabilities and strategic management. Strategic Management Journal 18, 509-533

Troy, L., C., Szymanski, D., M., Varadarajan, P.R., 2001. Generating new product ideas: An initial investigation of the role of market information and organizational characteristics. Journal of the Academy of Marketing Science 29, 89-101

Tsang, E.W.K., 2002. Acquiring knowledge by foreign partners from international joint ventures in a transition economy: learning-by-doing and learning myopia. Strategic Management Journal 23, 835-854

Tsinopoulos, C., Mena, C., 2015. Supply chain integration configurations: process structure and product newness. International Journal of Operations & Production Management 35, 1437-1459

Un, C.A., Asakawa, K., 2015. Types of R&D Collaborations and Process Innovation: The Benefit of Collaborating Upstream in the Knowledge Chain. Journal of Product Innovation Management 32, 138-153

Un, C.A., Cuervo-Cazurra, A., Asakawa, K., 2010. R&D Collaborations and Product Innovation. Journal of Product Innovation Management 27, 673-689

van der Duin, P.A., Ortt, J.R., Aarts, W.T.M., 2014. Contextual Innovation Management Using a Stage-Gate Platform: The Case of Philips Shaving and Beauty. Journal of Product Innovation Management 31, 489-500

Veugelers, R., Cassiman, B., 1999. Make and buy in innovation strategies: evidence from Belgian manufacturing firms. Research Policy 28, 63-80

Villena, V.H., Revilla, E., Choi, T.Y., 2011. The dark side of buyer-supplier relationships: A social capital perspective. Journal of Operations Management 29, 561-576

Wales, W.J., Parida, V., Patel, P.C., 2013. Too much of a good thing? Absorptive capacity, firm performance, and the moderating role of entrepreneurial orientation. Strategic Management Journal 34, 622-633

Wang, T., Libaers, D., 2016. Nonmimetic Knowledge and Innovation Performance: Empirical Evidence from Developing Countries. Journal of Product Innovation Management, n/a-n/a

Weigelt, C., 2009. The impact of outsourcing new technologies on integrative capabilities and performance. Strategic Management Journal 30, 595-616

West, J., Bogers, M., 2014. Leveraging External Sources of Innovation: A Review of Research on Open Innovation. Journal of Product Innovation Management 31, 814-831

Westphal, J.D., Gulati, R., Shortell, S.M., 1997. Customization or Conformity? An Institutional and Network Perspective on the Content and Consequences of TQM Adoption. Administrative Science Quarterly 42, 366-394

Wu, L.-Y., 2007. Entrepreneurial resources, dynamic capabilities and start-up performance of Taiwan's high-tech firms. Journal of Business Research 60, 549-555

Xu, S., 2015. Balancing the Two Knowledge Dimensions in Innovation Efforts: An Empirical Examination among Pharmaceutical Firms. Journal of Product Innovation Management 32, 610-621

Yli-Renko, H., Autio, E., Sapienza, H.J., 2001. Social Capital, Knowledge Acquisition, and Knowledge Exploitation in Young Technology-Based Firms. Strategic Management Journal 22, 587-613

Zahra, S.A., George, G., 2002. Absorptive capacity: a review, reconceptualization, and extension. Academy of Management Review 27, 185–203

Zucker, L.G., 1983. Organizations as Institutions, In: Bacarach, S.B. (Ed), Research in the Sociology of Organizations. JAI Press, Greenwich, CT, pp. 1-42

Table 1 Regression Model Variable Definitions in CIS 4-7 Dataset

$$\textit{Model 1: Process Innovation}_{ijt} = \beta_0 + \beta_{11,t-1}\textit{External Cooperation} + \beta_{12,t-1}\textit{External Information} + \beta_{13,t-1}\textit{External R\&D} + \textit{Control Variables} + \mu_i + \varepsilon_{ij}$$

$$\textit{Model 2: Process Innovation}_{ijt} = \beta_0 + \beta_{21,t-1}\textit{External Cooperation} + \beta_{22,t-1}\textit{External Information} + \beta_{23,t-1}\textit{External R\&D} + \beta_{24,t-1}\textit{Legitimation Motivation} + \textit{Control Variables} + \mu_i + \varepsilon_{ij}$$

$$\textit{Model 3: Process Innovation}_{ijt} = \beta_0 + \beta_{31,t-1}\textit{External Cooperation} + \beta_{32,t-1}\textit{External Information} + \beta_{33,t-1}\textit{External R\&D} + \beta_{34,t-1}\textit{Legitimation Motivation} + \beta_{35,t-1}\textit{External Cooperation} \times \textit{Legitimation Motivation} + \textit{Control Variables} + \mu_i + \varepsilon_{ij}$$

$$\textit{Model 4: Process Innovation}_{ijt} = \beta_0 + \beta_{41,t-1}\textit{External Cooperation} + \beta_{42,t-1}\textit{External Information} + \beta_{43,t-1}\textit{External R\&D} + \beta_{44,t-1}\textit{Legitimation Motivation} + \beta_{45,t-1}\textit{External Cooperation} \times \textit{Legitimation Motivation} + \beta_{46,t-1}\textit{External Information} \times \textit{Legitimation Motivation} + \textit{Control Variables} + \mu_i + \varepsilon_{ij}$$

$$\textit{Model 5: Process Innovation}_{ijt} = \beta_0 + \beta_{51,t-1}\textit{External Cooperation} + \beta_{52,t-1}\textit{External Information} + \beta_{53,t-1}\textit{External R\&D} + \beta_{54,t-1}\textit{Legitimation Motivation} + \beta_{55,t-1}\textit{External Cooperation} \times \textit{Legitimation Motivation} + \beta_{56,t-1}\textit{External Information} \times \textit{Legitimation Motivation} + \beta_{57,t-1}\textit{External R\&D} \times \textit{Legitimation Motivation} + \textit{Control Variables} + \mu_i + \varepsilon_{ij}$$

	Definitions
Process Innovation	Whether the firm introduces any new or significantly improved processes for producing or supplying goods or services (coded 1) or not (coded 0)
External R&D	Whether R&D is undertaken by acquisition from external parties such as other businesses within the establishment's group, or by public or private research organizations (coded 1) or not
External Cooperation	The number of external parties the firm cooperates with on any innovation activities with (coded 1 or not): - suppliers of equipment, materials, services or software; - clients, customers or end users; - competitors or other businesses in the firm's industry; - consultants, commercial labs, or private R&D institutes; - universities or other higher education institutions; - government or public research institutes.
External Information	Importance of using external information from (high, medium, low): - suppliers of equipment, materials, services or software; - clients, customers or end users; - competitors or other businesses in your industry; - consultants, commercial labs, or private R&D institutes; - universities or other higher education institutes; - government or public research institutes; - conferences, trade fairs, exhibitions; - professional and industry associations; - technical, industry or service standards; - scientific journals and trade/technical publications.

Legitimation Motivation (LM)	Importance of meeting regulatory requirements (including standards) in decision to innovate in goods or services and/or processes (high, medium, low)
External Cooperation × LM	Interaction term of external cooperation and legitimation motivation
External Information × LM	Interaction term of external information and legitimation motivation
External R&D × LM	Interaction term of external R&D and legitimation motivation
Control Variables	
Turnover	Natural logarithm of annual turnover
Firm size	Natural logarithm of the number of firm employees
Labor productivity	Company turnover per employee
INNOV1	The percentage of the firm's total annual turnover from goods or services that were new to the market.
INNOV2	The percentage of the firm's total annual turnover from goods or services that were only new to this business.
INNOV3	The percentage of the firm's total annual turnover from goods and services that were significantly improved.
INNOV4	The percentage of the firm's total annual turnover from goods and services that were unchanged or only marginally modified.
Industry	Categorical variable representative of 7 UK industries divided by 2 digit Standardized Industry Code
Region	Categorical variable representative of 12 government office regions in the UK
μ_i	Company-specific random effects
ε_{ij}	Random error term

Table 2 Descriptive Statistics and Correlation

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	VIF
1.Process innovation	0.27	0.44														1.23
2. External cooperation	0.63	1.47	0.21*													1.57
3. External information	1.97	0.70	0.21*	0.35*												1.20
4. External R&D	0.17	0.37	0.24*	0.32*	0.32*											1.30
5. LM	1.40	1.22	0.14*	0.16*	0.47*	0.16*										4.08
6. Turnover	8.71	1.94	0.16*	0.15*	0.20*	0.14*	0.13*									3.89
7. Firm size	4.37	1.57	0.14*	0.13*	0.17*	0.13*	0.12*	0.81*								1.10
8. Labor productivity	0.03	0.19	0.01	-0.01	-0.01	-0.01	-0.01	-0.08*	0.02*							1.02
9. Industry	1.40	1.95	-0.10*	-0.07*	-0.10*	-0.05*	0.01	-0.07*	-0.07*	-0.01*						1.00
10. Region	6.50	3.47	0.00	0.00	-0.01	0.01	0.01	-0.03*	-0.02*	0.01	0.01					2.31
11. INNOV1	4.64	18.46	0.01	-0.01	0.03*	-0.01	0.06*	-0.10*	-0.10*	0.01*	0.01	-0.01				2.18
12. INNOV2	4.73	18.71	0.01	-0.02	0.02	-0.01	0.05*	-0.10*	-0.10*	0.01*	0.01	-0.01	0.98*			2.43
13. INNOV3	4.70	18.53	0.01	-0.01	0.03*	-0.01	0.07*	-0.10*	-0.10*	0.01*	0.01	-0.01	0.99*	0.98*		1.35
14. INNOV4	11.45	25.68	0.02*	0.05*	0.10*	0.01	0.06*	-0.09*	-0.08*	0.01*	0.01	-0.01	0.96*	0.96*	0.96*	1.23

* The correlation is significant at the 0.05 level. N =7645.

Table 3 Regression Summary Statistics

	Model 1	Model 2	Model 3	Model 4	Model 5
Wald Chi Square	267.68	285.118	246.893	255.001	247.41
p-value of Wald Chi test	0.000	0.000	0.000	0.000	0.000
Log likelihood	-3727.7	-3434.1	-3432.8	-3427.2	-3427.0
lnsig2u	1.532	2.385	2.361	2.386	2.378
σ_u	2.151	3.295	3.256	3.296	3.284
ρ	0.585	0.767	0.763	0.768	0.766
AIC	7513.366	6928.012	6927.740	6918.332	6920.084
BIC	7717.41	7136.266	7142.936	7147.470	7149.163

N=7645.

Table 4 Average Marginal Effect of Coefficients[†]

	Model 1		**Model 2**		**Model 3**		**Model 4**		**Model 5**	
	dy/dx		dy/dx		dy/dx		dy/dx		dy/dx	
Turnover	0.041***	(0.007)	0.021***	(0.004)	0.021***	(0.004)	0.021***	(0.004)	0.021***	(0.004)
Firm size	-0.005	(0.008)	-0.001	(0.004)	-0.001	(0.004)	-0.001	(0.004)	-0.001	(0.004)
Labor productivity	0.068**	(0.031)	0.035**	(0.017)	0.036**	(0.018)	0.036**	(0.017)	0.036**	(0.017)
INNOV1	0.004***	(0.000)	0.002***	(0.000)	0.002***	(0.000)	0.002***	(0.000)	0.002***	(0.000)
INNOV2	0.002***	(0.000)	0.001***	(0.000)	0.001***	(0.000)	0.001***	(0.000)	0.001***	(0.000)
INNOV3	0.003***	(0.000)	0.001***	(0.000)	0.001***	(0.000)	0.001***	(0.000)	0.001***	(0.000)
INNOV4	0.002***	(0.000)	0.001***	(0.000)	0.001***	(0.000)	0.001***	(0.000)	0.001***	(0.000)
External cooperation	0.033***	(0.005)	0.018***	(0.003)	0.017***	(0.003)	0.016***	(0.003)	0.016***	(0.003)
External information	0.111***	(0.010)	0.062***	(0.009)	0.064***	(0.009)	0.063***	(0.009)	0.063***	(0.009)
External R&D	0.129***	(0.018)	0.069***	(0.012)	0.071***	(0.012)	0.069***	(0.012)	0.070***	(0.012)
LM			0.001	(0.003)	-0.001	(0.003)	0.001	(0.003)	0.001	(0.003)
LM x External cooperation					0.007**	(0.003)	0.007**	(0.003)	0.007**	(0.003)
LM x External information							-0.019**	(0.003)	-0.019**	(0.003)
LM x External R&D									-0.004	(0.003)

N=7645; *Standard Error* in parentheses: All two-tail tests.
[†]7 UK industries divided according to SIC code have been used in Models 1-5 as control variables.
Regression results of industry dummies and geographical location dummies are omitted in this table and available upon request.
All interaction terms are calculated according to methods introduced by Ai and Norton (2003).
* p<0.1 ** p<0.05 *** p<0.01

Table 5 Estimating Process Innovation and Performance Using SEM and Random Effects Model[†]

	Model 7		**Model 8**	
	SEM		Random Effects Model	
	DV: Turnover		DV: Turnover	
Process Innovation	0.296***	(0.024)	0.125***	(0.032)
	DV: Process Innovation			
Turnover	N/A		N/A	
INNOV1	0.016***	(0.002)	-0.001	(0.001)
INNOV2	0.013***	(0.002)	0.002***	(0.001)
INNOV3	0.012***	(0.002)	-0.001*	(0.001)
INNOV4	0.009***	(0.001)	0.003***	(0.001)
External cooperation	0.154***	(0.021)	0.018*	(0.011)
External information	0.673***	(0.053)	0.251***	(0.028)
External R&D	0.667***	(0.079)	0.509***	(0.065)
LM-Meeting regulatory requirements (including standards)	0.023	(0.028)	0.034**	(0.015)
LM x External cooperation	0.050**	(0.018)	0.014*	(0.009)
LM x External information	-0.129**	(0.041)	-0.059***	(0.020)
LM x External R&D	0.030	(0.066)	-0.020	(0.032)
Wald Chi2	N/A		751.821	
p-value of Wald Chi test	N/A		0.000	
Log likelihood	-76580.607		N/A	
AIC	153225.2		N/A	
BIC	153496.0		N/A	

N=7645; *Standard Error* in parentheses: All two-tail tests.
[†]7 UK industries divided according to SIC code have been used in the regressions as control variables. Regression results of industry dummies and geographical location dummies are omitted in this table and available upon request.
* p<0.1 ** p<0.05 *** p<0.01

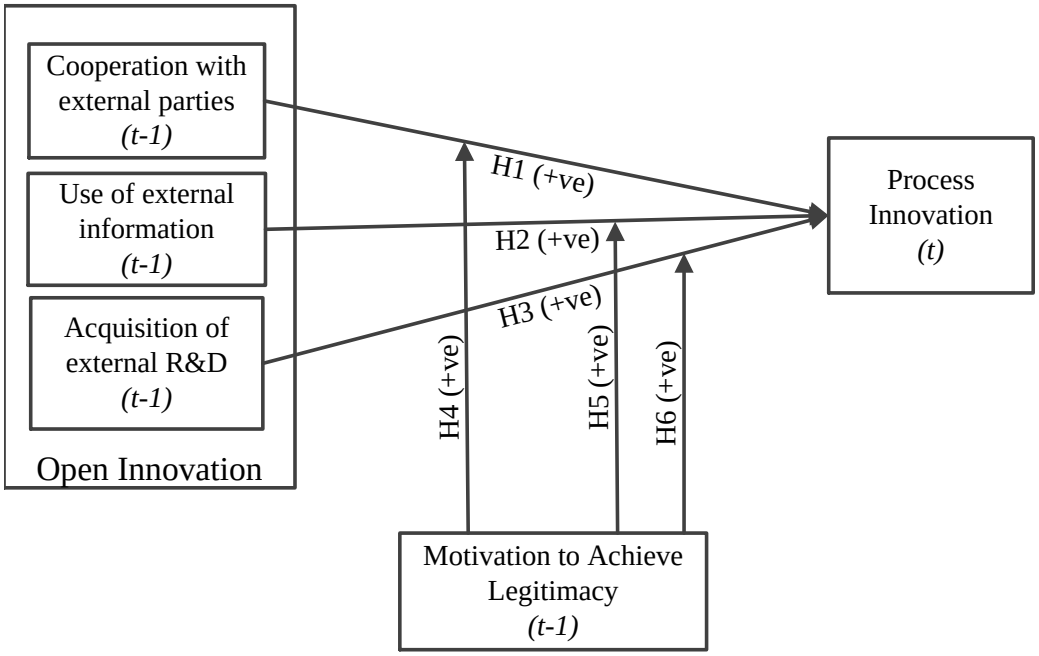

Figure 1 Proposed Theoretical Model