

State of the Art Review



What are the barriers to start-up and scale-up in R&D intensive firms?

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R&D investments enhance knowledge, underpin innovation and facilitate the creation of new firms; this recognised source of economic development has become integral to government policy in many countries. While all firms face difficulties engaging in R&D, new and young firms are most affected, facing internal and external factors that inhibit investment or impede the process. A decision to invest in R&D often stalls due to concerns about appropriation and/or limited access to appropriate finance, but once engaged the barriers are found in the nexus of knowledge, networks and skills that underpin dynamic capabilities and the enhancement of a firm's absorptive capacity. In particular, the emphasis placed in the beginning upon science/technology expertise, at the expense of managerial acumen, undermines a firm's ability to recognise and exploit commercial opportunities. Accepting that knowledge, network and skills are significantly influenced from the imprint established at start-up; it is the opportunity to learn during the reconfiguring process, as the firm seeks to commercialise the opportunity, that underpins scale-up. Although it is possible to identify individual barriers, this fails to recognise how they coalesce to create complex problems that require bespoke solutions.

Background

R&D expenditure is aimed at expanding knowledge to encourage innovation through basic and applied research and is a recognised source of economic development integral to government policy in many countries. A firm's R&D intensity is normally measured by expenditure on such activity in comparison to sales, profits or total assets (Cohen and Levinthal, 1990; Burgelman Christensen and Wheelwright, 2008). Research is the exploration into new themes, often related to science/technology, that create subject specific insight rather than solutions. Development is the process by which potential products or services evolve out of this insight. The latter may become innovations, but this normally requires a skill set that is broader than the research discipline. In essence, R&D investments enhance knowledge and identify opportunities; innovation is the process of creating business out of these opportunities. R&D and innovation are therefore closely linked and often part of a seamless continuum that involves the integration of competences in other disciplines, such as finance, marketing, and HR.

While it is reasonable to suggest that all firms, regardless of size and age, face difficulties in engaging in R&D; young small firms may face even higher barriers (Audretsch, Segarra, Teruel, 2014). Barriers faced by large established firms include path dependence, organisational inertia, established routines and lock in, which result in a reluctance to adapt competencies and previously successful organisational practices (Nelson and Winter, 1982; Ferriani, Garnsey and Probert, 2008). However, the barriers faced by new and young firms are primarily related to limited resources and market structure. The former includes finance (Schoonhoven, Eisenhardt, Lyman, 1990) knowledge, skills (Katila and Shane, 2005), and limited networks (Vohora, Wright and Lockett, 2004; Walter, Auer, and Ritter, 2006). The latter, market structure, can impose constraints as a result of less competitive markets; where high concentration ratios exist, larger firms are in a better position to capitalise on the capabilities for coordinating complementary assets which new firms often do not possess (Schoonhoven et al., 1990; Dean, Brown and Bamford, 1998).

The Impact of Barriers on Start-up and Scale-up

Previous work has suggested that barriers can be identified as being either 'deterring' or 'revealed' (D'Este, Lammarino, Savona and von Tunzelmann, 2012). The former refers to barriers that firms identify as insurmountable, limiting engagement; the latter to a firm's appreciation of the problems that arise as the result of some engagement. This highlights a 'disclosing' or 'learning' outcome as the result of direct experience and is congruent with a range of studies which report that innovative firms experience higher barriers than non-innovators and that firms with a high R&D and innovation intensity report the highest barriers (Galia and Legros, 2004; Mohnen and Röller, 2005).

R&D barriers can be both internal and external to the firm (D'Este et al.; 2012, Amara, D'Este, Landry, and Doloreux, 2014). Internal barriers relate to the difficulties in implementing internal changes in managerial and/or organizational practices due to insufficient knowledge, skilled personnel and limited management training which negatively impacts upon a firm's absorptive capacity. External barriers arise from problems in resource acquisition, most notably finance and knowledge often due to firms having limited access to appropriate networks. In addition, there are issues of market structure and competition that restrict access, limit appropriation and negatively impact upon start-up and scale-up. While barriers are most often identified on an individual basis there is some evidence to suggest that there are complementarities between barriers and that it is perhaps more logical to look at barriers as groups of impediments (Galia and Legros, 2004).

Finance

Finance is widely recognised as one of the major barriers in starting and growing a business (OECD, 2015; Brown, Martinsson and Peterson, 2017) despite evidence indicating that appropriate access to finance improves the post-entry performance of firms (OECD, 2015). However, in most countries there are few alternatives to debt, inappropriate for R&D intensive firms, and where equity is available, access has been a consistent problem. As a consequence, there is an identified funding gap for R&D investments especially for new and young innovative firms in high-tech sectors (Hall 2002; Canepa and Stoneman 2008; Colombo et al., 2013).

This funding gap is created due to uncertainty and information asymmetries (adverse selection and moral hazard), a feature of R&D projects, and exacerbated at start-up due to issues of legitimacy, credit history and/or collateral (Beck and Demirguc-Kunt, 2006; Czarnitzki, 2006). These issues create a higher risk profile and reduce the likelihood that traditional financial markets will invest in R&D intensive firms (Hall 2002; Canepa and Stoneman 2008); this negatively impacts upon the decision to start-up and hampers young firms striving for growth. The 'funding gap' creates a reliance upon internal funds which many new and young firms simply do not have (Hall, 2008); increasing the difficulty in pursuing R&D projects and affectively creating a 'growth capital gap' (Huergo and Moreno, 2017). As an alternative R&D intensive firms, for example in biotech or information technology, choose to seek out large firm partners that can offer the necessary resources to develop and market their innovations (Stam and Wennberg, 2009).

While business angel networks and boutique venture capital houses are positioned to fill this gap (Hellmann and Puri, 2002); evidence suggests a reluctance to invest because the scale and cost of due diligence is disproportionately high (Murray and Lott 1995; Lockett, Murray, and Wright 2002). In addition, where R&D leads on to the commercialisation of an idea further financial problems can occur; delays and cost over-runs can be onerous and, in certain conditions, significant market demand 'pulls' the firm into rapid, often uncontrollable, growth stretching the financial viability of the firm (Oakey, 1995, 2003). This problem has been exacerbated as a similar level of risk aversion appears to exist among public bodies established to address the gap and facilitate such investments (Huergo and Moreno, 2017). The existence of this funding gap, affecting both the start-up and scale-up of R&D intensive firms, has in part led to the evolution of crowdfunding platforms (Mollick, 2014).

Crowdfunding, a process where on-line platforms gather a group of potential investors and provide them with access to a range of business opportunities promoted on a website, have the potential to change the context in which R&D intensive firms access funds for start-up and scale-up. While the evolution of crowdfunding platforms has evolved in a limited number of countries the ubiquitous nature of the internet means their reach can be significant. The principle and process of on-line crowd platforms (equity, debt or reward) impact upon notions of agency, changing the dynamic between investor and investee and potentially altering the signals that increase the probability of investment (Wright, and Lockett, 2003, Ahlers, Cumming, Günther, and Schweizer, 2015). This new funding channel has been credited with increasing the number of investors, increasing the number of investment opportunities that investors can evaluate and, as a consequence, increasing the number of opportunities that receive funds (British Business Bank, 2015). Crowd platforms are relatively new and insufficient time has passed to offer a true evaluation; early signs, however, suggest that with their introduction R&D intensive firms have a greater opportunity to access appropriate funding for start-up and growth.

Knowledge, Networks and Skills

Knowledge, defined as information combined with experience, context, interpretation and reflection provides valuable information ready to be deployed in decision making (Davenport De Long, and Beers, 1998). The acquisition and application of knowledge has implications for the start-up and scale-up of early stage firms particularly where founders have limited business experience, resources and networks to inform this process (Stinchcombe, 1965; Ferguson and Olofsson, 2004). The failure amongst early stage firms to acknowledge weaknesses and search for external sources of managerial knowledge compounded by limited access to

networks combine to impact upon entrepreneurial capacity (Hughes et al., 2007; Amara et al., 2016). To take an absorptive capacity perspective, external networks provide the opportunity to acquire, assimilate and exploit new knowledge via networking (Zahra and George, 2002) that can support both research and development within a firm.

Constrained explorative activities arise as the founders of R&D intensive firms often originate from non-commercial environments that are constrained by context and offer limited access to personnel experienced in business development (Rasmussen, Mosey, and Wright, 2011). As such, they are short in the skills and resources necessary to facilitate the commercialisation process which augments development (Hayter, 2011). Broadening the scope of networks to address this issue is problematic as founders lack legitimacy with potential industry partners (Stinchcombe, 1965; Zahra, Van de Velde and Larrañeta, 2007). Relationships created under such conditions, are characterised by resource dependency and asymmetric power that limit an early stage firm's ability to broker advantage and scale-up. However, where good external links exist, a variety of commercial and social resources are available (Mosey and Wright, 2007) helping to exploit new opportunities and increase growth potential; (Tolstoy and Agndal, 2010; Hayter, 2013). Therefore, as imprinting theory suggests, any opportunity to strengthen social capital, increase legitimacy and broaden networks during the start-up stage can increase a firm's potential to scale-up (Ganco and Agarwal, 2009; Milanov and Fernhaber, 2009; Huynh, Patton, Arias-Arand, and Molina-Fernández, 2017).

Recognising and addressing skill limitations through training or the addition of new staff can help facilitate internal changes in managerial and/or organisational practices to support the scale-up of R&D intensive firms (Oakey, 2003). In particular, within R&D intensive firms, evidence would support the need for 'balance' between the technical/scientific skills of founders that establish the concept, and the managerial skills in the areas of finance, marketing and HR, required to build this into a commercial concern (Oakey, 1993, 2003). Unfortunately, those skilled in R&D can exhibit a prejudice towards, and an unwillingness to understand, the relevance and importance of business skills that enables commercialisation (Oakey, 2003). This preconception negatively impacts on the development of the HR pool within R&D intensive firms, discouraging training initiatives and/or the need to recruit suitable personnel. It can also lead to problems when external investment is sought to grow the firm; as a prerequisite of such investment is often a strengthening of the management team with commercially experienced people. While technology founders often find this unwarranted, potentially leading to disagreement, it is credited as helping firms achieve their full potential (Fraser et al., 2013).

Knowledge, networks and skills underpin the heterogeneous bundles of tangible and intangible assets that enhance a firm's competitive advantage (Wright et al., 2001); effectively facilitating an ability to reconfigure assets as dynamic capabilities (Teece, Pisano and Shuen, 1997). At the centre of this reconfiguration is the opportunity to exploit R&D and innovate (Rumelt, 1987). While the commercialisation of R&D can offer direct benefits, they may also create indirect benefits in learning how to manipulate and enhance capabilities, increasing absorptive capacity and becoming more perceptive and adaptable, improving response rates to future environmental change (Griffith, Redding and Van Reenan, 2003). Such qualities enable firms to improve opportunity recognition, identify and exploit appropriate technologies, and change the perceptions associated with the risk of investing in R&D (Alvarez and Buzenitz, 2001). In effect, the combination of a firm's knowledge, networks and skills helps to expand its absorptive capacity, enhance competitive advantage and facilitate the potential to scale-up.

Market Structure

The presence of significant competitors in markets often limits successful entry and this holds true for the introduction of new technologies that evolve from R&D (D'Este et al., 2012; Leten, Belderbos and Van Looy, 2016). Highly concentrated markets, where the market is dominated by a few large firms, leads to advantages of scope and scale that offer significant advantages to incumbents at the expense of new and young firms (Hewitt- Dundas, 2006). Such advantages often deter R&D intensive firms from seeking to independently enter markets and instead sell potential opportunities onto incumbent large firms (Stam and Wennberg, 2009; D'Este et al., 2012). Where R&D intensive firms decide to enter concentrated markets the intensity of competition that arises from, the response of existing and new competitors, the ease of product substitution, and the speed of obsolescence of products and technologies is an impediment to appropriation. The propensity to undertake R&D is therefore closely related to potential opportunities and profit margins that can be expected from such investments and market structure is an important factor in this calculation.

Summary

In the majority of western countries (e.g. USA and Germany) a 2:1 ratio exists between private and public R&D investment and governments would like to encourage more private sector involvement to enhance productivity and address regional inequalities. Removing barriers that inhibit start-up and growth is therefore essential to achieve government goals and while all firms, irrespective of age and size, face barriers, certain problems are more keenly felt by new and young R&D intensive firms. Although it is possible to itemise individual barriers this fails to address the complexity of the problem R&D intensive firms face in the start-up and scale-up of business ideas. Firstly, it is important to acknowledge that certain barriers inhibit engagement; market structure and access to finance are clearly important but so too is the emphasis placed upon science/technology which can limit a firm's ability to recognise and exploit commercially viable opportunities. Secondly, once engaged in the process the barriers are found in the nexus of knowledge, networks and skills that underpin the evolution of dynamic capabilities and enhance absorptive capacity. Such capabilities become fine-tuned as they are reconfigured to adapt to change and this learning exercise identifies weaknesses that, if resolved, further improve a firm's absorptive capacity. Accepting that knowledge, network and skills are significantly influenced from the imprint established at start-up; it is the opportunity to learn during the reconfiguring process that underpins scale-up. Finally, internal and external barriers should not be seen in isolation these impediments regularly overlap and combine requiring multifaceted and bespoke solutions to the problem of start-up and scale-up in R&D intensive firms.

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