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Exploring market failures in open innovation

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Abstract

There is now considerable empirical evidence demonstrating the innovation and performance benefits that accrue to firms engaging in Open Innovation (OI). Here, we use novel data on micro-businesses to show that the average level of engagement in open innovation falls well below the optimal level, a finding that reflects that of other empirical studies. We identify and examine three market failures which may help to explain this result. These relate to: firms' lack of understanding of the potential benefits of OI; a lack of information about the capabilities of potential partners; and, a lack of information about the trustworthiness of potential partners. Our findings provide evidence that policy initiatives designed to offset these information failures are likely to increase the range of partners with which firms engage with significant benefits for innovation.

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Keywords: Open Innovation, micro-businesses, market failure

JEL Codes: O32, L1, O38; Q34; L26

Exploring market failures in open innovation

1. Introduction

Research on open innovation (OI) has demonstrated the benefits to individual firms and identified the main strategic and operational requirements of implementing open innovation (Sieg, Wallin, and von Krogh 2010; Hung and Chiang 2010; Lichtenthaler and Lichtenthaler 2009). Partnering for innovation has been found to stimulate creativity, reduce risk in the innovation process, accelerate or upgrade the quality of the innovations made, and signal the quality of firms' innovation activities (Powell 1998). Innovation partnerships may also increase firms' access to technology developed elsewhere and their ability to appropriate the returns from innovation (Gemser and Wijnberg 1995; Leiponen and Helfat 2010). Yet, despite the apparent advantages, the adoption of OI among the population of firms and, in particular, among small firms, remains limited (van de Vrande, de Jong, Vanhaverbeke and de Rochemont 2009; Wynarczyk, Piperopoulos and McAdam 2013). And, where firms do adopt OI, the degree of openness - measured, for example, by the number of types of innovation partners with which firms are working - often remains well below the optimal level (e.g. Vahter et al. 2014). Because of the innovation benefits of OI, this under-investment has negative implications for firms' innovation performance, an outcome which may be more serious in smaller enterprises (Laursen and Salter 2006). In addition, the potential for positive externalities from openness during the innovation process (Roper, Vahter, and Love 2013), and from improved innovation outcomes (Czarnitzki and Kraft 2012), means that firms' under-investment in OI also has wider implications for performance at the level of the regional and national economy (Weber and Rohracher 2012). Here, our focus is whether market failures can explain why firms either fail to adopt OI or, where they do adopt OI, why they invest sub-optimally in the activity.

Our focus is on micro-firms for which there is little robust evidence on the drivers of innovation (Tu, Hwang and Wong 2014). This represents a marked contrast to much of the OI literature which has focused on large, typically multinational, enterprises such as Procter & Gamble (Dodgson, Gann and Salter 2006), Intel (MacCormack and Herman 2005), or on sectoral and national investigations of the prevalence of OI (Su, Wu and Vanhaverbeke 2010; Love Roper and Vahter 2014)¹. Arguably, micro-businesses have the most to gain from adopting OI which may help to overcome weaknesses in their internal knowledge resources (Narula 2004). In

¹ See Dahlander and Gann (2010) for a review and synthesis of the OI literature.

addition, micro-businesses tend to over-estimate the risks associated with pursuing growth and innovation (Allinson, Braidford, Houston and Stone 2006), and face difficulties in appropriating the benefits of innovation due to their liability of smallness (Carroll 1983). Undertaking OI may therefore offer partnerships that help micro-firms to share risks, supplement their own resources and pursue a more ambitious competitive strategy (Whittaker, Fath and Fiedler 2016).

Our analysis is based on unique data for micro-businesses and is unusual in providing a range of standard innovation and OI metrics alongside indicators of the barriers to the adoption of OI. As such the data extends the scope of most innovation surveys to include micro-businesses and expands the data on organisational and behavioural characteristics that is normally captured through such surveys. We argue that the barriers to adopting OI represent informational market failures, and identify and examine three specific market failures which may be limiting the adoption and extent of OI activity among micro-businesses. The first relates to firms' lack of understanding of the potential benefits of OI which may reduce firms' willingness to establish external innovation partnerships. The second market failure relates to a lack of information about potential OI partners which may increase search costs, again potentially reducing firms' willingness to engage with OI. The third market failure relates to the difficulty *ex ante* of assessing the motives and trustworthiness of potential partners. Identifying these market failures contributes to our understanding of OI adoption by smaller firms complementing more organisational – resource based – explanations of OI behaviour.

The remainder of the paper is organised as follows. Section 2 outlines our conceptual framework and hypotheses. In Section 3 the data and methods used in this study are outlined and the empirical results are presented in Section 4. Section 5 summarises the main conclusions and discusses the implications for policy measures to support OI among smaller firms. In particular we discuss policy initiatives which might support OI by addressing the three market failures we identify.

2. Understanding openness in micro-businesses - conceptual foundations

2.1 Openness and open innovation

Open Innovation (OI) has been defined as ‘... the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for the external use of innovation, respectively’ (Chesbrough 2006, p. 1). Engagement with open innovation may therefore involve purely inbound OI, where technology and knowledge moves from outside to inside the firm, outbound OI where technology and knowledge move from inside the firm to the outside, or both. Reflecting this distinction, one recent survey of UK firms identified three clusters of innovators: ‘Closed’ innovators who accounted for 32.1 per cent of innovative firms; ‘Hunters’ engaged primarily in inbound open innovation, which accounted for 41.9 per cent of innovators; and, ‘ambidextrous innovators’ - the 25.9 per cent of firms who were engaged both in inbound and outbound open innovation (Cosh, Zhang, Bullock and Milner 2011). OI relationships can at the same time be interactive – partnerships or alliances involving mutual learning by both parties – or non-interactive – copying or imitation in which learning is one-sided (Glückler 2013). The majority of OI studies, however, have focused on collaborative innovation partnerships typically measured by the number of collaborative partner types (Laursen and Salter 2006; Leiponen and Helfat 2010). Studies have demonstrated that such measures of ‘openness’ are strongly related to organisational learning and innovation outputs (Love et al. 2014).

Discussions of OI have also re-emphasised the importance of firms’ ability to identify, access and absorb external knowledge – or their absorptive capacity (Cohen and Levinthal 1990) - which has been linked both to firms’ R&D capabilities (Griffith, Redding, and Van Reenan 2003) and human capital endowments (Vinding 2006). Different aspects of absorptive capacity have also been linked to value chain or collaborative research interactions reflecting the knowledge content of different types of partnership (Schmidt 2010). For example, supply chain partnerships may require more modest levels of internal technical expertise than connections to universities or external laboratories (Tomlinson and Fai 2013).

While research in the early 2000’s was criticised for focusing on large technology-based firms and not accounting for differences in the innovation process between large and smaller firms (West and Gallagher 2006), more recent research has sought to address this imbalance (Van de Vrande et al. 2009; Lee, Park, Yoon and Park 2010; Vahter et al. 2014; Colombo, Piva and Rossi-Lamastra 2014)². As a result, we now have a much better understanding of the

² Cosh and Zhang (2012) present a review of recent literature exploring OI in SMEs.

antecedents of OI in SMEs (Schroll and Mild 2011), how OI enhances SME internal capabilities (Huizingh, 2011), the type of external partners and nature of relationships formed by SMEs for research exploration and innovation exploitation (Lee et al. 2010), and the performance benefits of adopting OI (Colombo, Laursen, Magnusson and Rossi-Lamastra 2012; Colombo et al. 2014). Studies have emphasised that smaller firms with lower absorptive capacity may find engaging in OI more difficult than larger firms (Chesbrough 2010): More limited managerial resources in SMEs may mean that allocating resources to identify appropriate partners may be more difficult, and smaller firms may also lack the capability to absorb external ideas and technology (Vahter et al. 2014; Masiello, Izzo and Canoro 2015). SMEs may also be perceived as being less attractive as innovation partners due to their resource constraints (Chesbrough 2010; Narula 2004). Each of these characteristics are exacerbated in micro-firms where technological risks are compounded by market-related risks associated with instability of demand. Micro-firms have a less established market position and therefore lack structural capital, including distribution channels and developed supply chains, weaker cognitive capital as well as relational capital in terms of reputation, legitimacy and trust (Powell and DiMaggio 1991; Hargadon and Douglas 2001). Rothaermel (2001) demonstrates how alliances between micro-businesses and larger incumbents in the pharmaceutical industry is mutually beneficial with micro-businesses benefiting from resource advantages and market legitimacy.

At the same time the heterogeneity in capabilities between firms creates the potential for learning (Dosi 1997) through inter-organisational collaboration and the transfer of tacit and explicit knowledge (Ingram and Baum, 1997). Nambisan and Sawhney (2011) succinctly summarise the private benefits which may arise from OI along four dimensions: increasing the *reach* of firms in identifying new ideas, technologies and markets; reducing the *cost* of innovation through partnerships with other organisations; similarly, reducing the *risk* of commercialising new ideas, technologies or products; and, increasing the *speed* of development from idea to innovation.

Innovation partnerships may also create disadvantages for the firm. For example, firms may face difficulties in defending their own intellectual property rights, which may limit their use of such partnerships (Lichtenthaler 2010). There are also transaction and resource coordination costs (Alston and Gillespie 1989). Search for suitable partners is costly. Most importantly, having a larger number of partnerships may lead to difficulties with management and

monitoring and with the absorption of knowledge simultaneously from a large number of sources (Alston and Gillespie 1989; Sieg et al. 2010; Laursen and Salter 2006). Due to these cognitive limits firms are likely to have a ‘saturation’ level in the number of partnerships; a point where the innovation benefits are maximised. Evidence of limits to the benefits of OI have been widely identified in the empirical literature, with a standard finding being an inverted U-shape relationship between the number of partner types and firms’ innovation performance (Laursen and Salter 2006; Leiponen and Helfat 2010; Vahter et al., 2014)³. Therefore while the returns to additional innovation type of partner may at first be positive, eventually the firm will reach a point at which each additional partner type diminishes innovation returns. This leads to our first two Hypotheses:

Hypothesis 1: As the number of types of innovation partners increases innovation outputs will increase.

Hypothesis 2: As the number of types of innovation partners increases the returns to adding additional partners will diminish.

2.2 Market failure and open innovation

Central to OI is the process of partner search and partnership development. Kim, Kumar and Kumar (2010) identify four distinct stages in this process, the first three of which relate closely to the market failures we consider here. These are: (i) identifying strategic needs; (ii) assessing and selecting a partner; (iii) implementing a partnership; and, (iv) re-assessing and re-shaping the partnership. The first stage in Kim et al.’s (2010) conceptualisation of the partnership formation process relates to firms’ ability to assess the strategic need for OI and its potential benefits. This is likely to be influenced by the first market failure:

Market failure 1: Lack of awareness - information failures may mean that firms are unaware of the potential benefits of OI, or are unable to predict the likely (private) returns. Incomplete information about the potential benefits from OI, may therefore mean that firms either fail to engage in OI activity or, where they do engage in OI, they will tend to under-invest in forming OI partnerships, and potentially in the internal capabilities required for effective open innovation (Spithoven, Clarysse, and Knockaert 2011). The impact of this market failure may diminish as firms become more experienced open innovators. Extant research has pointed to a learning effect which

³ This relationship differs significantly between small and larger firms, with the benefits of inbound OI greater for small firms but with small firms having a lower optimal number of innovation partners (Vahter et al. 2014).

gets stronger as firms increase their number of alliances and diversity of partners (Reuer Zollo and Singh 2002; Laursen and Salter 2006; Leiponen and Helfat 2010). This may reflect learning-by-using as firms which undertake OI, better appreciate the potential benefits, and are better able to predict and maximise the private returns (Lokshin, Hagedoorn and Letterie 2011; McWilliams and Zilbermanfr 1996).

The second stage of the partnership formation process identified by Kim et al. (2010) is the assessment and selection of potential partners. Here, a second market failure becomes important:

Market Failure 2: Limited information on functional capabilities - incomplete or asymmetric information on potential partners' functional capabilities may lead either to a failure to identify appropriate partners or the establishment of OI relationships with the wrong partners. This has been described as adverse selection and occurs pre-contractually. Where the wrong partners are selected this can result in inferior outputs (Kivisto 2005). Lee et al. (2010, p. 293) suggest that this information failure is particularly acute for small businesses due to more limited capability and financial resources to acquire partner information compared to larger firms 'who can often afford professional intelligence processes for scanning and monitoring their technological environments'. Both may mean that firms fail to maximise the potential private benefits of OI.

Once potential partners have been identified the third stage of the partnership formation process can begin – the implementation of the partnership (Kim et al. 2010). The nature of the partnership agreement established and its governance mechanisms may be influenced by a third market failure:

Market Failure 3: Limited information on trustworthiness – in most cases firms will have incomplete information on the reliability and integrity of OI partners i.e. inter-organisational trust (Squire, Cousins and Brown 2009). This comprises both confidence in the capabilities of partners as well as a commitment of partners to the relationship (Jiang, Henneberg and Naude 2011). Even where firms have complete information on the functional capabilities of potential OI partners, asymmetric information in terms of

potential partners' strategic aspirations or commitment may result in the establishment of relationships with inappropriate or inadequate governance mechanisms.

In the governance literature this has been discussed in terms of moral hazard and is exacerbated where partners' behaviour is difficult to observe and monitor. In such circumstances a partner may act in their own self-interest or may devote insufficient effort, leading to poor quality outputs. Innovation partners may therefore misrepresent their performance, again reducing the returns to OI below the private optimal level. Further, for micro-firms establishing relatively small scale collaborations with incumbents, this will have an effect on the stability and longevity of the collaboration. Shorter term alliances may therefore produce less satisfactory outcomes (Rahman and Korn 2014) in contrast to longer term alliances where complementary and more extensive collaborations produce more positive outcomes (Pangarkar 2003).

One approach to overcoming a lack of trust between partners is through legally enforceable contracts. This safeguards the innovation process between partners and the appropriation of rents. However, research on buyer-supplier relationships has found that trust between partners was more important than contractual arrangements in stimulating creativity (Wang, Bradford, Wu and Weitz 2008; Ashnai, Henneberg, Naude and Francescucci 2016).

In situations of full information where firms are able to accurately assess the benefits of OI and partners' capabilities and trustworthiness, firms would continue to invest in OI partnerships until, at the private optimum, the marginal costs and benefits of openness are equal. However, in the presence of market failures which mean that firms are unable to appreciate and realise the potential benefits of OI, levels of innovation partnering will remain below the optimum. This leads to our final Hypothesis:

Hypothesis 3: In the presence of market failures, the average number of external OI partner types will be below the private optimum level.

3. Data sources and methods

Our analysis is based on a survey of innovation among micro-businesses (with 1-9 employees) conducted in Northern Ireland and relating to firms' innovation activity during the three year period 1st January 2010 to 31st December 2012. Northern Ireland is the smallest of the devolved territories of the UK having a population of 1.8m at the time of the survey⁴. Linked by a land border with the Irish Republic, Northern Ireland has a long history as a centre for heavy engineering and textile manufacture. However, in common with the rest of the UK, significant industrial restructuring has taken place over recent decades with a loss of manufacturing activity and a growth in creative industries and other services. Around 1:6 of the workforce are now employed in manufacturing, with the economy dominated by micro, small and medium-sized companies. Labour productivity per hour worked has remained around 79-85 per cent of the UK average over the 2000-2010 period and was 17.2 per cent below the UK average in 2012⁵.

The micro-business survey targeted 6,800 businesses, with 1000 responses quota sampled to be representative of the Northern Ireland micro-business population⁶. Attempts were made during the fieldwork stage of the survey to counter potential non-response bias with a focus on particular sectors and firm size-bands where response was below the target quota (see Annex 2 and Annex 3 of DETI, 2014). In each case the most senior person in the firm was the survey respondent. To ensure that this was the case, a filter question was used in the telephone survey script and the interview only proceeded if the person being spoken to on the phone was the most senior person i.e. MD, CEO or proprietor. Where this was not the case then arrangements were made to re-contact the business at a later date to speak with the most senior person or alternatively the interview was terminated. Ensuring the most senior person was the respondent is important given research demonstrating that in micro- and smaller firms senior managers are highly influential in determining firm's innovation activities (De Mel, McKenzie and Woodruff 2009; Marcati, Guido and Peluso 2008; Galasso and Simcoe, 2011).

The survey closely followed the definitions and questions used in the EU Community Innovation Survey and the UK Innovation Survey but used a different survey methodology being conducted by telephone rather than post. The survey of micro-businesses is particularly useful for our analysis of market failure as it included novel questions relating to the barriers

⁴ Source: Region and Country Profiles – Population and Migration, Office of National Statistics, 30 May 2012.

⁵ Source: Region and Country Profiles: Economy, Office of National Statistics, 30 May 2012. Regional Economic Indicators, July 2014, ONS.

⁶ The original survey report and full questionnaire are available at: <https://www.economy-ni.gov.uk/publications/micro-business-innovation-survey>. (Accessed 18th November 2016).

to OI. Three questions were asked in the survey closely reflecting the information failures described earlier. In each case the basic question asked was ‘How influential or otherwise were each of the following factors in restricting you from becoming more involved in co-operation on innovation activities’? And, the three factors identified were: (a) uncertainty on the benefits of co-operating; (b) a lack of information on potential partners; and, (c) concern over sharing information with potential competitors. In each case, firms were asked to indicate whether these factors had been ‘Very influential’, ‘Fairly influential’ or ‘Not influential’ in their decision to engage in co-operation on innovation activities.

Our empirical approach comprises two stages. First, based on estimates of the relationship between firms’ innovation outputs and their level of OI activity we identify the level of OI activity that would maximise the contribution of openness to innovation outputs. This optimum occurs at a turning point in the innovation outputs-openness relationship, where the returns to more extensive OI become negative. Using this estimate we are then able to quantify the shortfall between firms’ actual level of OI activity and this optimum. This enables us to test Hypotheses 1 and 2. Second, using the responses to survey questions relating to information failures, we are able to test Hypothesis 3 that, in the presence of market failures, the average actual breadth of external OI partnerships will be below the optimum level⁷.

Our initial analysis is based on the concept of the innovation production function, which relates micro-businesses’ innovation outputs to the knowledge inputs to the innovation process (Griliches, 1995; Love and Roper, 2001; Laursen and Salter, 2006). This approach accounts for the enterprises’ characteristics and other elements of micro-businesses’ innovation strategies – e.g. investments in R&D, design – in estimating the optimal level of OI activity. More specifically, we use as our indicator for innovation output the percentage of firms’ total sales in 2012 derived from products or services newly introduced during the previous three years (See Annex 1). This variable has been widely used as an indicator of innovation output (Laursen and Salter 2006; Roper, Du, and Love 2008; Love, Roper, and Du 2009) and reflects not only firms’ ability to introduce new products or services to the market but also their short-term commercial success. On average, micro-businesses responding to the survey derived 4.9

⁷ Our empirical analysis relates to firms’ private returns to OI and the level of OI activity which is optimal for the individual firm. Positive externalities from openness (Roper et al. 2013) which cannot be appropriated by the individual firm mean however that the socially optimal level of OI is likely to be greater than the private optimum in each case.

per cent of their sales from new products or services (Table 1). Our other key variable relates to the extent of micro-businesses' OI activity (Annex 1). Here, we use the now standard measure of the 'breadth' of firms' set of innovation partnerships (Laursen and Salter 2006) which measures the number of different types of partner with which a firm has co-operated with as part of their innovation activity⁸. In the survey, seven different types of partner are identified and this variable therefore takes values 0 to 7. These are: suppliers of equipment, materials, services or software; clients or customers from the private sector; clients or customers from the public sector; competitors or other businesses in your industry; consultants, commercial labs or private R&D institutes; Universities or other higher education institutions; and finally, Government or public research institutes. Previous studies have highlighted an inverted-U shape relationship between this measure and innovation outputs and we therefore include a square of this variable in all models to capture the potential for this non-linear effect and *inter alia* identify the maximum contribution of OI to firms' innovative outputs (Vahter et al. 2014).

To control for other micro-business characteristics we include in the analysis three resource indicators (see Annex 1 for definitions). First, we include a binary variable to reflect the engagement of the business in R&D, which is generally associated positively with new product development (Crepon, Duguet and Mairesse 1998; Loof and Heshmati 2002; Roper et al. 2008). Second, we include a scale indicator to reflect micro-businesses' investment in other types of innovation investment such as design, training for innovation etc. Ten types of innovation investment are identified in the micro-business questionnaire with the variable taking a value between 0 and 10. The options were: (i) advanced machinery and equipment; (ii) computer hardware; (iii) computer software; (iv) purchase of licensing of patents and non-patented inventions, know-how and other types of knowledge from other businesses or organisations; (v) internal or external training for your personnel, specifically for the development and/or introduction of innovations; (vi) Engagement in all design activities, including strategic, for the development or implementation of new or improved goods, services and processes; (vii) Changes to product or service design; (viii) Market research; (ix) Changes to marketing methods; (x) Launch advertising.

⁸ Note this measure relates to the number of types of innovation partner rather than the specific number of innovation partners. Firms might be working with more than one partner of a specific type. This is a standard limitation of analyses using innovation survey data.

We anticipate this variable having a positive impact on innovation given evidence from other studies that, for example, investments in design and machinery are associated with higher innovation outputs (Marsili and Salter 2006; Love, Roper and Bryson 2011). We also include a variable indicating whether or not the micro-business received public support from either local, national or supranational agencies to support its innovation activity. Such support has been shown in the past to be positively linked to innovation outputs (Smith 1989; Hewitt-Dundas and Roper 2009; Gongora, Garcia, and Madrid 2010). Other controls include: the graduate share of the workforce; firm age (Balasubramanian and Lee 2008); an indicator of whether firms are selling in international markets (Love and Roper 2015); and finally, a binary variable to indicate whether firms are family-owned (Kotlar, Fang, De Massis and Frattini 2014; Matzler, Veider, Hautz and Stadler 2015)⁹.

4. Empirical results

Table 2 reports an estimate of the innovation production function for micro-businesses. For transparency we use OLS in this table although a Tobit estimator which takes into account the truncated nature of the dependent variable gives very similar results. The adjusted R-squared of our estimates is relatively low but this is common in similar cross-sectional studies based on survey data. Our results suggest the strong link between innovative sales and the extent of firms' OI activity and, in line with other studies (Laursen and Salter 2006; Vahter et al. 2014), point to an inverted 'U' shape relationship between innovation outputs and the breadth of firms' OI activity. Typically said to be the result of cognitive, managerial or absorptive limitations on the part of firms (Love, Roper, and Vahter 2014) the turning point in this relationship suggests the optimal number of types of innovation partner, at least in terms of the contribution of OI to innovation outputs. In fact our innovation production function suggests that the private optimum extent of OI is around 5.2 types of innovation partners (Figure 1a)¹⁰. Our empirical results therefore provide support for both Hypotheses 1 and 2. Micro-businesses that engage in OI, i.e. they undertake innovation activities with external partners, have higher innovation

⁹ The categorisation of businesses as family-owned and controlled has received substantial attention in the research literature and generated significant debate. In the current context we are limited to a single question in the micro-business survey which directly asked: 'Is the business family-owned?' and required a binary response. We have no information in the survey on whether a business is both family-owned and family-run.

¹⁰ This relationship is simply computed from the equation coefficients. If N is the number of types of innovation partners, the contribution of OI to innovation outputs depicted in Figure 1a is $4.956N - 0.496N^2$.

success (as measured by the share of total sales derived from products or services newly introduced in the previous 3 years). Further, as the firms' number of types of external partners increases, so too do the sales derived from innovation. However, beyond 5.2 types of external partners, the returns to further innovation partnerships diminish.

Figure 1b profiles the distribution of innovating firms by their number of types of innovation partner. The vast majority of innovating micro-businesses have levels of OI activity well below the optimum suggested in Figure 1a. Indeed innovating firms had an average of 1.8 types of partner, well below the 5.2 optimum. This reflects the findings of other similar econometric studies relating to other groups of firms. For UK manufacturing firms, Laursen and Salter (2006) find average OI engagement of 7.22 partner types and an optimum of 11.0. For Finland, Leiponen and Helfat (2010) find average breadth of 5.08 partner types and an optimum of 8.0. Vahter et al. (2014) find Irish small firms have 0.82 types of partner on average compared to optimum breadth of 4.2 types of partner.

To test if information failures existed in micro-businesses' decisions to engage in OI and if these impacted the gap between the private optimal level of activity and the actual level we draw on responses to the three novel survey questions (Table 3). Ideally, we would include these variables in the model in Table 2 but these questions were only asked for product/service and process innovators and not the whole sample and this limits our ability to directly estimate the effects of the market failures. We therefore adopt a more inferential approach. In Table 3, responses to the questions for all innovators (both product and process) are reported as well as the responses for 'open' and 'closed' innovators. A closed innovator is defined here as a firm which is innovating – having introduced a new product or service innovation over the 2010 to 2012 period – but which reported no innovation co-operation with any external partner. For these firms the market failures represent the barrier to moving into open innovation. Open innovator in the table are firms which did report some innovation co-operation, and for these firms the market failures are likely to be impacting on the extent of OI. For all innovators (product/service and process), the market failure most frequently cited as a barrier to cooperation with external partners for OI (as either 'very' or 'fairly' influential) was uncertainty over the trustworthiness of partners. This was cited by 50.9 per cent of innovators, compared to 43.7 per cent reporting uncertainty about the benefits of co-operation and 39.8 per cent who lacked information on the functional capabilities of potential partners (Table 3).

The relative importance of the three market failures is consistent for both closed and open innovators. For closed innovators, currently innovating but without cooperation, uncertainty over the trustworthiness of partners was cited by 40.0 per cent of firms, with 34.8 per cent uncertain of the benefits and 30.9 per cent lacking information on partners. ‘Open’ innovators seem more aware of each market failure with 56.8 per cent concerned about the trustworthiness of partners, 48.4 lacking information on the benefits of extending their open innovation activity and 45.2 per cent lacking information about partners (Table 3). One possibility, here, is that open innovators become more aware of the market failures as they develop their engagement – or try to develop their engagement - with new collaborators, a type of experiential learning effect. Similar learning effects have been noted elsewhere in terms of firms’ ability to learn from experience of collaboration in one period with subsequent benefits for collaboration in the next period (Love et al. 2014).

Our results therefore suggest a consistent picture with market failures linked to information on the trustworthiness of potential partners the most common barrier to both becoming an open innovator, i.e. cooperating with external partners for OI for the first time, as well as for those micro-businesses already undertaking OI. The high reported incidence of each of the three market failures is consistent with Hypothesis 3 and may explain why the average actual breadth of external OI partnerships is below the private optimum level (Figure 1b).

5. Discussion and conclusions

In this paper we examine levels of open innovation in micro-businesses and whether market failures can explain why firms either fail to adopt OI or, where they do adopt OI, have sub-optimal levels of external innovation partnerships. Our analysis suggests three main empirical conclusions. First, for the large group of micro-businesses considered here the actual level of open innovation activity, measured by the number of types of innovation partners, is well below the private optimum suggested by our econometric analysis. This finding is consistent with empirical evidence for larger enterprises (Laursen and Salter, 2006; Vahter et al. 2014). More important, however, is the implication of our finding that if micro-businesses were to extend the breadth of their open innovation partnerships there would be substantial innovation payoffs. This innovation payoff is evident from the positive link between OI and innovation outputs in our estimates of the innovation production function (Figure 1 and Table 2).

This leads to our second empirical conclusion: Extending the range of external innovation partners increases the innovation returns. However, beyond 5.2 types of partners, the additional returns decline. This inverted U-shaped relationship between the breadth of external innovation partner types and innovation sales has also been found elsewhere for SMEs (Vahter et al 2014). The implication is that while the initial returns to innovation partnering may be significant, for small and in particular micro-businesses, ‘the limited resources available within small firms for managing and developing these external relationships ... suggests the importance of the careful selection of the most appropriate or beneficial innovation partners’ (Vahter et al. 2014, 569).

Our third empirical finding relates to role of market failures in explaining why micro-businesses are – on average – adopting sub-optimal levels of OI. These market failures relate to a lack of awareness of the potential benefits of OI, a lack of information about potential partners and a lack of information on the trustworthiness of partners. Each of these market failures turns out to be significant for around 40-60 per cent of innovating firms, suggesting their importance in reducing levels of OI. It is, however, limited information on the trustworthiness of external partners which is most commonly cited by micro-businesses as being influential in their decision to form or not to form external partnerships. As Wang et al. (2008) found, trustworthiness is even more important than contractual arrangements, especially in the area of innovation and creativity and where the behaviour of the partners is difficult to monitor.

These market failures may provide a rationale for public intervention both to encourage firms to invest in OI up to the private optimum and, potentially, beyond to the social optimum¹¹. Intermediary organisations playing a brokering and capability building role are likely to be central to any such interventions (Watkins and Horley 1986; Mantel and Rosseger 1987; Gould and Fernandez 1989; Howells 2006; Clarysse et al. 2014)¹². While the role of innovation intermediaries varies widely Howells (2006, p. 720) describes their central activities as

¹¹ This is warranted by analysis of the positive externalities from R&D and innovation which suggest that these effects can be significant (Mansfield, Rapoport, Romero, Wagner and Beardsley 1977), strongly localised (Ceh 2009; Feldman 2003) and vary markedly by technology type (van Beers and van der Panne 2011; Kesidou, Caniels, and Romijn 2009; Moreno, Paci, and Usai 2005; Fritsch and Franke 2004). As such this argument for intervention in supporting OI activities directly parallels the standard justification for public R&D and innovation support with its benefits to generate positive externalities (Crespo, Fontoura, and Proenca 2009; Norberg-Bohm 2000; Mohnen 1996).

¹² Intermediaries have been defined as ‘actors who create spaces and opportunities for appropriation and generation of emerging technical or cultural products by others who might be described as developers and users’ (Stewart and Hyysalo 2008, p. 296).

‘scanning and recognition; communication and assimilation; and application’, functions which closely mirror the three market failures we have identified. For example, in terms of Market Failure 1 (Lack of awareness) intermediaries such as the University Enterprise Network (I-UEN), supported by the European Regional Development Fund and based at Coventry University, UK, has undertaken a range of showcase and workshop events to promote awareness of the value of partnering in innovation¹³. Similarly, advocacy related to OI has also been part of the function of the Eindhoven based Holst Centre supported by the Dutch and Flemish governments (Mina, Connell, and Hughes 2009)¹⁴.

Market Failure 2 relates to firms’ lack of information about potential OI partners. Overcoming this type of information failure is a standard function for innovation intermediaries helping firms to identify partners with suitable capabilities. The Enterprise Europe Network, for example, provides a series of on-line and informational resources to firms with the objective of developing new innovation partnerships¹⁵. The final, and in our data most frequently cited, market failure relates to the difficulties firms face in establishing the trustworthiness of potential partners. Here, innovation intermediaries can help by playing a brokering role, helping to develop inter-personal relationships between potential OI partners, and so addressing both the issue of capabilities and – often in tacit form – trust. For example, funded by local government, Central Technology Belt (CTB) Ltd in the UK brokers innovation partnerships between the leadership and technology teams of local firms. Key to this role is the role of CTB as an ‘honest broker’ funded by a party outside the relationship and therefore with no incentives other than the success of the partnership¹⁶. Similarly, in many universities a brokering role is played by staff in technology transfer offices and incubators helping firms to identify research staff with appropriate skills. Spithoven et al. (2011), for example, describe the role of technology advisors within the Collective Research Centres in Belgium which form a first point of contact for businesses looking to resolve technical problems.

Our analysis represents a first step in developing an understanding of the role of market failures in shaping firms’ engagement with OI. There are however limitations to our analysis. First, OI is concerned with both inbound and outbound flows of knowledge. However, here we are unable to disaggregate the direction of knowledge sharing. This limitation is common to

¹³ See <http://www.coventry.ac.uk/business/technology-park/business-support/i-uen/theme=main>.

¹⁴ See also: www.holstcentre.com.

¹⁵ See <http://een.ec.europa.eu/>.

¹⁶ <http://www.centraltechnologybelt.com/>

similar empirical investigations of larger enterprises (Vahter et al. 2014). Second, in this paper we have focused on the breadth of external OI partnerships represented by the number of types of partner. While this measure stems directly from our survey data, and has been widely used, it measures only one dimension of firms' collaboration for innovation. For example, our measure of the breadth of firms' OI activity is limited in that it does not account for the intensity or frequency of interactions with specific types of partner, e.g. supply chain partners or knowledge partners such as universities. Third, associated with a lack of information on the intensity of interactions, we are unable to identify the spatial proximity of partners. Substantial empirical evidence stresses the localised nature of innovation partnerships due to the tacit nature of knowledge and the greater accessibility of 'local' knowledge. Therefore, it would be anticipated that informational market failures would increase with distance between partners, the most extreme being for inter-national collaborations faced with linguistic, cultural and regulatory differences. Fourthly, we are unable here to examine formally the impact of the market failures we discuss and their impact on the adoption and intensity of firms' OI activity. Instead, the structure of our survey data means we have to adopt a more inferential approach. Further work on this theme might usefully adopt a hurdle model reflecting the impact of the market failures on the decision to innovate and the intensity of any OI activity. Finally, our research has been conducted on micro-businesses in Northern Ireland and efforts to replicate these findings in other regions or countries would be beneficial.

Table 1: Descriptive statistics for micro-businesses, 2010 to 2012

	Innovators (N=190)		Non-innovators (N=718)		All firms (N=908)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Innovative sales (% sales)	23.368	24.149	0.000	0.000	4.890	14.559
Types of innovation partnerships (no.)	1.884	1.805	0.252	0.920	0.594	1.338
R&D in the firm	0.395	0.490	0.103	0.304	0.164	0.371
Investment in other innovation	3.284	1.470	1.742	1.418	2.065	1.560
Public support for R&D	0.089	0.286	0.052	0.221	0.059	0.237
Graduate share of the workforce	0.600	0.491	0.435	0.496	0.469	0.499
Family owned business	0.811	0.393	0.806	0.395	0.807	0.395
Business age (average)	17.442	18.515	21.964	19.808	21.018	19.621
Exporting firm	0.100	0.301	0.033	0.180	0.047	0.213
Number of employees	4.068	2.106	3.774	2.104	3.836	2.107

Notes and sources: Innovators are those firms introducing either product or service innovations during the 2010 to 2012 period. Variable definitions are included in Annex 1. **Source:** Micro-business innovation survey.

Table 2: Innovation production function for micro-businesses: 2010 to 2012

Dependent variable: Innovative sales (%)		
	Coefficient	t-stat
Types of innovation partnerships (no.)	4.956***	4.84
Types of innovation partnerships - squared	-0.496***	-2.45
R&D in the firm	1.396	1.00
Investment in other innovation	0.837***	2.33
Public support for R&D	-1.259	-0.63
Graduate share of the workforce	0.198	0.20
Family owned business	1.040	0.87
Business age (average)	-0.023	-0.94
Exporting firm	1.931	0.85
Employment	-0.123	-0.54
Constant	11.088	1.11
Number of observations	908	
F(24,883)	6.11	
Adjusted R ²	0.119	

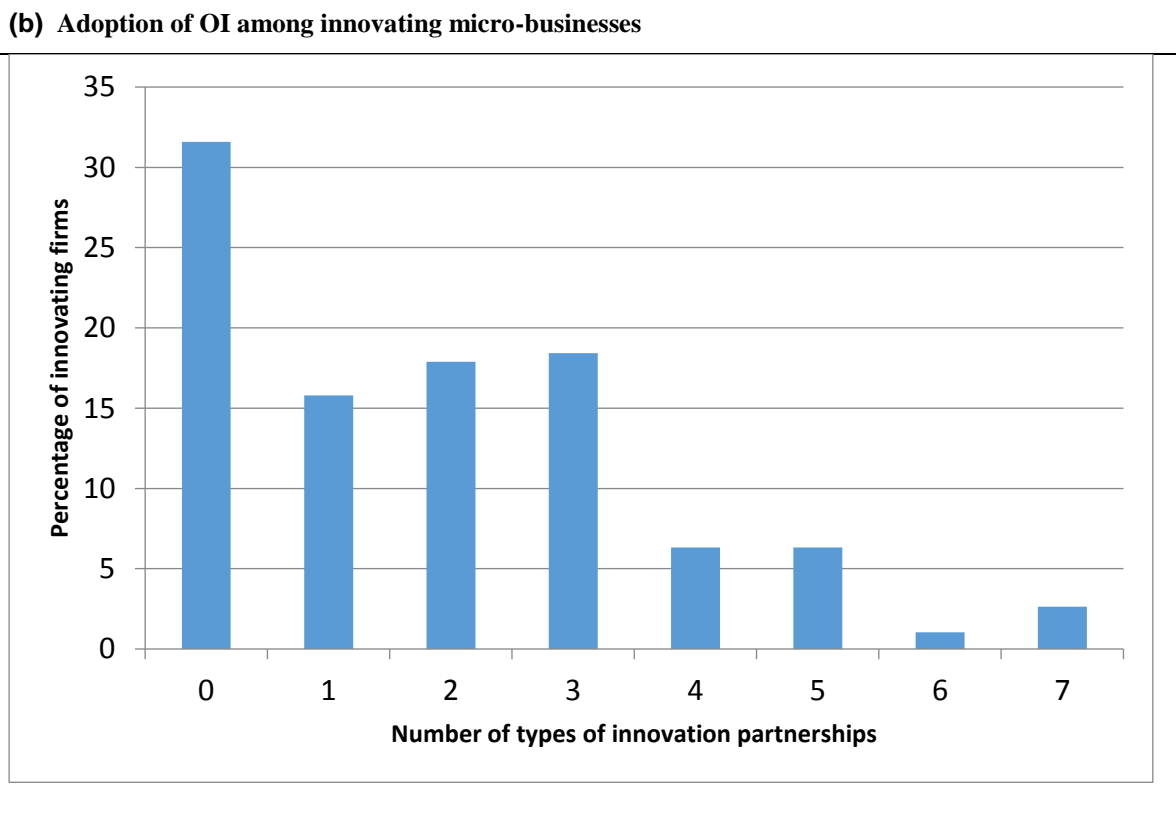
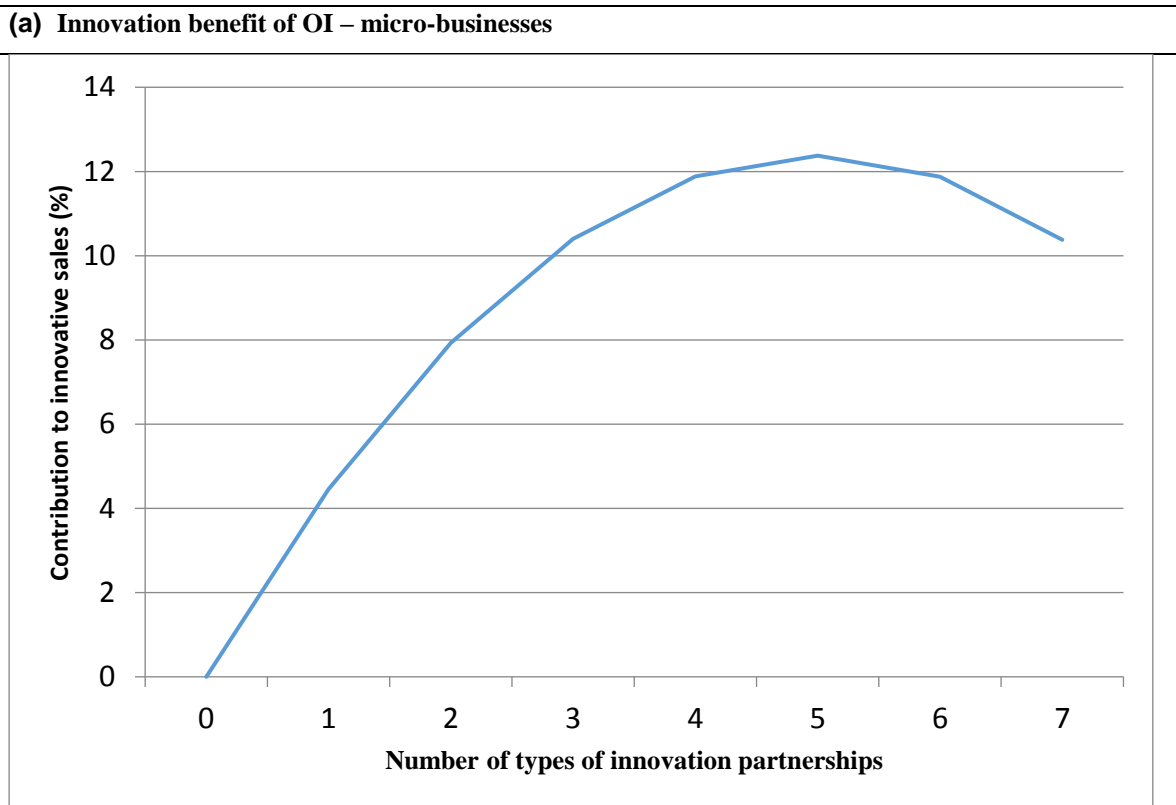
Notes and sources: Coefficients reported are from OLS estimation. Model includes sectoral dummies at the 2-digit level (not reported). *** denotes variables significant at the 1 per cent level.

Table 3: Open innovation market failures among product and process innovators

	Open innovators (N=250)	Closed innovators (N=135)	All Innovators (N=385)	Open innovators %	Closed innovators %	All Innovators %
Market Failure 1: Lack of awareness of the benefits of co-operating						
Very or fairly influential	121	47	168	48.4	34.8	43.7
Not influential	129	88	217	51.6	65.2	56.4
Total	250	135	385	100	100	100
Market Failure 2: Limited information on functional capabilities of potential partners						
Very or fairly influential	113	41	154	45.2	30.3	40.0
Not influential	137	94	231	54.8	69.6	60.0
Total	250	135	385	100	100	100
Market Failure 3: Limited information on trustworthiness						
Very or fairly influential	142	54	196	56.8	40.0	50.9
Not influential	108	81	189	43.2	60.0	49.1
Total	250	135	385	100	100	100

Notes and Sources: Innovators here are firms introducing either product or process changes or both during the three years prior to the survey. In each case the distribution of responses between closed and open innovators was significantly different at the 1 per cent level. Test statistics as follows: Market Failure 1: Pearson $\chi^2(2) = 13.0615$ Pr = 0.001; Market Failure 2: Pearson $\chi^2(2) = 10.7932$ Pr = 0.005; Market Failure 3: Pearson $\chi^2(2) = 9.9964$ Pr = 0.007. Source: Micro-business innovation survey.

Figure 1: Return from OI (a) and reported extent of OI (b) among micro-businesses



Notes and Sources: (a) derived from Table 2. Source: Micro-business innovation survey.

Annex 1: Variable definitions

Variable	Definition
Innovative sales (% sales)	The percentage of sales derived from products or services newly introduced during the previous three years.
Types of innovation partnerships (no.)	A count variable referring to the number of types of innovation partner with which a firm engaged during the previous three years (values 0 to 7).
R&D in the firm	A dummy variable taking value 1 if the firm is engaging in in house R&D activity.
Investment in other innovation	A count variable referring to the number of other investments a firm had made in its innovation activity, e.g. design, advanced machinery etc. (values 0 to 6)
Public support for R&D	A dummy variable taking value 1 if the firm received public support for its innovation activity during the previous three years.
Graduate share of the workforce	The share of the workforce with a degree or equivalent qualification (%)
Family owned business	A dummy variable taking value 1 if the firm was family owned.
Business age (average)	The vintage of the business in years
Exporting firm	A dummy variable taking value 1 if the firm was exporting outside the UK
Number of employees	The number of employees in the firm at the start of the survey reference period

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