Collaborations between universities and entrepreneurial ventures: A micro-firm perspective

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Abstract

Purpose

As the Open Innovation (OI) literature suggests that smaller firms may derive greater advantages from collaborations, micro-firms stand to benefit significantly from engaging in this process. Furthermore, as micro-firms exhibit a preference for separating cooperation from competition, universities may make a suitable partner for OI. Despite these assertions, the extant literature is under-developed with respect to micro-firms' university collaborations. Given this, the purpose of this paper is to examine university collaboration among micro-firms to establish: 1) the degree to which they develop collaborative links with universities and 2) identify the characteristics of micro-firms which influence their propensity to engage in these collaborations.

Design/methodology/approach

Using data from the Longitudinal Small Business Survey, we utilise a logistic regression model that uses a sample of 1001 UK micro-firms (those with < 10 employees) to test a set of hypotheses examining the influence of the firms' networking, performance, capabilities, and location on university collaboration.

Findings

The propensity of micro-firms to collaborate with universities is based on three key factors. Firstly, university collaboration is typically part of a range of collaborative links for micro-firms. Secondly, the need for knowledge to underpin competitiveness in export markets also drives micro-firm's university collaborations. Finally, micro-firms' university collaboration is related to the knowledge intensity of their location, with those in less knowledge intensive regions more likely to collaborate with universities.

Originality/Value

The study responds to calls for a greater focus on the open innovation activities of micro-firms through presenting a systematic examination of the propensity of these firms to engage in university collaboration. The paper therefore contributes new insights into micro-firms, namely that university collaboration is part of a broader engagement strategy with a range of external partners. Furthermore, as university collaboration is more likely among those that are engaged with actors that are organisationally similar to universities, we posit that organisational proximity is an important consideration in the formation of these collaborative links. Thirdly, we identify a 'market push effect', where engaging in exporting increases the propensity to collaborate with universities, and 'location push effect', whereby those micro-firms located in less knowledge intensive regions are driven towards university collaboration as there are fewer alternative partners with which to pursue OI

Key Words: university-industry links; open innovation; micro-firms; collaboration

1. Introduction

Two key themes emerge from the extant literature on Open Innovation (OI). The first suggests that smaller firms stand to benefit most from OI due to the parsimony of their resources (Bogers et al., 2018; De Marco et al., 2020; Huizingh, 2011; Vahter et al., 2014; Wang et al., 2022; West & Bogers, 2014; Wynarczyk, 2013). Given this observation, micro-firms, which tend to possess the fewest resources and suffer most from the 'liability of smallness,' stand to benefit significantly from engaging in OI (Dahlander & Gann, 2010). While specific insights into the OI practices of micro-firms (those employing fewer than 10 workers) are rare, the leitmotif within the existing literature is that these firms' OI efforts are 'sub-optimal,' exhibiting lower levels of collaboration compared to small or medium-sized firms (Hewitt-Dundas & Roper, 2017; Spithoven et al., 2013; Teirlinck & Spithoven, 2019). Yet, despite their sub-optimal engagement in OI there is evidence that micro-firms are innovative despite their resource constraints (Baumann & Kritikos, 2016; Hewitt-Dundas & Roper, 2017), leading to calls for the OI activities of micro-firms to be examined further (Freel & Robson, 2017). Indeed, given that there are over 1.1 million micro-firms currently registered in the UK, representing around 82% of all firms and 22% of total employment (Department for Business, Energy, and Industrial Strategy, 2022), this represents fertile territory for new insights into OI.

A second theme in the extant literature suggests that universities are key partners in the OI process (Bogers et al., 2018; H. Chesbrough, 2017; Dahlander et al., 2021; Enkel et al., 2009; Gassmann, 2006). Indeed, the benefits to smaller firms from university collaborations are well documented suggesting that for resource constrained micro-firms they may be useful partners (Dada & Fogg, 2016; Fontana et al., 2006; Johnston & Huggins, 2021; Jones & Corral de Zubielqui, 2017). As existing evidence suggests that, when it comes to collaborative partners, micro-firms prefer separating cooperation from competition (Granata et al., 2018), universities would appear to be appropriate collaborative partners for those micro-firms engaging in OI (Lavie & Drori, 2012; Messeni Petruzzelli & Rotolo, 2015). Indeed, the wider literature on SMEs' collaboration with universities suggests that such linkages allow

smaller firms to boost their knowledge resources, enhance their organisational learning, and be more innovative (Bishop et al., 2011; Dada & Fogg, 2016; Messeni Petruzzelli & Murgia, 2021). Yet, despite the apparent gains available to smaller firms from university collaboration, evidence from studies on OI and micro-firms have highlighted the university collaboration is typically eschewed by these firms in favour of external collaborations based on trading relationships (Chell & Baines, 2000; Phillipson et al., 2006).

Given this evidence, there is a need to systematically examine the extent to which micro-firms' pursue OI activities through collaborations with universities to better understand the extent and drivers of these links. Therefore, the aim of this paper is to: 1) establish the degree to which micro-firms report collaborative links with universities, and 2) identify the characteristics of micro-firms which influence their propensity to engage in these collaborations. To achieve these objectives, data on UK based micro-firms from the Longitudinal Small Business Survey (Department for Business, Energy and Industrial Strategy, 2022) is used to test a set of hypotheses relating to the extent to which characteristics such as networking, capabilities, and performance influence micro-firms' pursuit of OI through university collaboration.

The results presented in this paper provide new insights into micro-firms' collaboration with universities. In broad terms, we suggest that university collaboration is driven by the micro-firms' existing networks, their performance, and their location. These results highlight three new contributions to the literature: 1) university collaboration is one element of micro firms' open innovation and is undertaken alongside activities with a range of other external partners; 2) as university collaboration is more likely among those that are engaged with actors that are organisationally similar to universities, we posit that organisational proximity is an important consideration in the formation of these collaborative links; and 3) we identify a 'market push effect', where engaging in exporting increases the propensity to collaborate with universities, and a 'location push effect', whereby those micro-firms located in less knowledge intensive regions or where firm

diversity is lower are driven towards university collaboration as there are fewer alternative partners with which to pursue OI are identified. The paper is organised as follows. Section 2 sets out the conceptual framework. Section 3 then outlines the data and methods used. Section 4 outlines the results, while Section 5 discusses their theoretical implications. Finally, Section 6 concludes.

2. Conceptual Framework and Literature Review

2.1 Open Innovation and Micro-Firms

Open innovation captures a process whereby firms utilise knowledge from outside their boundaries (inflows), seek to commercialise their own knowledge through collaboration with others (outflows), or a combination of both (Chesbrough, 2003; Enkel et al., 2009; Nambisan et al., 2018). One key theme pervading the OI literature is that for smaller firms, typically viewed as resource constrained and lacking the internal knowledge to innovate, open innovation is something of a panacea (van Burg et al., 2012). Consequently, the procurement of knowledge through inter-organisational networks is posited as the key mechanism for promoting innovation in smaller firms who may lack the resources to realise this alone (Freel & Robson, 2017; Gentile-Lüdecke et al., 2020; S. Lee et al., 2010; Livieratos et al., 2022; Van de Vrande et al., 2009).

Importantly, there is evidence that while micro-firms do adopt OI practices (Bigliardi & Galati, 2016; Faherty & Stephens, 2016; Oakey, 2013; Wynarczyk, 2013), their adoption rates are a significantly lower than for larger firms (Barham et al., 2020). Yet, while smaller firms may be less open than their larger counterparts, they tend to have a higher marginal gain from each additional linkage, highlighting the value of OI (Vahter et al., 2014). Indeed, the extant literature presents evidence to highlight the innovativeness of micro-firms (Baumann & Kritikos, 2016; Hewitt-Dundas & Roper, 2017). Furthermore, despite suggestions that the OI efforts of micro-firms are sub-optimal (Hewitt-Dundas & Roper, 2017), there is also evidence that micro-firms do collaborate externally, typically focussing on actors with which they have trading relationships (Chell & Baines, 2000; Phillipson et al., 2006). However, as Hewitt-Dundas and Roper (2018) argue, micro-firms tend to be less established within

their markets and possess far fewer knowledge resources as well as less-developed supply chains. Indeed, as OI is not always costless or successful (Chaudhary et al., 2022; Christensen, 1997; Lauritzen & Karafyllia, 2019), micro-firms' participation in such activities can be seen as inherently risky.

2.2 Open Innovation and University Collaboration: The Micro-Firms Perspective

A second theme within the OI literature is the importance of university collaboration for procuring external knowledge (Huggins et al., 2020; Janeiro et al., 2013; Perkmann & Walsh, 2007). Indeed, universities by their nature are typically 'open' in nature, as one of the key roles is to create and disseminate knowledge into wider society (Striukova & Rayna, 2015). As OI scholars have shifted their attention towards the activities of smaller firms, greater attention has been placed on collaborations between SMEs and universities (Johnston and Huggins, 2021). Yet, while firm size has been shown to have a negative effect on a firm's propensity to develop a U-I linkage (Laursen & Salter, 2004; Maietta, 2015), the tendency of micro-firms to separate cooperation from competition (Granata et al., 2018) suggests that universities could be suitable collaborative partners for OI (Lavie & Drori, 2012; Messeni Petruzzelli & Rotolo, 2015).

The extant OI literature provides several broad insights into U-I links involving small firms. This literature has been summarised in detail elsewhere (Johnston & Huggins, 2021), but in brief, scholars have shown that university engagement brings multiple advantages to SMEs through boosting innovation capabilities, improving knowledge and expertise, and enhancing problem solving capacity (Apa et al., 2021; Dada & Fogg, 2016; Messeni Petruzzelli & Murgia, 2021; Wang et al., 2022). Indeed, for small firms, collaboration with universities has been shown to boost their knowledge resources, promote learning, and facilitate innovation (Bishop et al., 2011; Dada & Fogg, 2016; Messeni Petruzzelli & Murgia, 2023).

Importantly, for resource constrained micro-firms the risk of a failed collaboration may be detrimental to its very existence, as not all university collaborations successfully implement their ideas or create a viable output (Johnston & Huggins, 2021). Furthermore, university collaboration consumes scarce firm

resources regardless of the outcome of the project (Johnston, 2022). Therefore, for micro-firms, the potential benefits from engaging in university collaboration may be outweighed by the additional resources consumed through engaging in external collaboration.

As little is known about the specifics of U-I collaboration patterns of micro-firms, we set out a general framework that draws on empirical work relating to U-I links among SME sector more broadly to assess which may be important determinants of U-I collaboration among micro-firms alone. The remainder of this section examines each in turn and sets out several hypotheses with respect to the drivers of university collaboration amongst micro-firms.

First, the extant OI literature stresses the importance of firms' ability to utilise networks and develop links with actors within their external ecosystem (Ankrah & AL-Tabbaa, 2015; Johnston, 2022; Liu et al., 2021). While networking is an important part of the open innovation process (Corredoira & McDermott, 2020; Huggins & Thompson, 2017), the evidence with respect to the networking behaviours of micro businesses is mixed. For example, there is evidence that micro-firms are much less likely to be well networked than other SMEs (Greenbank, 2000). In contrast, where micro businesses are involved in networking, their links tend to be confined to trading relationships (Chell & Baines, 2000; Phillipson et al., 2006).

Importantly, the existence of links with external actors such as customers, suppliers, rivals, public and private sector laboratories or government organisations has been found to act as a signal for the overall openness of the firm and its proclivity towards external collaboration (Laursen & Salter, 2006). Furthermore, given the socio-technical nature of the collaboration process, existing links with external actors suggests that a firm possesses, or can develop, the social, technological, and organisational proximity to work effectively with other organisations (Johnston, 2022; Knoben & Oerlemans, 2006; Messeni Petruzzelli & Murgia, 2021). Therefore, those micro-firms that have developed relationships within their supply chains will also possess the ability to collaborate with other external actors (Capone & Zampi, 2019; Hakami et al., 2022; Johnston, 2022; Marrocu et al., 2013). Consequently, while micro-

firms may be resource constrained, their stance towards and ability to develop external connections and collaborations may offer mitigation. Therefore, our first hypothesis states that:

> **Hypothesis 1:** a positive relationship exists between the extent of the collaborative networks of micro-firms and their propensity to collaborate with universities.

Importantly, OI also relies on a firm's ability to absorb and utilise knowledge to innovate (Bogers et al., 2018; Han et al., 2020; Huizingh, 2011). Therefore, as well as access to networks, OI is also influenced by the capabilities possessed by a firm to absorb and manage knowledge as well as transform it into new outputs (Cohen & Levinthal, 1990; Lichtenthaler & Lichtenthaler, 2009; Melnychuk et al., 2021; Muscio, 2007). Furthermore, firm capabilities such as financial management, strategy formation, and management of the workforce are crucial to the successful operation of a business (Kor & Mahoney, 2005; Teece et al., 2016). Indeed, innovation is one of many concurrent activities undertaken within small firms, suggesting that a range of capabilities drive the ability of these firms to introduce new products, services, and processes (Saunila, 2014).

The extant literature is also clear that micro-firms possess distinct capabilities despite their lack of resources (Kevill et al., 2021; Rastrollo-Horrillo, 2021). In addition, among the broader SME population, higher levels of innovation and organisational management capabilities have been found to have a positive influence on the propensity for SMEs to develop collaborative linkages with universities (Giuliani & Arza, 2009). As such, firm capabilities underpin a wide range of activities within firms and that their existence underpins not only innovation but engagement with universities. Therefore, while micro firms may be resource constrained, there is no evidence to suggest that they lack capabilities. As such, our second hypothesis suggests that:

> **Hypothesis 2:** a positive relationship exists between the capabilities of micro-firms and their propensity to collaborate with universities.

In general, the extant literature presents evidence that SME performance signals innovativeness (Audretsch et al., 2023), particularly with respect to productivity, or output per worker (Baumann & Kritikos, 2016; Hall et al., 2009; Saunila, 2014). For micro-firms, a similar relationship is observed between labour productivity and innovativeness (Baumann & Kritikos, 2016). Therefore, those firms that outperform others in terms of efficiency are generally more innovative, suggesting they have a higher demand for knowledge.

In addition, broader measures of performance, such as engaging in the export of goods/services are also positively related to innovation in SMEs (Andersson & Lööf, 2012; Love & Roper, 2015; Roper & Love, 2002). This is typically explained by the fact that overseas markets are more competitive, suggesting that export orientated SMEs have to offer either superior goods or services to their rivals or a larger range to tailor outputs to different markets (Westhead et al., 2004). Furthermore, as Love and Roper (2015) argue, SMEs that compete in foreign markets are more likely to undertake higher levels of market research and have broader supply chains; therefore, they interact with a greater number of external actors. As such, this evidence suggests that export performance promotes innovation and openness among SMEs. Therefore, the superior export performance of micro-firms can be interpreted as a signal for increased demand for knowledge for innovation. Given this evidence, our third hypothesis suggests that:

> **Hypothesis 3:** a positive relationship exists between the performance of micro-firms and their propensity to collaborate with universities.

3. Data and Method

To test the hypotheses set out in this paper, data from the Longitudinal Small Business Survey (LSBS) is utilised (Department for Business, Energy and Industrial Strategy, 2022). While this dataset covers around 15,000 firms, this paper's focus on the university collaboration, meant that the data utilised is from the 2015 iteration of the survey as this question was not asked in subsequent years. However, existing data sources on innovation activities, e.g. the Community Innovation Survey, tend to overlook

micro-firms making the LSBS a valuable insight into the innovation activities of a hard-to-reach firm population. Accordingly, micro-firms were identified according to standard definitions as those employing between 1 and 9 people (Gherhes et al., 2016; Wilson et al., 2022). In total, the dataset contained details of 2004 micro businesses.

3.1 Analytical approach

The analysis presented in this paper utilises a logistic regression model (1) to assess the probability that firm *i* was involved in a collaboration with a university. The model takes the following form:

$$(1)\ UC_i = \alpha + \beta X_i + \varepsilon_i$$

where, UC_i captures whether firm i collaborated with a university on innovation or not, α is a constant parameter, β represents model coefficients, with X representing a vector of firm characteristics and location characteristics. Finally, ε_i captures the variance unaccounted for by the model. Expanding the model gives the following equation for estimation:

$$(2)\ UC_i = \alpha + \beta_1 NO_i + \beta_2 P_i + \beta_3 C_i + \beta_4 S_i + \beta_5 Z_i + \varepsilon_i$$

with NO being the networking/open innovation activities of micro businesses, P their performance, C the firms' capabilities, S firm controls, and finally Z is a vector of location variables.

3.2 Variables

Dependent variable

The extant literature on university collaboration outlines a wide range of activities that underpin these partnerships (Ankrah & AL-Tabbaa, 2015; D'Este & Patel, 2007; Perkmann & Walsh, 2007). The nature of the LSBS means the binary dependent variable (UC) captures whether a micro business reported that it had introduced an innovation in the previous 3 years through a collaboration with a university or other higher education institution or otherwise. As such, the dependent variable captures *successful* collaborations with universities in that they have resulted in the introduction of an

innovation. While we acknowledge that university collaboration can also involve informal activities as well as unsuccessful outcomes (Apa et al., 2021; Johnston, 2022), the nature of the LSBS necessitates a binary dependent variable.

Independent variables

To test the hypotheses outlined in Section 2, a broad range of variables were used to assess the characteristics of micro businesses. Firstly, networking activity and openness of the firms were captured through dummy variables that highlighted whether the firm had collaborated with the following in the previous three years: a) other businesses within firm's enterprise group, b) suppliers of equipment, materials, services or software, c) clients or customers from the private sector, d) clients or customers from the public sector, e) competitors or other businesses in the firm's industry, f) consultants, commercial labs or private R&D institutes, or g) government or public research institutes.

Firm performance was captured using two variables: firm productivity and a dummy variable that captured whether the firm was an exporter. The productivity measure employed in the paper is calculated by dividing the turnover of firm *i* by its employment:

$$Productivity_i = \frac{Turnover_i}{Employment_i}$$

This measure of productivity is widely adopted in the literature and captures the resource efficiency of micro-firms in terms of their revenue, or sales, per worker (Baumann & Kritikos, 2016; Muzi et al., 2023; Johnston & Prokop, 2024). While other scholars have captured productivity in greater detail, incorporating materials, physical capital, knowledge, and data as well as labour inputs (Wu et al., 2020), data availability restricts us to this measure of productivity. However, scholars using revenue/sales per worker as measure of productivity have highlighted a positive relationship with innovation and firm survival, validating this approach (Baumann & Kritikos, 2016).

Firm capabilities were included in the model using the measures captured in the LSBS through a set of five ordinal-type measures focussed on: a) people and management, b) developing and implementing

a business plan and strategy, c) developing and introducing new products or services, d) accessing external finance, e) operational management. These are measured on a scale of 1-5, with 5 representing the highest level of capabilities.

Control Variables

Several control variables were included in the model. Firstly, the age of the firm was included, captured on an ordinal scale from 0-9 as no continuous variable available in the 2015 version of the LSBS. In addition, as OI relies on accessing networks and external knowledge resources, it is regarded as location dependent (Love & Roper, 2001; Tojeiro-Rivero & Moreno, 2019); therefore the proclivity of firms towards networking and collaborative behaviours, crucial for underpinning OI activities, varies spatially as different cultures and organisational working may be found in different places (Fritsch, 2003; Huggins & Thompson, 2015; Lechner et al., 2006). Furthermore, the knowledge base of regions may vary, meaning firms have access to differing but distinct knowledge sources (Presutti et al., 2011; Tojeiro-Rivero & Moreno, 2019). Given these arguments we also control for the socio-economic characteristics of the SMEs' location. These were integrated into the model through using NUTS 1 level data on gross expenditure on research and development (GERD) per capita, regional employment levels, and industrial structure were obtained from the Office for National Statistics (ONS) and matched to each firm's region. While the first two are self-explanatory, our industrial specialisation variable was adopted from Fotopoulos (2014). Essentially, this variable is based on the industrial specialisation of a NUTS 1 region across 14 industrial sectors in comparison to the rest of the country (Fotopoulos, 2014). A similar regional-level approach has been used by Prokop et al. (2019), where a detailed description of the variable construction is available.

A summary of the data is presented in Appendix 1, where Table A1 along with descriptive statistics for the variables included in the analysis. Table A2 presents a correlation matrix and highlights no issues with multicollinearity. However, in order to assure the robustness of the analysis we use standardised

variables in the regression. Furthermore, as all VIF figures were under 5, no issues of multicollinearity are apparent.

While 2004 micro-firms were identified as fitting the criteria of having fewer than 10 employees, due to missing data the regression analysis used 1001 observations (50%). Tests of differences between the included and excluded observations found no statistically significant differences in levels of university collaboration between the two groups, with 10.8 % of the firms included in the model reporting a successful university collaboration compared with 10.1% for all micro firms (Mann-Whitney Test: Chi-square = 0.955, p= 0.328). However, further tests revealed statistically significant differences in age distribution, exporting, people management capabilities, and finance capabilities which are all slightly lower among the sub-sample of micro-firms that were included in the model. However, examining the relationships between these variables and university engagement for the whole cohort of micro-firms via bi-variate analysis revealed that the relationships were the same in terms of sign and significance as in the final model, suggesting that there is no bias within the sub-sample that would undermine the robustness of the regression model.

4. Findings

Using a Mann-Whitney Test of Difference, we first compare the proportion of micro-firms in the LSBS dataset (i.e. those firms with 1-9 employees) collaborating with universities with the proportion of the remaining SMEs in the LSBS dataset (i.e. those with 10-249 employees) collaborating with universities. The findings illustrate that micro-firms are less likely to collaborate with a university than SMEs overall (Mann-Whitney U Test: Chi Squared = 19.930; P=0.00). As illustrated in Table 1, around 10% of micro-firms report a university collaboration compared with 14% for all SMEs. Yet, while they may be less likely than other SMEs to collaborate with universities, this evidence confirms that micro-firms do innovate through establishing linkages with universities.

Table 1 around here

Table 2 presents the logistic regression models. Models 1-5 highlight the various specifications of the model to highlight robustness. The full model is presented in Model 6, and Model 7 (with robust standard errors). In addition, Model 8 presents a Probit model as a robustness check and presents similar results in terms of significance and direction of relationships.

The first result highlighted by the analysis is that micro-firms are relatively homogenous in their collaborations with universities as characteristics such as the total number of employees or the age of the firm have no effect on their propensity to collaborate with universities. In addition, the final model finds no evidence that industrial sector has a bearing on the propensity to collaborate with a university confirming their homogeneity.

Instead, it is the openness and networking behaviours of micro-firms that have a significant and positive effect on their propensity to collaborate with universities, confirming Hypothesis 1 which suggested that overall openness of the firms in terms of collaborations with other external actors would have a positive effect on collaborating with a university. Therefore, a proclivity towards open innovation involving members of the same enterprise group ($\beta=0.524$, $p<0.05$), customers from both private ($\beta=0.645$, $p<0.001$) and public sectors ($\beta=1.267$, $p<0.001$), consultants and private laboratories ($\beta=0.788$, $p<0.001$), and government or private research institutes ($\beta=1.057$, $p<0.001$) suggests that a micro firm is more likely to collaborate with a university.

Furthermore, the analysis reveals more fine-grained insights into the effect of engaging in open innovation with specific partners. For example, the highest coefficients are found on the public sector customers ($\beta=1.267$, $p<0.001$) and government or PRIs variables ($\beta=1.057$, $p<0.001$), suggesting that university collaborations are more likely where the firms are also collaborating with partners that are organisationally similar to universities. These findings also provide confirmation of previous work that suggests micro-firms prefer to separate competition from collaboration as collaboration with non-competitive actors has the highest marginal influence on university collaboration, while rival firms are not a significant factor.

Hypothesis 2 suggested that the capabilities of micro-firms will have a positive effect on their propensity to collaborate with universities. However, the analysis suggests that the capabilities possessed by micro-firms do not influence their propensity to collaborate with universities as none of the coefficients on these variables are significant. Therefore, the relative capabilities of micro-firms are not responsible for differing levels of engagement with universities and Hypothesis 2 is rejected.

Hypothesis 3 suggested that firm performance has a positive effect on the propensity of micro-firms to collaborate with universities. However, this hypothesis is only supported in terms of export performance ($\beta=0.014$, $p<0.001$) as the analysis suggests that productivity is not a significant factor. Therefore, it is not the efficiency of the firm in terms of revenues per worker that determines the propensity of micro-firms to engage in university collaboration but their participation in more competitive markets. Thus, exporting may act as a driver for university collaboration as export markets demand more innovative products and services, more efficient production techniques, and an emphasis on business model adaptation to suit different markets. In the same vein, we argue that internationalisation promotes the university collaboration among micro-firms as this enables the firm to gain access to the knowledge required for the innovation needed to be successful in these markets.

Finally, the results show that location is important in terms of the knowledge intensity of the immediate region in which the firm is based. However, this relationship is in fact negative, suggesting that micro-firms in more knowledge-intensive regions are less likely to collaborate with a university ($\beta=-0.502$, $p<0.001$). In addition, we observe a negative relationship between the level of specialisation in the region in terms of employment and university collaboration ($\beta=0.-274$, $p<0.05$). Therefore, micro-firms located in regions with a more specialised economic structure are less likely to collaborate with a university. Given this result it appears that diversity is an important driver, suggesting that a regional economy with containing fewer similar firms pushes these firms towards universities as a collaborative partner.

In summary, the analysis suggests that networking, performance, and location are all important factors influencing the propensity of micro-firms to collaborate with universities. Networking in terms of a proclivity to open innovation activities with other actors makes university collaboration more likely as does higher levels of export revenues. In contrast, being located in a more knowledge intensive region or a region with a greater level of economic specialisation makes university collaboration less likely.

Table 2 around here

5. Discussion

Several theoretical implications for open innovation from the findings presented. The first implication is that, for micro-firms, university collaborations do not represent stand-alone behaviour as they form one part of their wider OI engagement. Therefore, micro-firms' university collaborations can be viewed as one aspect of their OI activities. Consequently, this behaviour signifies the *recognition* of a lack of resources within micro-firms, as those pursuing university collaborations are doing so while concurrently developing collaborative links with a range of partners to actively pursue the means to address their knowledge asset parsimony. While universities are regarded as an important means to address lack of knowledge for innovation (Apa et al., 2021; Dada & Fogg, 2016; Messeni Petruzzelli & Murgia, 2021), for micro-firms they can be considered as complementary to other sources of knowledge when it comes to open innovation.

The second implication of the findings is that as those micro-firms collaborating with universities are those that are more likely to be engaged with other non-market actors such as public laboratories or customers from the public sector. Therefore, those micro-firms most likely to be engaging with universities are those who not only recognise their own knowledge asset parsimony but also possess a preference for collaborating with non-market or non-competitive actors. Consequently, we posit that organisational proximity is an important consideration in the formation of collaborative links between micro-firms and universities (Aguilera et al., 2012; Knoben & Oerlemans, 2006). Where

micro-firms pursue OI through university collaboration, their preference or ability to work in a certain manner that drives the formation of links with specific actors such as universities. Indeed, as collaboration with universities has been found to minimise cooperation failures (Lhuillery & Pfister, 2009), this appears to be a rational strategy for firms where the consequences of failure are increased due to a lack of resources and where the leakage or spillover of knowledge to competitors could have a significant impact on the firm. Therefore, micro-firms may eschew coopetition for the 'safer' process of university collaboration (Granata et al., 2018; M. J. Lee & Roh, 2023). Given these findings, we propose a more nuanced understanding of OI through university collaboration among micro-firms by suggesting that university collaboration can be regarded as a solution for micro-firms' relative lack of resources where the firms possess a preference for collaboration to coopetition.

Importantly, while OI has been found to be influenced by the capabilities possessed by a firm to absorb, manage knowledge, and transform it into new outputs (Cohen & Levinthal, 1990; Lichtenthaler & Lichtenthaler, 2009; Melnychuk et al., 2021; Muscio, 2007), in the case of micro-firms their relative level of capabilities does not have any effect on their propensity to engage in university collaboration. While firm capabilities such as financial management, strategy formation, and management of the workforce have been highlighted as being important determinants of success of micro-firms (Kevill et al., 2021), in the case of micro-firms their homogeneity in terms of these capabilities do not differentiate the firms in terms of university collaboration. While the study does not examine the causes of variations in these capabilities within the firms, based on the extant literature we offer some insights to explore this finding in more detail. Importantly, we note that while absorptive capacity is a clear determinant of the capability to engage in OI (Spithoven et al., 2011), university collaboration has also been shown to increase the absorptive capacity of SMEs (Apa et al., 2021). Consequently, we posit that in the case of micro-firms these capabilities may not determine their propensity to engage in university collaboration, but they may instead develop through the course of the collaboration(Kobarg et al., 2018). While this finding diverges from the extant literature which suggests capabilities and the ability to absorb knowledge is important in the formation and

function of university-industry collaborations (Apa et al., 2021; Bishop et al., 2011; Fabrizio, 2009), we suggest that micro-firms collaborating with universities may require time to develop these capabilities during their collaborations. Therefore, any differences in capabilities and absorptive capacity among micro-firms may be evident in the medium to long-term following a university collaboration. Given this, we suggest that examining the temporal aspect of micro-firms' university collaborations as a future avenue to explore.

The third implication of the results is the suggestion of a market driven motive for micro-firms' collaboration with universities (Cassiman & Golovko, 2011; Esteve-Pérez & Rodríguez, 2012). With export markets tending to be more competitive and more difficult to enter, the results give further credence that micro-firms' university collaborations are driven by a 'market push effect' that prioritises the exploitation of knowledge for commercialisation, rather than any proclivity towards exploration (Yang et al., 2014). As such, the need for knowledge to innovate and improve their products and services to survive in the competitive markets in which they operate is the motivation for university collaboration as engaging in more competitive markets may magnify the micro-firms' lack of knowledge and act as a push towards pursuing these collaborations to fill this gap. From this, we infer that the preference for collaborative links with universities among micro-firms is driven by commercial gain. Indeed, as internationalisation drives innovation (Cassiman & Golovko, 2011), it also provides the impetus for the formation of university links for micro-firms as they seek to improve goods/services, processes, and their business model to remain competitive.

Importantly, in terms of performance, productivity levels do not appear to be a useful predictor of university collaboration among micro-firms. The extant literature is clear SMEs' performance signals their innovativeness (Audretsch et al., 2023). Furthermore, the extant literature suggests that productivity, or output per worker, is also positively related to innovativeness (Baumann & Kritikos, 2016; Hall et al., 2009; Saunila, 2014), and this relationship also holds for micro-firms (Baumann & Kritikos, 2016). Indeed, engaging in OI has been found to have a positive influence on labour

productivity within the firm and its R&D activities (Caputo et al., 2016; Greco et al., 2021), motivating our investigation into its role in promoting university collaborations among micro-firms. As such, the fact that no relationship is found between productivity in micro-firms and university collaboration suggests that engaging in OI promotes changes in firm productivity rather than differences in firm productivity promoting variations in engagement in OI.

Finally, university collaboration among micro-firms appears to be driven by the recognition of a need for knowledge coupled with a lack of alternative sources from which to obtain it. Indeed, open innovation is recognised as location dependent, emphasising access local networks to procure external knowledge resources (Love & Roper, 2001; Tojeiro-Rivero & Moreno, 2019). Therefore, in less knowledge-intensive regions, micro firms use the university as a substitute for private sector knowledge creators (Zhang et al., 2016). This highlights a 'location push effect' whereby context is an important factor when examining the OI process; it is not simply a matter of suggesting all resource constrained micro-firms should be collaborating with universities but understanding which actors are available to them as potential collaborative partners. Therefore, where OI among micro-firms focuses on university collaboration, the location push effect means this is driven by a lack of choice rather than an active strategy. This reinforces the fact that, for micro firms, universities complement other external sources when they are available but for those in locations with fewer options, they are a substitute.

6. Conclusions

Given the predominance of micro-firms within the overall firm population, this paper examined the factors that influence their propensity to collaborate with universities. Firstly, the results establish that micro-firms do collaborate with universities. Therefore, despite assertions that micro-firms' networking tends to focus on trading relationships (Chell & Baines, 2000; Phillipson et al., 2006), this insight shows that universities are potential collaborative partners for micro-firms to pursue open

innovation. Secondly, we theorise that the propensity of micro-firms to collaborate with universities is based on three key factors: their networking behaviour, performance, and location.

For micro-firms, university collaboration is part of an overall systemic approach to innovation where university collaborations are only part of a package of interactions. Indeed, as micro-firms tend to shy away from coopetition (Granata et al., 2018), collaborating with non-rival organisations are important predictors of university collaboration. In addition, we identify two important effects that influence the propensity of micro-firms to collaborate with universities. The first is a 'market push effect', where engaging in exporting increases the propensity to collaborate with universities. Here, the university collaboration is driven by a need to constantly update products, services, processes, or business models to stay competitive across many markets. The second is a 'location push effect', whereby those micro-firms located in less knowledge intensive regions or where firm diversity is lower are driven towards university collaboration as there are fewer alternative partners with which to pursue OI.

Consequently, these insights make a new contribution through examining an under-researched area of open innovation and present new insights into the process of university collaboration in the context of micro-firms. Indeed, as open innovation continues to be an important ambition of policymakers (De Marco et al., 2020; Herstad et al., 2010), the findings also have important implications that provide a rationale for innovation policy. Encouraging greater numbers of micro-firms to collaborate with universities should entail focussing on identifying those most likely to match the characteristics identified in this paper and supporting effective formation and function of the projects. Therefore, for technology transfer officers it is important to illustrate the benefits of university collaboration to these firms and the entrepreneurs that own and operate them. Furthermore, policy initiatives to support collaborations between micro-firms and universities may be best targeted at less knowledge intensive regions to take advantage of the locational push effect we identify.

While the paper provides important new insights, the paper represents a first step into looking at OI and university collaboration in the context of micro-firms meaning there are several limitations. First,

the nature of the dataset means that the types of collaboration undertaken by these firms is not known. Indeed, it would be useful to examine the nature of these collaborations in terms of a focus on products, services, processes, or business model innovation. In addition, further research is required to examine the interactions of micro-firms and universities to assess the level of formality of these links, what types of collaboration are occurring, and their purpose. Indeed, the specific impacts of university collaboration on micro-firms, such as boosting innovation capacity, gaining knowledge, enabling problem solving, and training the workforce (Apa et al., 2021; Bishop et al., 2011; Wang et al., 2022) requires more investigation to get a clear picture of the impacts of these collaboration beyond simply identifying which firms are likely to collaborate. Furthermore, as the activities of micro-firms typically revolve around the founder/entrepreneur it appears to be pertinent to examine the micro-foundations of OI activities to understand how the learning processes and activities of these individuals involved influence this (Love et al., 2014; Sengupta & Sena, 2020).

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Table 1: University Collaboration – Micro-firms and SMEs

	Micro-firms	Non-Micro SMEs
University Collaborator	203 (10.13%)***	806 (14.01%)***
No University Collaboration	1801 (89.87%)***	4940 (85.97%)***
n	2004	5746

*** Significant at 1% level, Mann-Whitney Test; Chi- squared = 19.930 (p=0.000)

Source: Authors' own work

Table 2: Regression Results

	Model 1 (Logit)			Model 2 (Logit)			Model 3 (Logit)			Model 4 (Logit)		
	B	SE	p	B	SE	p	B	SE	p	B	SE	p
Networking/Open Innovation												
Collaborates with Enterprise Group				0.558	(0.237)	**						
Collaborates with Suppliers				0.267	(0.251)							
Collaborates with Customers from Private Sector				0.667	(0.245)	***						
Collaborates with Customers from Public Sector				1.219	(0.241)	***						
Collaborates with Competitors				0.140	(0.249)							
Collaborates with Consultants or private Labs				0.780	(0.278)	***						
Collaborates with Government or PRIs				1.090	(0.365)	***						
Performance												
Exporter							0.016	(0.005)	***			
Productivity							-0.111	(0.141)				
Productivity2							-0.009	(0.028)				
Capabilities												
People management Capability										-0.056	(0.118)	
Strategic Capability										0.169	(0.13)	
Innovation Capability										0.062	(0.129)	
Finance Capability										0.008	(0.114)	
Operational Capability										0.016	(0.13)	
Controls												
Number of employees	2.543	(1.77)		2.410	(1.927)		2.386	(1.809)		2.368	(1.816)	
Age of Firm	-0.082	(0.089)		-0.002	(0.102)		-0.065	(0.091)		-0.080	(0.09)	
Production	0.025	(0.635)		0.538	(0.7)		0.071	(0.661)		0.061	(0.647)	
Manufacturing	-1.037	(0.543)	*	-0.653	(0.593)		-1.223	(0.561)	**	-1.054	(0.545)	*

Construction	-0.550	(0.55)		-0.715	(0.608)		-0.479	(0.559)		-0.540	(0.554)	
Wholesale/Retail	-1.278	(0.495)	***	-0.869	(0.548)		-1.311	(0.508)	***	-1.305	(0.497)	***
Transport/Storage	-0.822	(0.834)		-0.386	(0.885)		-0.967	(0.852)		-0.792	(0.836)	
Accommodation/Food	-1.147	(0.711)		-0.627	(0.769)		-1.153	(0.711)		-1.147	(0.711)	
Information/Communication	-0.107	(0.48)		-0.034	(0.539)		-0.347	(0.496)		-0.106	(0.484)	
Financial/Real Estate	-1.302	(0.821)		-0.490	(0.863)		-1.210	(0.834)		-1.336	(0.825)	
Professional/Scientific	-0.419	(0.435)		-0.167	(0.494)		-0.528	(0.445)		-0.446	(0.44)	
Administrative/Support	-0.962	(0.597)		-0.631	(0.647)		-0.965	(0.607)		-0.955	(0.602)	
Education	0.219	(0.571)		-0.198	(0.647)		0.095	(0.576)		0.228	(0.572)	
Health/Social Work	0.001	(0.553)		0.245	(0.606)		-0.037	(0.553)		0.039	(0.555)	
Arts/Entertainment	0.463	(0.61)		0.362	(0.695)		0.453	(0.613)		0.502	(0.617)	
GERD per Capita (NUTS 3 Region)	-0.373	(0.146)	**	-0.479	(0.162)	***	-0.390	(0.147)	***	-0.378	(0.146)	***
Employment (NUTS 3 Region	0.125	(0.135)		0.114	(0.15)		0.102	(0.138)		0.123	(0.136)	
Industrial Specialisation	-0.123	(0.111)		-0.256	(0.124)	**	-0.158	(0.114)		-0.117	(0.112)	
Urban	0.457	(0.276)	*	0.471	(0.3)		0.429	(0.277)		0.457	(0.277)	*
Constant	-0.259	(0.964)		-2.005	(1.081)	*	-0.390	(0.99)		-0.348	(0.978)	
LL	-322.065			-276.330			-316.289			-320.689		
AIC	684.131			606.661			678.579			691.377		
DF	19			26			22			24		
N	1001			1001			1001			1001		

*** Significant at the 1% level.

** Significant at the 5% level.

* Significant at the 10% level.

Table 2 – Cont'd

	Model 5 (Logit)			Model 6 (Logit)			Model 7 (Logit) robust SE			Model 8 (Probit)		
	B	SE	p	B	SE	p	B	SE	p	B	SE	p
Networking/Open Innovation												
Collaborates with Enterprise Group	0.518	(0.24)	**	0.524	(0.241)	**	0.524	(0.247)	**	0.255	(0.13)	**
Collaborates with Suppliers	0.255	(0.255)		0.277	(0.256)		0.277	(0.257)		0.155	(0.133)	
Collaborates with Customers from Private Sector	0.644	(0.247)	***	0.645	(0.247)	***	0.645	(0.249)	***	0.302	(0.13)	**
Collaborates with Customers from Public Sector	1.292	(0.246)	***	1.267	(0.247)	***	1.267	(0.248)	***	0.680	(0.132)	***
Collaborates with Competitors	0.158	(0.253)		0.140	(0.254)		0.140	(0.263)		0.097	(0.137)	
Collaborates with Consultants or private Labs	0.765	(0.28)	***	0.788	(0.282)	***	0.788	(0.289)	***	0.428	(0.156)	***
Collaborates with Government or PRIs	1.023	(0.37)	***	1.057	(0.372)	***	1.057	(0.385)	***	0.612	(0.214)	***
Performance												
Exporter	0.013	(0.005)	***	0.014	(0.006)	***	0.014	(0.006)	***	0.007	(0.003)	**
Productivity				-0.166	(0.162)		-0.166	(0.141)		-0.082	(0.087)	
Productivity2				-0.027	(0.031)		-0.027	(0.024)		-0.015	(0.018)	
Capabilities												
People management Capability	0.035	(0.127)		0.024	(0.127)		0.024	(0.134)		0.002	(0.067)	
Strategic Capability	0.145	(0.14)		0.158	(0.141)		0.158	(0.149)		0.078	(0.074)	
Innovation Capability	-0.062	(0.145)		-0.079	(0.146)		-0.079	(0.134)		-0.025	(0.078)	
Finance Capability	0.079	(0.129)		0.088	(0.129)		0.088	(0.141)		0.053	(0.067)	
Operational Capability	0.101	(0.142)		0.111	(0.143)		0.111	(0.149)		0.052	(0.074)	
Controls												
Number of employees	2.003	(2.029)		1.555	(2.081)		1.555	(1.963)		0.984	(1.098)	
Age of Firm	-0.013	(0.103)		-0.007	(0.103)		-0.007	(0.102)		-0.013	(0.055)	
Production	0.463	(0.713)		0.643	(0.73)		0.643	(0.647)		0.302	(0.401)	
Manufacturing	-0.868	(0.608)		-0.772	(0.614)		-0.772	(0.58)		-0.414	(0.329)	
Construction	-0.808	(0.619)		-0.704	(0.625)		-0.704	(0.627)		-0.329	(0.339)	

Wholesale/Retail	-0.983	(0.551)	*	-0.884	(0.558)		-0.884	(0.54)		-0.412	(0.296)	
Transport/Storage	-0.532	(0.89)		-0.423	(0.896)		-0.423	(0.853)		-0.226	(0.477)	
Accommodation/Food	-0.683	(0.77)		-0.680	(0.771)		-0.680	(0.679)		-0.415	(0.415)	
Information/Communication	-0.311	(0.561)		-0.281	(0.563)		-0.281	(0.554)		-0.127	(0.309)	
Financial/Real Estate	-0.619	(0.868)		-0.491	(0.877)		-0.491	(0.857)		-0.264	(0.448)	
Professional/Scientific	-0.337	(0.504)		-0.301	(0.505)		-0.301	(0.491)		-0.139	(0.278)	
Administrative/Support	-0.784	(0.66)		-0.687	(0.665)		-0.687	(0.653)		-0.324	(0.351)	
Education	-0.299	(0.648)		-0.299	(0.647)		-0.299	(0.628)		-0.139	(0.367)	
Health/Social Work	0.200	(0.61)		0.209	(0.609)		0.209	(0.618)		0.166	(0.339)	
Arts/Entertainment	0.282	(0.703)		0.312	(0.708)		0.312	(0.737)		0.234	(0.392)	
GERD per Capita (NUTS 3 Region)	-0.511	(0.163)	***	-0.502	(0.163)	***	-0.502	(0.161)	***	-0.269	(0.083)	
Employment (NUTS 3 Region	0.096	(0.151)		0.104	(0.152)		0.104	(0.151)		0.070	(0.079)	
Industrial Specialisation	-0.276	(0.126)	**	-0.274	(0.127)	**	-0.274	(0.128)	**	-0.137	(0.067)	
Urban	0.475	(0.304)		0.475	(0.305)		0.475	(0.306)		0.208	(0.155)	
Constant	-2.161	(1.113)	*	-2.421	(1.144)	**	-2.421	(1.083)	**	-1.303	(0.609)	
LL	-271.650			-271.066			-271.066			-271.398		
AIC	609.301			612.133			612.133			612.796		
DF	32			34			34			34		
N	1001			1001			1001			1001		

*** Significant at the 1% level.

** Significant at the 5% level.

* Significant at the 10% level.

Source: Authors' own work

Appendix

Table A1: Descriptive Statistics

Variable	min	max	mean	Sd
University Collaboration (DV)	0	1	0.108	0.302
Collaborates with Enterprise Group	0	1	0.29	0.45
Collaborates with Suppliers	0	1	0.57	0.50
Collaborates with Customers from Private Sector	0	1	0.42	0.49
Collaborates with Customers from Public Sector	0	1	0.25	0.43
Collaborates with Competitors	0	1	0.24	0.43
Collaborates with Consultants or private Labs	0	1	0.15	0.35
Collaborates with Government or PRIs	0	1	0.05	0.22
Productivity	60	15000000	175208.7	602766.6
Exporter	0	1	0.81	0.39
People management Capability	1	5	4.14	0.78
Strategic Capability	1	5	3.76	0.95
Innovation Capability	1	5	3.8	0.93
Finance Capability	1	5	3.05	1.32
Operational Capability	1	5	3.87	0.84
Number of employees	1	9	3.7	2.43
Age of Firm	1	9	7.57	1.45
Production	0	1	0.04	0.20
Manufacturing	0	1	0.11	0.31
Construction	0	1	0.06	0.24
Wholesale/Retail	0	1	0.18	0.39
Transport/Storage	0	1	0.02	0.15

Accommodation/Food	0	1	0.04	0.21
Information/Communication	0	1	0.09	0.29
Financial/Real Estate	0	1	0.04	0.19
Professional/Scientific	0	1	0.19	0.40
Administrative/Support	0	1	0.07	0.25
Education	0	1	0.03	0.18
Health/Social Work	0	1	0.04	0.20
Arts/Entertainment	0	1	0.02	0.15
Other Service	0	1	0.05	0.22
GERD per Capita (NUTS 1 Region)	200	909	511.96	204.65
Employment (NUTS 1 Region	717000	5042000	2998000	1125502
Industrial Specialisation	0.03	0.144	0.07	0.04
Urban	0	1	0.29	0.46

Source: Authors' own work

Table A2: Correlation Matrix

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	Dependent Variable - Colllaboration with HEIs	1																																	
2	Collaborates with Enterprise Group	.160**																																	
3	Collaborates with Suppliers	.069*	.167**																																
4	Collaborates with Customers from Private Sector	.142**	.170**	.146**																															
5	Collaborates with Customers from Public Sector	.250**	.135**	0.043	.165**																														
6	Collaborates with Competitors	.112**	.224**	.106**	.122**	.160**																													
7	Collaborates with Consultants or private Labs	.176**	.166**	.154**	.131**	.067*	.124**																												
8	Collaborates with Government or PRIs	.198**	.102**	.064*	0.061	.142**	.124**	.213**																											

9	Exporter	.104**	.121**	.072*	.132**	0.0006	0.0005	.122**	.120**																												
10	Productivity	-0.062	0.008	0.061	-0.012	-.130**	0.000	0.031	0.010	.079*																											
11	Productivity^2	0.013	0.030	0.045	0.034	-0.0006	-0.028	.067*	0.049	.078*	-.453**																										
12	People management Capability	-0.001	-0.041	-0.033	-0.027	0.003	0.002	-.072*	-0.031	-.111**	-0.025	-0.025																									
13	Strategic Capability	0.039	0.030	-0.026	-0.004	-0.017	0.027	0.041	-0.003	-0.008	0.038	0.015	.375**																								
14	Innovation Capability	0.010	0.018	.073*	0.045	0.024	0.042	0.035	0.031	0.049	-0.050	0.009	.170**	.280**																							
15	Finance Capability	0.008	-.068*	0.023	-.072*	-0.022	-0.023	-0.010	-0.034	-.094**	0.035	0.030	.177**	.261**	.136**																						
16	Operational Capability	0.018	-0.012	0.017	0.017	0.004	0.016	-.064*	-0.033	-.063*	0.046	0.015	.324**	.313**	.241**	.233**																					
17	Number of employees	0.035	0.024	0.001	-0.053	0.038	-0.026	0.011	-0.050	0.040	-.111**	-0.055	-0.049	0.023	0.010	.176**	.066*																				

18	Age of Firm	-0.028	-0.048	0.029	-.108**	-0.018	0.012	-0.011	-0.050	-.069*	.071*	0.000	0.019	-0.017	-0.038	.132**	0.034	.177**																
19	Production	0.008	-0.035	0.001	-0.026	-0.038	0.021	0.055	-0.026	-0.051	.091**	.096**	-0.006	-0.030	-.121**	.071*	-0.031	-.077*	.078*																
20	Manufacturing	-0.046	-0.020	0.011	-0.062	-0.053	-0.043	0.023	0.009	.124**	0.034	0.013	-.071*	-0.052	.085**	-0.007	-0.056	0.046	-0.014	-.072*															
21	Construction	0.004	0.055	0.015	.101**	0.046	0.029	-0.001	0.016	-.081**	0.042	0.002	0.033	-0.013	-0.024	0.008	0.066*	0.001	-0.001	-0.054	-.088**														
22	Wholesale/ Retail	-.080*	-0.034	0.045	-.069*	-.065*	0.000	-.063*	-0.027	-0.030	.110**	-0.032	0.031	0.037	.116**	0.030	-0.022	0.037	0.033	-.099**	-.162**	-.121**													
23	Transport/Storage	-0.012	-0.028	-0.048	0.039	0.002	-0.012	-0.028	-0.036	0.021	0.026	-0.009	0.039	0.006	-0.015	-0.021	-0.013	0.049	-0.002	-0.033	-0.054	-0.040	-.074*												
24	Accommodation/Food	-0.027	-.094**	-0.020	-.093**	0.013	-0.041	-0.047	-0.005	-.067*	-.088**	-0.025	0.030	0.004	0.047	0.013	0.029	.078*	0.038	-0.045	-.074*	-0.055	-.101**	-0.034											
25	Information/Communication	0.047	0.019	-0.005	.077*	0.062	0.024	-0.003	0.022	.147**	-0.014	-0.027	-0.013	-0.036	0.031	-.084**	.071*	-.103**	-.122**	-.066*	-.109**	-.081*	-.149**	-0.050	-.068*										
26	Financial/Real Estate	-0.034	-0.020	0.042	-0.027	-.075*	-0.012	-0.051	-0.021	-0.035	.102**	0.003	0.026	0.045	-0.032	0.056	0.013	0.004	-0.022	-0.041	-.067*	-0.050	-.092**	-0.031	-0.042	-0.062									

27	Professional/Scientific	0.016	.063*	0.042	.084**	-.093**	-0.024	0.061	0.012	0.033	-0.043	0.048	-0.035	.081*	-.078*	-0.037	-0.019	-.141**	-0.049	-.103**	-.169**	-.126**	-.232**	-.077*	-.105**	-.156**	-.096**							
28	Administrative/Support	-0.030	-0.007	0.019	0.020	-0.007	-0.032	-0.022	-0.044	-0.026	0.050	-0.015	0.002	-0.027	-0.052	0.028	.072*	.063*	0.005	-0.056	-.093**	-.069*	-.127**	-0.042	-0.058	-.085**	-0.053	-.133**						
29	Education	.062*	0.017	-0.042	0.059	.116**	0.026	0.051	0.059	0.009	-.113**	-0.013	0.017	-0.006	0.010	0.003	-0.023	0.055	-0.014	-0.039	-.064*	-0.047	-.087**	-0.029	-0.040	-0.058	-0.036	-.091**	-0.050					
30	Health/Social Work	0.058	0.023	-.105**	-0.043	.093**	-0.023	-0.043	-0.025	-0.052	-.135**	-0.014	0.014	-0.021	-0.031	0.022	-0.026	.119**	.088**	-0.043	-.071*	-0.053	-.097**	-0.032	-0.044	-.065*	-0.040	-.102**	-0.056	-0.038				
31	Arts/Entertainment	.072*	.072*	-0.022	-0.027	.077*	.095**	0.009	0.023	-0.028	-0.035	-0.018	-0.020	-0.022	-.071*	-0.036	-0.037	0.019	0.001	-0.033	-0.054	-0.040	-.074*	-0.025	-0.034	-0.050	-0.031	-.077*	-0.042	-0.029	-0.032			
32	GERD per Capita (NUTS 3 Region)	-.086**	0.000	0.005	0.005	0.030	0.037	.069*	-0.042	.071*	.082**	0.037	0.033	0.039	0.029	0.040	0.007	0.029	0.047	0.029	0.033	-0.052	-0.018	-0.006	-0.041	0.051	0.032	0.018	0.006	0.010	-0.039	-0.018		
33	Employment (NUTS 3 Region	-0.013	0.017	0.049	0.046	0.002	0.018	.110*	0.012	.133**	.094**	0.037	0.009	0.002	0.027	-0.057	-0.015	-0.015	-.067*	-.100**	0.011	-0.005	-0.039	-0.022	-0.043	.086**	.088**	0.039	0.015	0.032	-0.053	-0.031	.433**	
34	Industrial Specialisation	-0.005	0.017	0.037	.082**	-0.010	-0.034	.072*	.070*	.095**	-0.037	.078*	-0.051	-0.031	-0.026	-.069*	-0.013	-.066*	-.145**	0.000	-0.024	-0.020	-0.010	0.022	-0.039	-0.011	.066*	-0.004	0.025	0.008	-0.036	0.027	-.169**	.187**	
35	Urban	-.069*	-0.031	0.035	-0.027	-0.037	0.005	0.013	-0.050	-0.035	.072*	-0.030	-0.008	0.006	-0.018	0.022	-0.021	-0.015	.065*	.259**	.063*	0.007	-0.003	0.014	0.012	-0.044	-0.045	-.068*	-0.008	-0.021	-0.056	-0.001	.093**	-.163**	-.180**

*significant at the 5% level

** significant at the 1% level

Source: Author’s own work