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Peripherality and University collaboration: Evidence from Rural SMEs in the UK

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Abstract

While innovation is viewed as crucial means of promoting competitiveness of rural SMEs, rural areas can be blighted by an 'underdeveloped innovation environment'. Perhaps due to an urban bias in innovation research, open innovation through university collaboration among rural SMEs has not been extensively examined. Using a dataset of 880 rural SMEs from the UK, the paper suggests that rural SMEs are less likely to collaborate with a university than urban SMEs. Furthermore, higher numbers of employees and export revenues have a positive influence on the propensity to collaborate with a university. In addition, collaborating with organisations such as private laboratories and public sector research institutes increases the propensity to engage in university collaboration.

Key Words: rural SMEs; University-industry links; university collaboration; open innovation; rural development

1. Introduction

Increasing attention has been paid to innovation in a rural context as it is viewed as crucial means of promoting competitiveness of rural SMEs (Eder 2019). While rurality is not necessarily a barrier to innovation among SMEs (D North and Smallbone 2000; David North and Smallbone 2000), it has been argued that rural areas may be blighted by an 'underdeveloped innovation environment' due to poor infrastructure, lower trust, and under-developed markets for knowledge (Yin, Chen, and Li 2019). Therefore, while there is evidence that innovation is possible for rural SMEs, they may face constraints on their ability to undertake these activities due to their location. Moreover, these location-based constraints are in addition to the resource constraints faced by SMEs that impede their innovative activity (Hewitt-Dundas 2006). Consequently, rural SMEs may be doubly constrained when it comes to innovating.

Traditionally, Open Innovation (OI), the procurement of external knowledge through membership of inter-organisational networks, is posited as a response for SMEs that face size related resource constraints to effectively innovate (Huggins et al. 2015; Huizingh 2011; Vicente-Saez and Martinez-Fuentes 2018; Van de Vrande et al. 2009). OI allows SMEs to access knowledge they would not be able to develop alone through collaborating with external actors. Indeed, within this paradigm universities

are typically highlighted as a key partner in OI as they are regarded as creators and repositories of new knowledge (Dada and Fogg 2016; Gunasekaran, Rai, and Griffin 2011; Huggins et al. 2014).

Yet, opportunities to engage in OI through university collaboration may be limited for rural SMEs by the fact that universities are less prevalent in rural areas (Charles 2016). Indeed, not only are there fewer opportunities for rural SMEs to engage with universities, when they do occur the collaborations take place over larger distances possibly reducing their efficiency (A Johnston and Huggins 2016). Consequently, while open innovation through university collaboration may offer a solution to resource parsimony of rural SMEs, they still face locational constraints to developing successful collaborations.

Despite these constraints, there is evidence that rural SMEs are innovative (David North and Smallbone 2000; Reidolf 2016). Therefore, there appears to exist both the scope and motivation for these firms to engage in university collaboration. However, efforts to understand collaborative links between rural SMEs and universities are sparse, perhaps reflecting the urban bias that exists in innovation and enterprise studies, making in-depth examination of rural SMEs and their innovative activities less common (Eder 2019; Phillipson et al. 2019).

This paper addresses this gap in the extant literature through answering two research questions: 1) are rural SMEs less likely to engage in U-I collaboration than their urban counterparts? 2) Which characteristics of rural SMEs influence their propensity to collaborate with universities? Using a logit regression model that draws on data from the UK Longitudinal Small Business Survey to address these questions, the findings illustrate that 1) rural SMEs are overall less likely to engage in a university collaboration than their urban counterparts; 2) rural SMEs with higher numbers of employees and export revenues are more likely to collaborate with universities, as are those that collaborate with partners that are organisationally similar, i.e. public sector organisations and laboratories; and 3) the socio-economic characteristics of their home regions are not related to university collaboration among rural SMEs. This paper makes key contributions to the economic geography literature, firstly, it defines the extent and characteristics of rural SME-university collaboration adding to better understanding of innovation and development of remote rural areas; secondly, it builds on the existing evidence of SME-university collaboration through examining rural firms.

The paper is structured as follows: Section 2 presents the conceptual framework, setting out the hypotheses. This is followed by Section 3 which outlines the data sources and analytical techniques employed and Section 4 that presents the results. Section 5 discusses the implications of the findings, while Section 6 concludes and discusses the policy implications of the findings.

2. Conceptual Framework

2.1 Rural Resilience and Development and SME Innovation

Both rural development and resilience are important themes within regional economic development policy (Schouten et al., 2012). Indeed, rural SMEs have been identified as important drivers of the economic development of their environs (Agarwal, Rahman, and Errington 2009). Significantly, this relationship appears to be bi-directional, as the surroundings may also shape the behaviour of rural businesses (Steiner and Atterton 2015). Therefore, while businesses may play a key role in promoting the economic development and resilience of rural areas (Steiner and Atterton 2014), their performance may also be shaped by their location (McAdam, McConvery, and Armstrong 2004).

Promoting innovation within rural SMEs is viewed as an important mechanism for promoting the development of the rural economy (Leick and Lang 2018). However, rural regions may face significant

barriers to innovation as they lack the connectivity, digital infrastructure, human capital, mobility, and agglomeration economies enjoyed by urban regions (Bosworth et al. 2020; Leick and Lang 2018). Even if digital infrastructure becomes available in such regions, there is insufficient human capital to employ it (Salemink, Strijker, and Bosworth 2017)). In short, rural regions may be blighted by an 'underdeveloped innovation environment' (Yin et al, 2019), meaning that, due to their location, rural SMEs face significant constraints in terms of their ability to innovate.

In spite of these barriers, there is evidence that rural SMEs are innovative (Reidolf 2016); their peripheral location may in fact spur innovation efforts (OECD, 2014; Anderson et al., 2005). However, little consideration has been given to collaborations between rural SMEs and universities. The following section sets out a conceptual framework for assessing their propensity to engage in such collaborations.

2.2 Rural SMEs and Open Innovation through University-Industry Collaboration

While SMEs are typically conceptualised as agile, nimble, flexible, and therefore innovative, organisations, they are concurrently considered to be resource constrained (Freel 2000; Vossen 1999). This requirement for knowledge to innovate pushes SMEs towards what has been termed 'acquisitive learning' (Dess et al., 2003), whereby knowledge resources are assimilated into the firm from external resources (Huggins and Johnston 2010). This process of open innovation is therefore regarded as increasingly important for SMEs to improve their innovativeness as it is an effective means for circumventing their resource constraints (Ebersberger et al. 2012). Conceptions of open innovation envisage universities as important members of innovation networks, and sources of knowledge (Chesbrough 2003; Huizingh 2011). As such, universities are recognised as 'engines of growth' (Veugelers 2016) and 'anchors' of the innovation process within regions (Goddard et al. 2014). Indeed, policy development initiatives across industrialised economies (European Commission 2011; OECD 2007), and particularly in the UK (Dowling 2015; Wilson 2012), regard access to university knowledge as the key to promoting innovation.

However, SME-university collaboration is often overlooked, primarily due to the perception that there is a lack of engagement between the two. Indeed, while there is evidence to suggest that smaller firms are less likely to collaborate with universities than their larger counterparts (Bodas Freitas, Geuna, and Rossi 2013; Fontana, Geuna, and Matt 2006), this does not mean that SMEs do not engage with universities, only that *vis a vis* larger firms, it is the latter that are more prone to developing these collaborative links.

Indeed, a careful reading of the literature reveals several interesting insights and reveals a relationship between firm size and university collaboration is more nuanced; for example, while SMEs are less likely to collaborate with a university, when they do they tend to engage in a higher number of projects than larger firms (Motohashi 2005). Additionally, the nature of the collaborative projects that SMEs collaborate with universities is different, with SMEs less likely to be engaged in *formal* interaction with universities than larger firms (Bodas Freitas et al. 2013). SMEs may also focus on longer term projects, centred on organisational learning that is less hurried and more deliberate in nature (Broström 2010). Furthermore, the advantages to firms from engaging with a university, such as improving understanding, gaining knowledge, problem solving, and training the workforce appear to be unrelated to firm size (Bishop, D'Este, and Neely 2011). In addition, smaller firms have been found to benefit higher levels of growth after receiving public funding for research projects (Vanino, Roper, and Becker 2019). Given these findings, universities are regarded as important sources of external knowledge for SMEs (Johnston and Huggins 2021).

Increasingly SME-university interaction has come to be regarded as a socio-technical process, highlighting the importance of connection and understanding to the facilitation and function of these links (AL-Tabbaa and Ankrah 2016; Al-Tabbaa and Ankrah 2019; Johnston and Huggins 2021; Steinmo and Rasmussen 2018).

The socio-technical nature of SME-university collaboration means that these interactions are predicated on the ability of the partners to both connect and understand one another. Therefore, the connection of actors reveals the need for networks and networking in underpinning SME-university collaboration (Johnston and Huggins 2021). However, the socio-spatial characteristics of remote rural SMEs are distinct from that of urban firms, typically characterised by sparse and organisationally thin. As such, their networks may be less expansive due to the fact they are further away from sources of knowledge and support and lack of local business networks (Curran and Storey 1993; Greenberg, Farja, and Gimmon 2018; Smallbone, North, and Vickers 2003). Furthermore, as prior evidence suggests that collaborative ties may be supported by the exploitation of links with graduates from the universities, rural SMEs face an additional disadvantage as fewer rural universities mean fewer graduates into these regions (Fernández Guerrero 2020), and those that left rural areas for higher education tend to stay away (Artz and Yu 2011; Rérat 2014), indicating a fragmentation and breakage in human capital connections. These arguments are distilled into Hypothesis 1, which states that:

> **Hypothesis 1:** Rural SMEs have a lower propensity to collaborate with universities than their urban counterparts.

However, while rural SMEs may lack spatial proximity to universities, the evidence suggests that this merely results in these firms collaborating over larger distances (Charles 2016; Huggins et al. 2015; Huggins, Izushi, and Prokop 2016; A. Johnston and Huggins 2016). Therefore, a rural location does not preclude SME-university collaboration. Indeed, while rural networks may be less dense physically due to the distance between partners, networking remains of crucial importance to rural SMEs (Freire-Gibb & Nielsen, 2014). Furthermore, evidence from Swedish farmers in remote rural regions suggests rural networks may be based less on spatial proximity and more around non-spatial proximities (Dubois 2018). Therefore, where the SMEs lack physical proximity to their partners, they compensate in terms of drawing on other types of closeness such as social, technological, and organisational proximity (Freire-Gibb and Nielsen 2014). As such, having prior or accumulated networks (i.e. any type of greater network centrality) is a precursor or determinant of future network formation with universities. This is formalised in Hypothesis 2:

> **Hypothesis 2**: Remote rural SMEs with greater networking resources will have a higher propensity to develop collaborative links with universities.

As the openness of firms has been shown to be an important factor in promoting U-I links (Laursen and Salter 2004), the existence of links with other external actors such as customers, suppliers, rivals, public and private sector laboratories or government organisations may be a signal of openness which suggest that an SME is open to external collaboration and may do so with a university. Indeed, the relative paucity of universities within remote rural areas means that SMEs may be forced to engage with other actors within the ecosystem (Charles 2016). Therefore, university collaboration may not only be more likely among rural SMEs with higher levels of openness will be more likely to collaborate with universities. This is formalised in Hypothesis 3:

> **Hypothesis 3:** Rural SMEs collaborating with other external organisations will have a higher propensity to develop collaborative links with universities.

As well as networking and proclivity towards openness, there is evidence that rural SMEs do not lack in performance, when examined using metrics such as profitability, employment, and growth (Phillipson et al. 2019). In general, SME performance has been shown to signal innovativeness, in particular with respect to productivity, or output per worker, where a positive relationship between productivity and innovativeness is observed (Baumann and Kritikos 2016; Hall, Lotti, and Mairesse 2009; Saunila 2014). In addition, broader measures of performance, such as engaging in export goods/services have also been found to be positively related to innovation in SMEs (Roper and Love, 2002; Love and Roper, 2015), suggesting that export orientated SMEs, whether urban or rural, are likely to be those that are more innovative (Westhead, Ucbasaran, and Binks 2004). Given this evidence, Hypothesis 4 suggests that:

> **Hypothesis 4:** Rural SMEs with higher levels of performance are more likely to collaborate with universities.

Capabilities represent the routines and practices within the firm that drive its competitiveness and, therefore, underpin performance and success (Pett and Wolff 2011; Teece, Peteraf, and Leih 2016). Importantly, innovation is viewed as predicated on the firm possessing the capabilities to manage knowledge and transform it into new outputs (Lichtenthaler and Lichtenthaler 2009). Furthermore, the capabilities a firm possesses also support the operation of the business in terms of financial management, strategy formation, and management of the workforce (Kor and Mahoney 2005; Teece et al. 2016). Importantly, superior innovation and organisational management capabilities have been found to increase the propensity for SMEs to develop collaborative linkages with universities (Giuliani and Arza 2009) (Giuliani & Arza 2009). Given this evidence, Hypothesis 5 suggests that:

> **Hypothesis 5:** Rural SMEs that possess superior capabilities are more likely to collaborate with universities.

3. Methodology

Data on the characteristics of rural SMEs in the UK is derived from the Longitudinal Small Business Survey (LSBS) commissioned by the Department for the Business, Energy, and Industrial Strategy (BEIS). The survey gathers data on firm demographics, performance, and openness, offering a comprehensive overview of a large sample of UK SMEs (defined according to accepted conventions as firms with fewer than 250 employees). The full dataset covers nearly 19,000 firms, however given this paper's focus on the university collaboration, the relevant questions were only asked in the 2015 run of the survey, limiting our sample framework to 7,750 SMEs.

The first task was to identify peripheral rural SMEs. Importantly, the LSBS captures the detailed urban/rural characteristics of the firms' location allowing these to be used as the basis for this identification. However, multiple definitions are used depending on whether the SMEs are located in England and Wales, Scotland, or Northern Ireland. For SMEs located in England or Wales, rural firms were defined as those whose location is described as rural hamlet or isolated dwelling, rural hamlet or isolated dwelling in a sparse setting, rural town and fringe, rural town and fringe in a sparse setting, rural village, or rural village in sparse setting. In Scotland, rural SMEs were defined as those located in 'remote rural areas,' 'remote small towns', 'very remote rural', 'very remote small towns', and 'very remote small towns'. In Northern Ireland, this included SMEs located in areas described as a 'small village, hamlet, or open countryside', or 'village'. In all cases, SMEs located in rural areas described as 'accessible' or 'fringe' were omitted as these could describe those located on the edges or close to urban areas. Therefore, they are all firms that are located in areas of low population density that are

not connected to larger settlements. While nearly 2000 rural SMEs were identified within the dataset, missing data among the variables meant that only 808 valid observations constitute our final sample with consistent data availability across a number of measures outlined below.

3.2. Analytical approach

The analysis uses a logit 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

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

With NR being the network resources, the O representing the openness of rural firms, P their performance, C standing for capabilities, and finally Z is a vector of control variables that includes sector and locational characteristics.

3.3. Variables

Dependent variable

While university collaboration covers a broad range of interactions from actors within industry and academia (Ankrah and AL-Tabbaa 2015; D'Este and Patel 2007; Perkmann and Walsh 2007), the limitations of the LSBS mean that our dependent variable (UC) is binary in nature, capturing whether an SME 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.

Independent variables

To provide a holistic examination of the propensity for SMEs to engage with universities, and test the hypothesis outlined in Section 2, a broad range of variables were used to assess the characteristics of both rural SMEs. Firstly, networking resources were captured using the number of employees within the firm as a proxy, captured on a nominal scale within the survey.

In order to evaluate the importance of the overall openness of rural SMEs on their propensity to collaborate with universities, dummy variables were included that captured 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, g) universities or other higher education institutions, h) government or public research institutes.

SME performance was captured using two variables, firm productivity and the proportion of turnover generated by exports. The productivity measure employed in the paper is calculated by dividing the turnover of firm i by its employment:

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

SME 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

In order to provide robustness to the model, several control variables were included. 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 to the age of the firm the socio-economic characteristics of the SMEs' location is an important consideration due to the fact that more dynamic locations result in a different spatial organisation of activities, denser networks, higher levels of human capital resulting in higher levels of innovation (Crescenzi, Rodríguez-Pose, and Storper 2007; Rodríguez-Pose and Wilkie 2019; Storper 2011). Furthermore, regional innovation activity has been found to be path-dependent in nature suggesting that prevailing socio-economic characteristics shape the development paths of regions in the long run (Barrios, Flores, and Martínez 2019). It is also important to note that rural regions are not necessarily homogenous; while they may share a set of core characteristics, there are significant variations in their socio-economic performance, connectivity, and remoteness (Bosworth et al. 2020; García-Cortijo, Castillo-Valero, and Carrasco 2019; Laurin, Pronovost, and Carrier 2020). Therefore, location characteristics were integrated into the model through using NUTS 3 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 SME's region. While the first three are self-explanatory, our industrial specialisation was adopted from Fotopoulos (2014) and calculates the industrial specialisation of a NUTS 3 region across 14 industrial sectors in comparison to the rest of the country. A similar regional-level approach was used more recently in Huggins and Thompson (2017) and Prokop et al. (2019), where a detailed description of the variable construction is available.

Finally, a set of industry dummies were included to capture the sector in which each firm operates, based on the two-digit aggregations used by the Office for National Statistics.

A summary of the data is presented in Table 1 along with descriptive statistics for the variables included in the analysis. Table 2 presents a correlation matrix and highlights no issues with multicollinearity. However, standardised variables are used in the regression in order to improve robustness and VIF figures from these are all under 5 suggesting this model is robust.

Table 1: Descriptive Statistics around here

Table 2 – Correlation matrix around here

4. Findings

The first step of the analysis examines whether remote rural SMEs differed from the rest of the SME population in their propensity to collaborate with universities using bivariate statistical tests. Evidence

from Table 3 suggests that they are less likely to collaborate with universities than non-rural SMEs, with around 11% reporting a university collaboration compared with 13% of non-rural SMEs. Furthermore, the observed difference is statistically significant (χ^2=7.038; p=0.008) confirming a clear difference in behaviour of SMEs with respect to their rural/urban location, providing evidence for Hypothesis 1. In addition, the picture with respect to overall levels of innovation within rural and urban SMEs is mixed; rural SMEs are less innovative overall, with around 41% reporting the introduction of a new good or service in the previous 3-year period compared to nearly 44% of urban SMEs (χ^2=7.956, p=0.005). However, while rural SMEs are less innovative, overall, they report the introduction of a higher proportion of innovations that are new to the market (χ^2=9.327, p=0.002), indicating their stronger propensity for radical innovation.

Table 3: University Collaboration and Innovation: Rural Vs. Non-Rural SMEs around here

Importantly the proportion of SMEs engaging with universities was identical to the whole sub-sample (χ^2=0.00, p=0.995). However, we find statistically significant differences in several of the variables when comparing the observations included and excluded from the final analysis. Therefore, the observations included in the regression analysis have a higher number of employees (32.78 for SMEs in the models vs. 18.73 for the whole sub-sample, Z=1975172, p=0.000 Mann-Whitney U Test) and generate a higher proportion of revenue from exports (8.48% vs. 4.79% for the whole sub-sample, Z=1586081, p=0.000, Mann-Whitney U-Test). Furthermore, the 808 SMEs included in the regression analysis report having slightly lower people management capabilities (4.02 vs. 4.12 for the whole sub-sample, Z=17.177, p=0.000; Kruskal-Wallis Test), and slightly higher innovation capabilities (3.84 vs. 3.66 for the whole sub-sample, Z=19.825, p=0.000; Kruskal-Wallis Test).

To examine the robustness of the results presented in the previous section, we model SME-university innovation collaboration across the variables presented independently before. This highlighted a statistically significant and positive relationship between both the number of employees and the proportion of turnover generated from exports and university collaboration, thus any positive relationship highlighted in the regression model is likely to be robust. Conversely, no statistically significant relationships were noted between people capabilities or innovation capabilities, suggesting that a similar result in the regression model is likely to reflect the entire sample.

Table 4: Regression Results around here

The results of the regression analysis are presented in Table 4. The coefficient on the number of employees variable is both positive and significant, suggesting that those rural SMEs with a larger workforce and, therefore, greater networking resources are more likely to collaborate with a university. Given this evidence, Hypothesis 2 is accepted.

Next, the openness of the SMEs is examined to assess whether engaging in other collaborations is indicative of a higher propensity to collaborate with a university. The results show that concurrent collaboration with public sector customers, competitors, consultants or private laboratories, and government or public research institutes have a positive influence on the SMEs' propensity to collaborate with a university. Therefore, there is evidence that while a rural SME's overall proclivity towards open innovation is important, it is their openness towards partners that are organisationally similar to universities is the most important effect. Therefore, Hypothesis 3 is accepted.

In terms of firm performance, the results suggest that this does have some effect on the propensity to collaborate with a university. While productivity was not a significant influence, the positive and significant coefficient on the export revenue variable suggests that those rural SMEs generating a higher proportion of turnover from export sales are more likely to collaborate with a university.

Therefore, Hypothesis 4 is partially accepted. Conversely, no statistically significant findings were noted for the capabilities, suggesting collaboration with universities being independent from the level of capabilities within the SME. Therefore Hypothesis 5 is rejected. Finally, the results also suggest that regional dynamics and the sector in which a firm operates does not influence their tendency to collaborate with universities.

5. Discussion

Importantly, the results have established that rural SMEs have a lower propensity to collaborate with universities than their urban counterparts, suggesting that their location may indeed represent a constraint. Yet, the results also establish that university collaboration is indeed prevalent among rural SMEs and is not only the preserve of urban firms. Therefore, rural transformation through promoting innovation through SME-university collaboration can be considered a viable strategy.

However, given this result, the key question is why are rural SMEs less likely to collaborate with universities than urban firms? The results do not appear to suggest that the lower rate of university collaboration is due to rural SMEs being less innovative, quite the opposite in fact. We find that rural SMEs are marginally less innovative overall (41% reporting the introduction of an innovation as opposed to 44% of urban SMEs), but a higher proportion reported that their innovations were new to the market (12.5% for rural SMEs vs. 10.8% for urban SMEs), suggesting their greater need for a larger technological leap, or knowledge exploration (Huggins et al. 2014). Therefore, there is a clear demand for knowledge among rural SMEs. Considering this evidence, coupled with the fact that the socio-economic characteristics of the regions were not significant predictors of university collaborations, suggests that the lower levels of university collaboration observed are due the fact that there are fewer potential partners for rural SMEs, as universities tend to be based in urban areas (Charles, 2016), suggesting that a lack of spatial proximity to universities may be a significant barrier to the formation of collaborative links with universities for rural SMEs. Given the spatial disadvantage of rural SMEs in terms of access to universities, their lower propensity to collaborate may be explained by the fact that the distance between them means that it is more resource intensive to develop such a collaborative link. Therefore, rural SMEs may only wish to engage with universities if they can be sure of a successful outcome, i.e. the gains from collaboration must be greater than the costs of interacting and co-creating knowledge with a remote partner. For rural SMEs, therefore, university collaboration must reflect a remoteness compensation mechanism. Consequently, Yin et al.'s (2019) characterisation of rural areas as 'under-developed innovation environments' may be due more to connectivity issues regarding the supply of university knowledge rather than demand.

Where rural SMEs do collaborate with universities, the significance of network resources suggests non-spatial proximities are important, while the significance of exporting activity suggests performance is also an important push factor. Firstly, the importance of networking highlights that the pursuit of collaborative links with universities among rural SMEs can be regarded as a socio-technical process as the closeness of the partners organisationally, technologically, or socially, has been found to underpin the networking activities (AL-Tabbaa and Ankrah 2016; Ankrah et al. 2013; Ankrah and AL-Tabbaa 2015). Indeed, the importance of organisational proximity is also echoed in the finding that rural SMEs are more likely to collaborate with a university where they also collaborate with partners that are organisationally similar to universities, i.e. public sector organisations or laboratories. Yet, the lower level of university engagement suggests that it may be insufficient to address the overall lack of spatial proximity.

Secondly, university collaboration among rural SMEs is also driven by their performance, specifically engaging in the export of their output. As international markets are typically more competitive in

nature, this may push the firms towards being more innovative (Ganotakis and Love 2011), which in turn promotes university collaboration as a means of delivering innovative outputs. Furthermore, those rural SMEs that are trading outside the region may be less constrained by the regional limitations or have a niche that means their output is more traded in nature. As such, a focus on extra-regional markets focus may encourage the development of links outside the region, thereby overcoming lack of local universities in rural regions.

6. Conclusions

As the performance of rural SMEs is viewed as crucial to the economic development of these regions, greater scrutiny has been made to their innovation activities. This paper contributes new insights into the innovation activities of rural SMEs through examining their propensity to collaborate with universities. The first contribution of the paper is to highlight that rural SMEs are less likely than their urban counterparts to engage in university collaboration. Given that the evidence suggests these SMEs are no less innovative than urban SMEs, And are more likely to be developing new to market innovations we posit that this result stems from the relative isolation of rural SMEs and the lack of potential partners in close spatial proximity. However, the important point is that university collaboration is not the domain of urban firms alone as rural SMEs clearly do collaborate in this way.

Furthermore, the paper contributes a new insight into the behaviours of rural SMEs through highlighting the characteristics of increase the propensity to engage this way. Therefore, those that possess greater networking resources, organisational proximity to universities through working with similar organisations, and operate in more competitive export markets are more likely to collaborate with universities. Finally, the socio-economic dynamics of rural regions appear to have no effect on SMEs' propensity to collaborate with a university.

These results have important implications for economic development policies in rural contexts. Given the benefits to SMEs from engaging in this type of collaboration, such as improving understanding, gaining knowledge, and enhancing problem solving abilities (Bishop et al. 2011), encouraging and supporting these collaborations represents a viable strategy for tackling the 'under-developed innovation environment' observed in rural regions (Yin et al. 2019). Indeed, economic development strategies are increasingly highlighting university collaboration as a means of promoting innovation among SMEs in the UK and other industrialised economies (OECD 2019). Importantly, the lack of influence of the socio-economic characteristics of their region suggests that university collaboration among rural SMEs is independent of broader dynamics of their location. Therefore, these SMEs are not necessarily constrained by the dynamics of their location but by its connectivity to university knowledge networks.

The results suggest, therefore, that promoting university collaboration among rural SMEs is a viable approach to encouraging and supporting innovation in rural areas. Therefore, there is scope to promote collaborative links of this type as a tool to support and boost innovation among rural SMEs. However, as the results demonstrate that rural SMEs are less prone to establishing these links, care must be taken not to neglect the barriers they face in doing so. Given the clear demand for knowledge for innovation among rural SMEs, interventions to increase supply of university knowledge appear to be most appropriate. Therefore, if universities are to truly anchor the innovation system (Goddard et al. 2014), they require a broader focus than the immediate urban area to also ensure that they reach out into the rural hinterland.

Given the increasingly place-based focus of economic development policy, tailoring policy to the issues faced by a locale through building on regional strengths and tackling regional weakness (Bailey, Pitelis,

and Tomlinson 2018; Barca, McCann, and Rodríguez-Pose 2012; McCann and Ortega-Argilés 2015), there is scope for policy initiatives for rural regions and SMEs to encourage university collaboration through focussing on those rural SMEs that do not collaborate in this way. The evidence from this paper suggests that networks are a key determinant of university collaboration, and therefore rural development policies (Murdoch 2000).

As such, to boost innovation among rural SMEs, policymakers could target non exporters and firms with fewer networking resources. Importantly, improving openness among SMEs so that collaboration with partners that are organisationally similar to universities could also pay dividends in terms of fostering greater university collaboration.

The results also highlight avenues for further research in this area. Firstly, given the conclusion that lack of opportunities for collaboration is holding back rural SMEs, more research is required into links between academics and SMEs in peripheral regions. The extant literature has highlighted the need to understand the formation of university-industry links from the point of view of the academic (Perkmann et al. 2021), therefore more attention could be given to understanding how academics may effectively connect with rural firms.

Furthermore, the paper poses many unanswered questions around the types of interaction between rural SMEs and universities. Indeed, the dataset only records instances of collaboration, leaving the question as to the formal or informal nature of this unanswered. Therefore, there may be differences in patterns of collaboration based around the level of formality of the project. Also, there is no data on the university partner, the distances between the partner, or the academic discipline of the knowledge utilised. Further investigation of these areas will allow a more in-depth assessment of the non-spatial proximities in existence between the partners.

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Table 1 – Descriptive Statistics

Variable	min	max	mean	Sd
Number of employees	1	247	32.78	42.952
Age of Firm	0	9	8.16	1.45
People management Capability	1	5	4.04	0.757
Strategic Capability	1	5	3.83	0.883
Innovation Capability	1	5	3.84	0.897
Finance Capability	1	5	3.36	1.287
Operational Capability	1	5	3.93	0.821
Productivity	60	5000000	118883.561	227741.407
Proportion of Revenue from Exports	0	100	8.48	21.03
Collaborates with Enterprise Group	0	1	0.259	0.439
Collaborates with Suppliers	0	1	0.614	0.487
Collaborates with Customers from Private Sector	0	1	0.416	0.493
Collaborates with Customers from Public Sector	0	1	0.238	0.426
Collaborates with competitors	0	1	0.200	0.400
Collaborates with Consultants or private Labs	0	1	0.202	0.402
Collaborates with Government or PRIs	0	1	0.050	0.217
GERD per Capita (NUTS 3 Region)	200	909	519.19	224.951
Employment (NUTS 3 Region	717000	5042000	2670630	911695
Industrial Specialisation	0.035	0.144	0.058	0.023

Table 2 – Correlation Matrix

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Number of employees																		
2	Exporter	-0.043																	
3	People management Capability	-0.008	0.124*																
4	Strategic Capability	0.056	0.038	0.379*															
5	Innovation Capability	0.022	-0.021	0.214*	0.284*														
6	Finance Capability	0.174*	0.033	0.140*	0.260*	0.143*													
7	Operational Capability	0.116*	0.062	0.282*	0.372*	0.162*	0.264*												
8	Membership of Formal Business Network	0.054	0.077*	0.091*	0.080*	-0.011	0.054	0.062											
9	Productivity	-0.109*	-0.127*	-0.073*	0.006	-0.005	0.060	-0.019	-0.059										
10	Collaborates with Enterprise Group	0.016	-0.066	0.010	0.022	0.017	0.028	0.038	0.062	0.031									
11	Collaborates with Suppliers	0.047	-0.008	-0.003	-0.049	-0.016	0.051	0.016	0.041	-0.008	0.193*								
12	Collaborates with Customers from Private Sector	0.008	-0.171*	-0.013	0.002	-0.015	-0.037	-0.047	-0.040	0.015	0.214*	0.159*							
13	Collaborates with Customers from Public Sector	0.118*	0.137*	0.066	0.127*	0.064	0.074*	0.018	0.044	-0.073*	0.062	0.064	0.169*						
14	Collaborates with competitors	--0.085*	0.019	0.034	0.074*	0.004	-0.005	0.033	0.048	0.059	0.304*	0.078*	0.056	0.095*					
15	Collaborates with Consultants or private Labs	0.104*	-0.088*	0.021	0.078*	0.016	0.065	0.004	0.115*	0.034	0.114*	0.123*	0.109*	0.085*	0.107*				
16	Collaborates with Government or PRIs	0.056	0.054	0.020	0.034	0.067	0.036	0.026	0.093*	-0.020*	0.150*	-0.013	0.077*	0.139*	0.149*	0.181*			
17	GERD per Cap-0.002ita (NUTS 3 Region)	-0.061	-0.064	-0.015	-0.052	0.003	0.006	-0.051	-0.031	0.071	0.023	-0.008	-0.019	0.014	0.039	0.052	-0.078*		
18	Employment (NUTS 3 Region	-0.042	-0.037	-0.016	-0.090*	-0.006	0.010	-0.034	-0.022	0.103*	-0.012	-0.016	-0.023	-0.037	0.055	0.160	0.081*	0.602*	
19	Industrial Specialisation	0.056	-0.021	-0.035	0.086*	0.023	-0.011	0.011	-0.031	-0.045	0.009	0.009	0.037	-0.002	-0.050	-0.064	-0.059	-0.362*	-0.749*

Table 3: University Collaboration and Innovation: Rural Vs. Non-Rural SMEs

	Rural SMEs	Non-Rural SMEs
University Collaborator	11.3%**	13.0%**
No University Collaboration	88.7%**	87.0%**
Introduced New Goods and Services	41.42%*	43.96%*
No New Goods/Services	58.79%*	56.04%*
Goods/Services are New to Market	12.52%*	10.82%*
Goods/Services not new to market	87.48%*	89.18%*

**differences are significant at the 0.01% level (Chi-Squared Test). *differences are significant at the 0.05% level (Chi-Squared Test).

Table 4: Regression Results

Variable	Model 1	Model 2
Number of employees	0.233**	0.226**
	(0.102)	(0.104)
Age of Firm	0.353	0.346
	(0.202)	(0.202)
People management Capability	-0.080	-0.074
	(0.143)	(0.145)
Strategic Capability	-0.092	-0.113
	(0.166)	(0.167)
Innovation Capability	0.205	0.216
	(0.159)	(0.161)
Finance Capability	0.186	0.181
	(0.146)	(0.148)
Operational Capability	0.035	0.029
	(0.152)	(0.155)
Collaborates with Enterprise Group	-0.328	-0.346
	(0.301)	(0.304)
Collaborates with Suppliers	0.233	0.227
	(0.283)	(0.284)
Collaborates with Customers from Private Sector	0.478	0.482
	(0.263)	(0.265)
Collaborates with Customers from Public Sector	0.698**	0.676**
	(0.278)	(0.281)
Collaborates with competitors	0.694**	0.709**
	(0.296)	(0.298)
Collaborates with Consultants or private Labs	1.212***	1.237***
	(0.261)	(0.265)
Collaborates with Government or PRIs	1.958***	2.080***
	(0.393)	(0.399)
Export Revenue	0.206**	0.229***
	(0.081)	(0.082)
Productivity	0.033	0.058
	(0.161)	(0.161)
Productivity Squared	-0.023	0.001
	(0.085)	(0.086)
GERD per Capita (NUTS 3 Region)		-0.200
		(0.159)
Employment (NUTS 3 Region)		-0.202
		(0.320)
Industrial Specialisation		-0.220
		(0.340)
Constant	-3.629***	-3.786***
	(0.306)	(0.358)
DF	17	20
Log-likelihood	451.286	446.727
Nagelkerke R-Squared	0.268	0.277
N	808	808

NOTE: Models 1 & 2 were also estimated with both sector and NUTS1 regional dummies included, although none were significant at the 5% level and all estimated coefficients remained approximately equal (results available on request).