Papers in Evolutionary Economic Geography

12.23

Original innovation, learnt innovation and cities:
Evidence from UK SMEs

Neil Lee and Andrés Rodríguez-Pose

Utrecht University
Urban & Regional research centre Utrecht

Original innovation, learnt innovation and cities: Evidence from UK SMEs

by

Neil Lee* and Andrés Rodríguez-Pose**

*Department of Economics, Lancaster University Management School, Lancaster LA1 4YQ, UK & Socio-Economic Research Centre, The Work Foundation, 21 Palmer Street, London SW1H 0AD, UK

**Department of Geography and Environment, London School of Economics, Houghton St., London WC2A 2AE, UK

Original innovation, learnt innovation and cities: Evidence from UK SMEs

Abstract

One of the key benefits of cities is that they allow the exchange of knowledge and information between economic actors. This may have two effects: it may create the conditions for entirely new innovations to emerge, and it may allow firms to learn innovations from those nearby. Yet few studies have considered the impact of an urban location on whether innovations are original or learnt. This paper tests these hypotheses using large-scale survey evidence for over 1,600 UK SMEs. We show that while urban firms tend to be both product and process innovators, urban firms are disproportionately likely to introduce process innovations which are only new to the firm, rather than entirely original. Instead, the urban advantage in product innovation appears to come from a combination of the effects. The results highlight a need for a nuanced view of the link between cities and innovation.

Keywords

Innovation; Cities; SMEs; Learning; United Kingdom

JEL classification: O31, O33, O38

1. Introduction

Cities are generally presumed to be more innovative than rural areas. One reason for this is that proximity enables the exchange of information between firms and entrepreneurs (Duranton and Puga 2001; 2004; Storper and Venables 2004). This allows firms to learn from one another, sharing tacit knowledge and information and may lead to higher levels of productivity (Glaeser 1999; Asheim and Isaksen 2002; Knudsen et al. 2008), processes which were exemplified by Marshall's (1920) quote that the secrets of industry are 'in the air'. Proximity to others allows firms to see visible innovations, such as improved design. It may also generate 'buzz': urban environments facilitate face-to-face contact and the exchange of other knowledge between firms with, for example, firms learning from their competitors about useful process innovations (Storper and Venables 2004). And proximity may intensify competition between firms, making them more likely to produce innovations following their competitors. These factors, amongst others, underpin the innovation advantage of cities.

Studies focused on innovation have only more recently begun to consider the types of innovation which cities might help. The majority of research has focused on patenting, showing a clear link between patent innovation and urban density (Crescenzi et al. 2007; Knudsen et al. 2008), implying that firms benefit from dense urban environments with frequent exchanges of knowledge and information – what is known as 'being there' – for innovation (Gertler 1995). Yet a wide literature has suggested that innovation is not a single outcome, but a highly diverse, context-specific phenomenon, which can be measured in several different ways (Fagerberg 2005). These issues have been greatly underexplored, and this paper focuses on two of them. First, cities may create the conditions for existing knowledge to be combined in new ways, creating original innovations. Cities also allow firms to learn from others nearby, opening up a second process: cities provide the conditions for innovations already introduced in local firms to be easily diffused to neighbouring firms. In short, cities allow firms to introduce original innovations, but they also allow them to learn innovations from other firms. Given that original innovations are costlier to introduce than learnt innovations (Bathelt et al. 2004) and that a greater effort is made to protect them from spilling over, we hypothesise that, while urban environments will assist all types of innovation, agglomerations are likely to be more conducive to learnt process-type innovation, through frequent interaction among economic actors, than to more radical and original product-type innovations (Fitjar and Rodríguez-Pose 2011a: 1252).

This paper tests the relationship between urban locations, learnt innovations and original innovations using the 2010 Small Business Survey, a survey of around 1,600 Small and

Medium Sized Enterprises (SMEs) across the United Kingdom. This data set contains information on the innovative activity of firms, their characteristics, such as age, sector or management ability, and other activities such as whether the firm engages in external knowledge sourcing. A series of probit regression models are estimated which test the influence of being in an urban location on a number of different measures of innovation.

As expected, we find that urban firms tend to be more innovative than rural firms. Urban firms are more likely to introduce new product innovations, with some limited evidence that this effect is principally driven by original innovations. Urban firms also have a greater probability of introducing process innovations and this is entirely driven by a learning effect – i.e. the new process innovations are learnt from other firms, rather than entirely original (Maskell et al. 2006). The distinction between the two may imply that new products are harder for urban firms to copy than new processes, which are less likely to be covered by copyright or patent protection. These results highlight an important economic role of urban areas in ensuring that new process innovations diffuse more rapidly, but suggests that the product innovation advantage of cities derives from other forces – such as creative inspiration, a wider range of approaches to problem solving, pipeline-type interaction with agents in distant locations, or better matching of demand and supply.

The paper is structured as follows. Section two outlines the literature on innovation, learning and cities and derives a series of hypotheses which are to be tested. Section three describes the data and methodology used to test these hypotheses. Section four presents the results of the models and describes their relevance to theory. Section five concludes with results for theory on urban economics and policy.

2. Innovation, learning and cities

Knowledge spillovers, learning and cities

A wide body of research has focused on the idea that innovation is not purely the result of activity within the firm, but that external factors such as location, external knowledge sources and the local 'milieu' are also important (Shefer and Frenkel 1998; Rodríguez-Pose 1999; Gordon and McCann 2000; 2005; Freel and Harrison 2006; Czarnitzki and Hottentrot 2009). These studies are based on the view that firms tend to source knowledge or ideas externally, with this meaning that firms located in certain cities or regions are more innovative.

One key strand of research in this area has considered the role of cities in innovation. The traditional view of the advantages of cities has focused on Marshallian agglomeration

economies: availability of specialized inputs, wide and deep labour forces and the idea of 'knowledge spillovers' that mean industrial secrets can be easily spread within individuals in the same city (Marshall 1920). More recent attempts to re-evaluate this formulation have derived micro-foundations for such processes. Duranton and Puga (2004) suggest that there are three main benefits from an urban location: sharing of costly infrastructure, matching of specialized inputs and outputs and – the focus of this paper – the ability to learn from other economic actors.

Research on the innovation advantage of cities highlights the role of knowledge exchanges or processes of learning in the economic advantages of cities. The actual mechanism through which knowledge spills over from one actor to another is not always clearly stated, however. Storper and Venables (2004) argue that face-to-face communication between individuals is a key transmission mechanism. This is particularly important for innovative economic activity, which may be reliant on new knowledge in fields which change rapidly. Boschma et al. (2009) study the impact of individuals moving from firm to firm and show that it can be improve firm performance, but that it depends on the extent to which the knowledge is new to the firm. Other work has stressed the importance of other local processes, such as firms learning from working together on joint projects (Martin and Moodysson 2011).

A related body of work focuses on processes of learning between different economic actors in a city. For example, Glaeser (1999) develops a model in which urban density increases the speed with which interactions between people in an area can take place. Evidence for wages, used as a proxy for productivity, shows that workers who move to cities gain over a five-year period, but do not lose this productivity advantage once they leave (Glaeser 1999). This is assumed to mean that individuals move to cities to learn, and that the learning stays with them once they leave. Such learning effects might be particularly likely in industries which are reliant on the exchange of tacit knowledge, rather than knowledge which it is easy to codify, as transmitting tacit knowledge requires interpersonal contact and physical proximity (Asheim and Isaksen 2002).

The assumption of an innovation advantage of urban areas or density has been the focus of much research (Knudsen et al. 2008). Crescenzi et al. (2007) show that part of the innovation gap between Europe and the United States relies on the greater ability of economic activity in the United States to agglomerate in ways which allow exchanges of knowledge. City density (Knudsen et al. 2008) and city size (Feldman and Audretsch 1999) have been identified as key factors behind innovation in the United States. The few studies which have considered small firms in the UK reach somewhat similar results. Smallbone and North (1999) found that

firms in remote rural firms were less likely to introduce advanced process innovation than those in more accessible rural areas (for example, computer guided equipment), although there was little difference in more basic process innovations (such as simple use of computers). Keeble (1997) uses a four-part distinction between the UK's relatively dense South East and industrial heartlands, and the less dense outer southern and periphery areas. He finds greater differences in the extent to which firms in these areas introduce process innovations than their introduction of new products.

New innovations versus learned innovations

If the literature discussed above applies, UK SMEs located in cities should be more innovative than those outside. This basic idea – that urban firms will be more innovative – becomes the first hypothesis this paper seeks to test:

> H_1: Firms in urban areas are more likely to introduce product and process innovations

An alternative, however, is that dense, urban locations are actually less important for innovative activity than is normally suggested in the literature. Innovative economic activity in London, for example, is not concentrated purely in the urban core, but is dispersed throughout peripheral parts of metropolis and the wider South East (Gordon and McCann 2005). Rather, the benefits of an urban location will play differently to some firms but not others, depending on the nature of the knowledge they require. These benefits will not be limited to the urban core, as evidence suggests that knowledge spillovers may apply over relatively large distances, with some estimates putting them at around 250 kilometres (Rodríguez-Pose and Crescenzi 2008). While such distances are important in the context of the United States, in the United Kingdom few firms are located this far from major cities. It may thus be the case that for many firms local context may be less important. Some studies have suggested that it is long distance, rather than local, links which are important for innovation, in general (Simmie 2003; Gordon and McCann 2005), and for radical product innovation, in particular (Fitjar and Rodríguez-Pose 2011a). For example Freel (2002) studies SMEs and finds that there is a relationship between only certain forms of collaboration and innovation, with "little evidence that these [linkages] are clustered geographically" (2002: 767). Similarly, North and Smallbone (2000) find only small differences in the likelihood of firms in remote and accessible rural areas innovating. Firms adapt their business strategies to cope with their location, as otherwise they would be less likely to survive (Smallbone and North 1999; North and Smallbone 2000; Lee and Cowling 2012).

A further objection to this basic characterisation is that the literature on cities assumes that these processes of knowledge exchange, learning and inspiration lead firms to be more innovative in a general sense. Yet a simple focus on cities as more innovative than other areas disguises considerable nuance. As Gordon and McCann (2005: 524) argue: "quite different forms of spatial and institutional arrangement may be appropriate for innovation in different kinds of business." Urban density can be important for innovation, but research suggests that this relationship is not sufficient. Peripheral regions can also be innovative, but other forms of proximity than geographical are necessary for this to happen (Fitjar and Rodríguez-Pose 2011b).

Further contributions have led to an increasingly nuanced view of the link between innovation and urban areas, in particular by hinting at a difference between the production of new ideas and improved processes of learning from other firms, two processes which may have different outcomes. In one such study, Duranton and Puga (2001) outline a model of firm learning, whereby firms gain from locating in 'nursery' cities where diversity of economic activity creates knowledge spillovers. Firms in the development stages locate in these cities and develop innovative processes but, once the innovation has been developed, relocate production activities to cities which are more specialized and lower cost.

A more nuanced view of innovation in cities divides the effect of urban location into two processes. First, research on urban diversity and innovation, or the importance of multiple perspectives suggests that the scale and diversity of knowledge in cities can help economic actors create entirely new innovations. For example, research focused on ethnically diverse cities suggests that the combination of new approaches and methods of problem solving leads to innovation (Ottaviano and Peri 2004; Lee and Nathan 2010; Niebuhr 2010; Nathan and Lee 2011).

However a second effect will operate simultaneously. Exchanges of knowledge between economic actors in a city will allow them to learn from each other in various ways. These might include staff moves as individuals go from firm to firm (Boschma et al. 2009; Eriksson and Lindgren 2009). Rather than creating entirely new innovations, this helps diffuse innovation between firms within the same city which are able to monitor each other (Asheim et al. 2007). Essentially, urban areas allow firms to mimic successful innovations created by other firms more easily and at lower costs than rural areas. This effect will be limited by legal protection such as copyright law, which might make process innovation easier to mimic than new products.

These two processes form the second and third hypotheses this paper is testing. The second hypothesis tests the validity of the learning effect. If cities provide the context for economic actors to introduce innovations already introduced in other firms, innovations would be less likely to be original.

H_2: Firms in urban areas are more likely to introduce innovations which are not entirely new, i.e. learnt from other firms

One objection to this hypothesis comes from the literature on related variety, which suggests that urban areas – with the right mix of sectors – may provide the context for reconfigurations of existing knowledge, with this creating entirely new innovations (Boschma et al. 2009; Neffke et al. 2012).[1] The processes of staff moves highlighted above, for example, may allow workers to use existing knowledge in new contexts, creating new ideas. This might make urban firms better at creating totally new products. If this is true, and cities instead provide the context for firms to create entirely new products and processes, then an additional hypothesis would be that:

H_3: Firms in urban areas will be more likely to introduce innovations which are original, i.e. entirely new

The null hypothesis is that cities do not provide this context, but that firms may be reliant on other forms of proximity to produce entirely new innovations. This has been found to be the case in peripheral cities in Norway (Fitjar and Rodríguez-Pose 2011a), and there is also considerable evidence that international links are important in London (Gordon and McCann 2005). Research considering SMEs in the United Kingdom has shown that firms in accessible rural areas may actually be more dynamic than their urban counterparts, driven by the characteristics of entrepreneurs (Keeble and Tyler 1995). In the remainder of this paper we set out to test these hypotheses in the UK case.

3. Data and methodology

The data

The data source for this paper is the Small Business Survey (SBS) 2010, a sample of Small and Medium Sized Enterprises (SMEs) across the UK taken by the Department for Business, Innovation and Skills. The survey asks information on a range of characteristics of the firms –

[1] We are grateful to a referee for this point.

these include size, age, ownership, a variety of measures of firm activities and, importantly, six measures of innovative activity. The sample for the survey was randomly taken from the Dun and Bradstreet database, but was stratified by size. Surveys were conducted using CATI (Computer Assisted Telephone Interviewing). One of the drawbacks of the SBS for the purpose of this analysis is that it was designed to cover a variety of topics rather than to have an exclusive focus on innovation. In addition, the structured nature of the questionnaire, relying solely on closed questions, imposes some limitations on how well it can capture different types of innovations. However, these drawbacks are counterbalanced by the sheer size of the sample of firms and by the provision of a fully comparable set of data for a large number of SMEs across the UK. Around 4,500 firms are asked questions as part of the SBS, although a number of these firms have incomplete responses and so to ensure results are not influenced by different samples, only those which have fully completed the questions used here are included. This results in a relatively large sample of 1,652 firms considered in the analysis.

Defining innovation

There are many different definitions of innovation. Definitions of innovation normally rely on the commercial exploitation of new ideas (Fagerberg 2005). More specifically, innovation can be defined as: "the successful implementation of a new product, service, or process, which for most activities entails their commercial success." (Gordon and McCann 2005: 525). Innovation can then be divided into two types: product innovation, or the introduction of new or significantly improved products, and; process innovation, where firms introduce new processes or methods of production. The SBS contains information on whether a firm has introduced either a product or process innovation in the past 12 months.

A second distinction is whether the product/process is entirely new ('original'), or merely new to the firm ('learned'). The SBS distinguishes between these two types of innovation, and this variable provides a measure of which type each innovation falls into. In practice, new products may involve the combination of both original and learned innovation, while truly 'original' innovations may be extremely rare. However, the survey will capture where firms feel the balance of contribution lies for each type of innovation. [2] Using this, six different measures of innovation are calculated. Details on these and the independent variables are given in table 1.

Table 1 around here

[2] We are grateful to the referees for these useful points. Furthermore, a referee notes that 'learned' innovations may not actually be 'innovations' at all, but simply existing products used in new contexts.

There are some limitations to these measures. They cannot account for the significance or number of innovations introduced by a particular company. As the question only asks for innovations produced in the past 12 months, firms introducing a small number of important innovations will not appear as innovative as firms introducing a large number of trivial new products. Past research has suggested that the success of innovations may also depend on geography (Smallbone and North 1999). It is unclear whether these measures apply equally well across all sectors. For example, manufacturing firms may respond differently to a particular question to those in services. And questions like this give little information about the actual type of innovation and the nature of learning processes.

These limitations need to be considered in the following analysis. However, innovation questions such as these are one of the few ways of developing comparable measures across a wide number of firms. The importance of geography for innovation is taken into account by the introduction of regional dummies for the nine government office regions, Wales, Scotland, and Northern Ireland in the analysis. The sectoral issues are addressed using dummy variables for the different sectors. Nevertheless, these relatively simple measures do not fully solve the complexity of these issues and, hence, our results should be interpreted with these caveats in mind and complemented by existing case study evidence.

The SBS shows that firms in urban areas are more likely to introduce new products than non-urban firms. Table 1 gives the proportion of urban and non-urban firms which innovate in each of these ways. Firms in urban areas introduce more new products than those outside, with 52% of urban firms doing, so compared to 46% of others. They are slightly more likely to introduce completely new products (14% compared to 12%), and considerably more prone to introduce new products which have been already used elsewhere (38%; 34%).

The urban/rural differences are more pronounced, however, when considering process innovation. 43% of urban firms introduced new process innovations, compared to 34% of others. Roughly the same proportions of urban and rural firms introduced entirely new processes (around 7%), yet there was a pronounced difference between the proportions introducing processes already in use elsewhere: 36% compared to 27%.

Our findings also suggest that firms are more likely to introduce new product and process innovations which are new to the firm than innovations which are entirely original. This finding is as would be expected: entirely new innovations are rare. The SBS may even

overstate them, as firms may be less likely to admit that they have 'learnt' innovations from elsewhere.

In short, urban firms tend to introduce both more process and product innovations, but the difference is most pronounced for process innovation, which supports our first two hypotheses (H_1 and H_2), but not our third (H_3). In the following, we set out a model which tests whether this is robust to controlling for other firm level characteristics.

The model

The model used here is a basic innovation production function, where the dependent variable is the binary response variable of whether a firm innovates or not. The model is specified for firm 'i' as follows:

$$INNOV_i = \alpha + \beta_1 FIRM_i + \beta_2 ACTIVITIES_i + \beta_3 URBAN_i + \upsilon_i + \varphi_i + \varepsilon_i \quad (1)$$

The model is essentially an innovation production function, which predicts whether a firm innovates (INNOV) based on a vector of variables for the characteristics of the firm (FIRM), whether the firm engages in innovation-related activities (ACTIVITES), and, our independent variable of interest, whether the firm is located in an urban area or not (URBAN). In addition, we control for the region in which the firm is located (υ) and for the sector of the firm (φ), in order to uncover the specific geographical and sector-based conditions which may affect a firm's innovative capacity. The constant is 'α' and the error term is 'ε'.

Table 2 around here

The principal variable of interest is whether a firm is located in an urban area or not. This is done using the standardized categories of urban for England, Wales and Northern Ireland and the Scottish categories of Large Urban Area and Other Urban Area. The variable takes the value of one if a firm is in an urban area, and zero otherwise. As such, this binary indicator is a relatively blunt instrument which can neither account for whether firms are located in large or small urban areas, nor can it take into consideration differences in rural locations. The level of rurality and peripherality is certainly not the same in, say, the Shetland Islands than in the the much more accessible rural areas of South East England, where the influence of London

for innovation could be strongly felt. Yet a simple indicator such as this does have the advantage of allowing testing well defined hypotheses and of providing clear results.[3]

Alongside this, a series of controls are included for the characteristics of the firms (FIRM). Definitions of all variables are given in table 2. The first of these is the size of firms, as larger firms may be expected to produce more innovations, simply by virtue of their scale. As the variable is skewed the logged value is used, an approach common to other similar studies (e.g. Czarnitzki and Hottentot 2009). This is calculated as the total number of employees, plus one added so the number can be logged. Whereas theory has often focused on dynamic groups of smaller firms in creating innovations, research suggests that larger firms tend to be more innovative (Roper et al. 2000; Gordon and McCann 2005). Part of this may be because of the way the question is asked, as firms are asked for an absolute value ('have you innovated?') rather than one relative to firm size ('how many innovations have you introduced per employee?') (Freel 2002).

Similarly, studies have often found that older firms are more innovative. Gordon and McCann's (2005) work on London is one such example. In contrast, work on high tech sectors in Israel has suggested that newer firms are only more innovative in high-technology industries; in 'traditional' industries younger firms are less innovative (Shefer and Frenkel 1998). Three dummy variables are used to control for this: one if the firm is aged between 1 and 3, a second for firms aged 4 to 10 and a third for those firms older than 11. The reference category is firms aged under one year.

We also use a control for legal structure. In common to similar studies this is a simple dummy variable which takes the value one when a firm is a Public Limited Company (PLC). This status shows a degree of professionalism, meaning that such firms are less likely to be lifestyle businesses, and so more likely to introduce new innovations. PLCs have to be responsible to a number of owners or shareholders, and therefore face greater pressure to innovate and grow.

A second ownership variable is whether the firm has changed ownership over the past three years. Changing ownership generally implies having introduced new structures and, possibly, an access to external knowledge through the new owners. Firms having undergone a change of ownership would thus be expected to be more innovative.

[3] In addition, the introduction of a more nuanced subdivision of urban and rural areas would not only reduce the size of the sample for each category, but equally raise questions about the definition of each urban and rural subcategory.

A further set of variables account for the activities of the firm. The first of these is whether the firm has a business plan, which is a sign of improved management quality – particularly demonstrating a focus on strategy – possibly making firms more innovative. A second issue is the competency of the leadership of the firm. The SBS contains eight questions each of which focuses on a different element of perceived leadership of the firm. Each of these questions asks 'How capable is your business at …' followed by the subcategories of: people management; designing and developing a business plan; using formalized business systems; entering new markets; developing and introducing new products; accessing external finance; operational improvement, and; taking decisions on regulation and tax. Each of these is asked on a scale of 1 to 5, where 5 indicates that a firm is very good and 1 poor. A simple average of the response on these eight questions is used to account for leadership quality, with better led or managed firms being more innovative (Rammer et al. 2009).

The international orientation of a firm also matters for innovation. Firms which serve international markets are more likely to be innovative as they may be more open to making international links, and have a greater awareness of new developments and innovations taking place elsewhere. This is controlled for using a variable for whether the firm exports or not. Firms with many sites may similarly have a greater awareness of multiple markets and so introduce new products or processes more easily. A variable for whether the firm has multiple sites is therefore also used.

Small firms may also access external expertise to create new innovations, such as where firms link use consultants for procedural changes (Scott 2006). A variable for whether the firm takes advice from outside the firm is available in the SBS and is included to control for this.

We also take into account whether a firm actually does not aim to grow in the future. Doing this allows to discriminate lifestyle businesses which may be less keen to introduce new products, and so may be naturally less innovative.

Finally, we control for region specific issues which may confound the results – such as R&D produced in other firms or competitive dynamics – by introducing a set of dummies for the government office regions of England, alongside Wales, Scotland and Northern Ireland are included in all models (Roper et al. 2000). The sector of the firm may also influence a firm's propensity to innovate and is added as a further control.

4. Results

Each model is estimated as a probit regression model with robust standard errors (Cameron and Trivedi 2009). The results for product innovation are presented in table 3, those for process innovation are given in table 4. As the only difference between the two tables is a change in the binary dependent variable the coefficients in the two tables are directly comparable.

Table 3 around here

Table 3 gives the results for the three measures of product innovation: whether the firm has introduced any product innovation, an original (entirely new) product innovation, and a learnt product innovation (new to the firm). The results suggest quite strongly that firms in urban areas are more likely, controlling for both their characteristics and the innovative activities in which they engage, to introduce new product innovations. This suggests that the emphasis on urban areas as the location of new innovations also applies here, and supports the existing literature on this point (Crescenzi et al. 2007; Knudsen et al. 2008; Nathan and Lee 2011). They also support the first hypothesis, that urban firms are more innovative, at least for product innovation.

When the distinction is made between whether firms introduce entirely new product innovations or simply product innovations which are new to the firm there is less evidence of a clear relationship. In both cases, the coefficient for urban firms is positive but in neither case is it significant at normal levels of significance (the variable for entirely new product innovation comes close to significance at the ten percent level).

The innovation advantage of urban firms is not specific to either learnt or original innovations individually. As the coefficients for both are positive, it is likely that both effects are operating simultaneously. It may be the case that the advantages of physical proximity help firms create both entirely new products, through exchanges of knowledge and information or diverse approaches to problem solving (Ottaviano and Peri 2004). Alongside this, firms in urban areas may also be more capable of introducing innovations learnt from other firms. Hypothesis two, which suggested urban firms were more likely to have introduced learnt innovations, is thus not fully supported by the data which shows a positive but insignificant result. Similarly, the results are only weakly supportive of hypothesis three, that urban firms are more likely to introduce entirely new innovations. While the coefficient is positive in this case, it is not significant. In short, the benefits of being located in a city for product

innovation are likely to be both complex and firm specific, meaning that they are not simply the result of either original or learnt innovations (Gordon and McCann 2005; Fitjar and Rodríguez-Pose 2011a; 2011b). The actual methods of sourcing knowledge which are used in product innovation may be more formal than the chance meetings which are often referred to in theory of agglomeration and urban areas (Martin and Moodysson 2011).

The control variables perform as expected. Larger firms are more capable of introducing new products, and these are more likely to be new to the firm, rather than entirely original. One explanation for this is that they are better able to access external knowledge, or they may be able to buy in new products from elsewhere (while smaller firms are less able to afford this). There appears relatively little relationship with firm age, in contrast to previous studies (Gordon and McCann 2005). Firms in the mid-age period of 4 – 10 years introduce fewer new product innovations, but the effect does not survive for other indicators of a firm's age.

Legal status also appears important. PLCs are significantly more likely to introduce product innovations, and these tend to be entirely new. Legal status may be introduced to protect these innovations, so the causality of this is not clear. Firms which export introduce more innovations which are only new to the firm, suggesting a tendency to source new products from abroad or built international links (Fitjar and Rodríguez-Pose 2011a). Firms which change owner introduce more product innovations, although this appears to be driven by a greater likelihood of new product innovations. This is perhaps surprising, as new owners are generally expected to bring innovations which are not new to the firm with them.

Firms with multiple sites, which presumably is both a signifier of success and provides access to a wider set of knowledge sources, are strongly related to both types of innovation. As would be expected from past research, firms with better management quality also have a greater probability of innovating (Rammer et al. 2009). Finally, there is a significant negative relationship between whether a firm does not aim to grow and all three measures of innovation. Firms seeking growth are more likely to introduce new products.

Table 4 around here

Table 4 reports the results of the analysis for the three measures of process innovation. One difference from product innovation is that process innovation may be less likely to be subject to copyright restrictions or other forms of intellectual property protection. The results highlight that urban firms have a greater propensity to introduce new process innovations overall. Explanations for this might include greater competition in urban areas which forces

firms to rapidly evolve their organisations. Alternatively, urban firms may see a more diverse range of knowledge sources, which may inspire them to create new organizational practices (Duranton and Puga 2001). Proximity to other firms may help urban firms learn from them, and introduce new processes which have been already been introduced elsewhere. Again, the results are supportive of our first hypothesis: urban firms are significantly more innovative than firms elsewhere.

Yet being located in an urban area appears no more or less likely to make firms create entirely new process innovations (Table 4, Regression2). As with product innovation, hypothesis two, that urban firms will introduce more original innovations, is not supported by the data. While the coefficient is positive, it is not significant. Other forms of proximity may be more important in the production of innovations of this type (Boschma 2005; Fitjar and Rodríguez-Pose 2011a). The benefits of being located in an urban area may be greater for sectors which are reliant on particular urban properties, such as the creative industries, but lower for science based industries (Asheim et al. 2007).

However, there is a strong relationship between an urban location and firms being able to introduce process innovations new to the firm (Table 4, Regression 3). This provides support for hypothesis two, that urban firms will introduce more learnt innovations. One interpretation is that urban firms have a greater access to external sources of information or knowledge about process innovations taking place in neighbouring firms, which they are able to introduce more easily than product innovations, which are subject to greater product protection.

This is consistent with the model presented by Duranton and Puga (2001) in which firms initially develop products in diverse cities, before moving to specialized cities to produce these. This model essentially relies on cities as generators of idea, but also as places where firms can 'borrow' new processes from other actors. The difference may be in the UK case where cities are closer together than theoretical models based on the United States case where there are larger distances involved (Crescenzi et al. 2007). Firms develop products in urban areas, but move outside the inner cities to bring these to mass production. Yet our evidence provides a degree of nuance with regard to the extent to which this happens. Both products and processes are introduced in cities, but the learning effect applies principally with process, rather than product, innovation.

Once again, the control variables tend to have the expected sign. Larger firms have a greater propensity to introduce all forms of process innovation, while younger firms are more likely

to introduce process innovations. The latter effect is primarily driven by entirely new innovations, and is similar to the impact derived from being a PLC. In both cases, it may reflect wider organisational necessities from managing a larger firm with a more complex legal structure. Exporting firms also have a greater tendency to introduce entirely new process innovations, but not to introduce those from elsewhere. This may, again, reflect the organizational difficulties of exporting or the need for firms to be competitive to do so.

In contrast to the results for product innovation, firms which have changed owner in the previous three years are more likely to introduce process innovations from elsewhere. This is the expected result, as it indicates new ownership bringing preferences for organizational structures experienced in previous firms. For firms with multiple sites, more complex structures favour the introduction of firm-specific process innovations.

The quality of management also matters for process innovation. Better managed firms engage in more process innovations, but these are generally from outside the firm. Neither having a business plan, nor seeking advice from elsewhere is important. As with product innovation, firms which do not aim to grow are less likely to introduce any form of innovation.

5. Conclusion and policy implications

Underlying the innovation advantage of cities are two separate processes. One may allow new approaches to problem solving and the development of entirely new products. Yet alongside this a second allows urban firms to learn, or rather mimic, other firms and gain an innovation advantage from this. Using a sample of over 1,600 firms in the UK, this paper has tested these advantages in accordance with our hypotheses. It finds strong support for hypothesis one, that urban firms are more innovative. In this respect, the results of the paper support the large number of studies in this area (Feldman and Audretsch 1999; Crescenzi et al. 2007; Knudsen et al. 2008).

However, our results suggest a greater degree of nuance with respect to the ways in which cities support innovation. We find that urban firms are more likely to produce both product and process innovations than those outside. The advantage for product innovation potentially derives from both effects, but the advantage for process innovation is explained entirely by learning effects. Hypothesis two, which suggests that urban areas will introduce more learnt innovation, appears to be supported – but only for process innovation. There is less evidence for hypothesis three, that urban firms will introduce more original innovations. Thus, the

results corroborate part of the existing research which suggests that radical product innovations are possible even in relatively remote locations (Fitjar and Rodríguez-Pose 2011a; 2011b). Other forms of proximity may be more important in these cases.

Urban areas facilitate the sharing of information, which allows firms to mimic one another. This applies to processes, which tend to be harder to copyright and less visible when replicated elsewhere. For product innovations these effects may be less apparent. Products are bound to be more protected by intellectual property legislation. It might also be that there is a different premium on new product innovations: firms introducing copycat products might actually see their reputation decline, whereas few customers care about the processes which firms follow. For product innovation, proximity may actually reduce the diversity of new thinking which operates, with new ideas less likely to be produced in homogenous situations (Fitjar and Rodríguez-Pose 2011a). All these factors may mean learning amongst urban firms favours processes rather than products.

Of course, these effects will differ according to the type of cities which are considered. In their model of 'nursery cities', Duranton and Puga (2001) suggest that some cities will be used to refine processes while others are used for production. Underlying the results here may be a difference in the role played by cities of different types. Research focused on London suggests innovation in the capital may often be process focused, and so localised learning of processes from other firms may be important there (Wood 2009). Cities with greater focus on science related activity, such as Oxford, may instead develop support structures for entrepreneurs who develop radical product innovations (Lawton Smith et al. 2008).

Theory in this area needs to consider this nuance, particularly when developing empirical models. The common use of patents as a measure of urban innovation only takes one particular type innovation into account. Other forms of innovation, such as the process innovations in our paper, may have more complex interactions with urban areas. Yet the results only capture one dimension of this detail. Product and process innovation are broad categories and disguise different 'learning' mechanisms. Aesthetic or other 'soft' product innovations are, for obvious reasons, more visible and able to be copied than complex technological changes (Stoneman 2009). The transmission mechanisms through which firms in a city will learn these will differ. Ignoring these will create biased pictures of innovative processes.

Moreover, 'learning' processes have implications for theoretical understandings of how firm growth relates to innovation. Research suggests that only a minority of innovating firms

experience growth as a result; most innovative firms benefit little from these innovations (Coad and Rao 2008). The processes we outline may be one reason why. Alongside this, they highlight a potential cost of locating in cities for innovative firms. The learning processes described here may be providing disincentives for urban firms to invest in genuinely new processes themselves. The overall costs and benefits of these approaches are unclear.

Our results have a number of implications for policy. Firms in different places will produce innovations in different ways, implying the need for spatially differentiated innovation policy. In the UK at least, there have been criticisms that changes in the institutions for economic development have led innovation policy to be centralised (Crowley 2011). The results also suggest that innovation in process and production practices may be harder for rural firms to learn from other firms. Efforts to improve productivity amongst rural SMEs may want to consider focusing networking and shared learning sessions on the introduction of new processes, equipment and ways of working, rather than new products.

These results open up other new avenues for research. A serious limitation in studies using innovation surveys is the broad nature of the questions asked. If further research was able to reduce these further – and ask supplementary questions, it would be possible to drill down these effects more closely. This might involve asking where firms introducing innovations which were not new to the firm had learnt those new processes from, and how. In particular, firms may take advice about new processes from many sources; better information on where firms take advice may help unpick this result. It may then be able to address concerns about the extent to which learned innovations are actually 'new' rather than simply taken from other contexts. Moreover, the results here are consistent with theoretical predictions for small firms, which are more likely to source knowledge externally, it would be useful to consider how these processes may change for larger firms which are more able to spread production across many cities (Scott 2006). Finally, future research could use a wider range of geographical identifiers – distinguishing, for example, between large and small cities or remote and accessible rural areas – to further unpick the relationships between geography and innovation (Smallbone and North 1999; North and Smallbone 2000).

Acknowledgements: We are grateful to a number of anonymous reviewers for insightful suggestions to earlier versions of the paper. Financial support by the European Research Council under the European Union's Seventh Framework Programme (FP/2007-2013)/ERC grant agreement no. 269869 is gratefully acknowledged.

References

Asheim, B. T. and Isaksen, A. 2002. Regional innovation systems: The integration of local 'sticky' and global 'ubiquitous' knowledge. Journal of Technology Transfer 27: 77 – 86.

Asheim, B. T., Coenen, L. and Vang, J. 2007. Face-to-face, buzz and knowledge bases: Sociospatial implications for learning, innovation and innovation policy. Environment and Planning C: Government and Policy 25(5): 655 – 670.

Bathelt, H., Malmberg, A. and Maskell, P. 2004. Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. Progress in Human Geography 28: 31 – 56.

Boschma, R. A. 2005. Proximity and innovation: A critical assessment. Regional Studies 39 (1): 61-74.

Boschma, R. A., Erikson, R. and Lindgren, U. 2009. How does labour mobility affect the performance of plants? The importance of relatedness and geographical proximity. Journal of Economic Geography 9 (2): 162-190.

Cameron, C. and Trivedi, P. K. 2009. Microeconometrics using Stata. Stata Press: College Station, TX.

Coad, A. and Rao, R. 2008. Innovation and firm growth in 'complex technology' sectors: A quantile regression approach. Research Policy 37: 633-648.

Crescenzi, R. A., Rodríguez-Pose, A. and Storper, M. 2007. The territorial dynamics of innovation: a Europe – United States comparative analysis. Journal of Economic Geography 7: 673 – 709,

Crowley, L. 2011. Streets ahead: What makes a city innovative? The Work Foundation: London.

Czarnitski, D. and Hottenrott, H. 2009. Are local milieus the key to innovation performance? Journal of Regional Science 49 (1): 81-112.

Duranton, G. and Puga, D. 2001. Nursery cities: Urban diversity, process innovation and the life cycle of products. American Economic Review 91 (5): 1454-1477.

Duranton, G. and Puga, D. 2004. Micro-foundations of Urban Agglomeration Economies. In J.V. Henderson and J.F.Thisse (eds) *Handbook of Regional and Urban Economics*, Vol. IV, , North-Holland, Amsterdam, 2063-2117

Eriksson, R. and Lindgren, U. 2009. Localized mobility clusters: Impacts of labour market externalities on firm performance. Journal of Economic Geography 9 (1): 33–53.

Fagerberg, J. 2005. Innovation: A guide to the literature. In Fagerburg, J., Mowery, D. C. and Nelson, R. R. (eds) *The Oxford Handbook of Innovation*, Oxford University Press, Oxford, 1–23.

Feldman, M. P. and Audretsch, D. B. 1999. Innovation in cities: Science-based diversity, specialization and localized competition. European Economic Review 43: 409–429.

Fitjar, R. D. and Rodríguez-Pose, A. 2011a. When local interaction does not suffice: sources of firm innovation in urban Norway. Environment and Planning A 43 (6): 1248 – 1267

Fitjar, R. D. and Rodríguez-Pose, A. 2011b. Innovating in the periphery: Firms, values and innovation in Southwest Norway. European Planning Studies 19 (4): 555 – 574.

Freel, M. 2002. Sectoral patterns of small firm innovation, networking and proximity. Research Policy 32 (5): 751 – 770.

Freel, M. and Harrison, R. 2006. Innovation and co-operation in the small firm sector. Regional Studies 40 (4): 289 – 305.

Glaeser, E. 1999. Learning in cities. Journal of Urban Economics 46: 254-277.

Gertler, M. S. 1995. `Being there': proximity, organization, and culture in the development adoption of advanced manufacturing technologies. Economic Geography 71: 1 – 26.

Gordon, I. and McCann, P. 2000. Industrial Clusters: Complexes, Agglomeration and / or Social Networks. Urban Studies 37 (3): 513-532.

Gordon, I. and McCann, P. 2005. Innovation, agglomeration, and regional development. Journal of Economic Geography 5 (5): 523-543.

Keeble, D. 1997. Small firms, innovation and regional development in Britain in the 1990s. Regional Studies 31 (3): 281 – 293.

Keeble, D. and Tyler, P. 1995. Enterprising Behaviour and the Urban-Rural Shift. Urban Studies 6 (32): 975 – 997.

Knudsen, B., Florida, R., Stolarick, K. and Gates, G. 2008. Density and creativity in US regions. Annals of the Association of American Geographers 98 (2): 461 – 478.

Lawton Smith, H., Romeo, S. and Bagchi-Sen, S. 2008. Oxfordshire biomedical university spin-offs: An evolving system. Cambridge Journal of Regions, Economy and Society 1 (2): 303 – 319.

Lee, N. and Nathan, M. 2010. Ethnic Diversity and Innovation in London: Evidence from Firm Level Data. Journal of Knowledge Based Development 1 (1/2): 53 - 7.

Lee, N. and Cowling, M. 2012. Place, sorting effects and barriers to enterprise in deprived areas: Different problems or different firms? International Small Business Journal, *forthcoming*.

Marshall, A. 1920. Principles of Economics. MacMillan: London.

Martin, R. and Moodysson, J. 2011. Innovation in symbolic industries: The geography and organization of knowledge sourcing. European Planning Studies 19 (7): 1183 – 1203.

Maskell, P., Bathelt, H. and Malmberg, A. 2006. Building global knowledge pipelines: the role of temporary clusters. European Planning Studies 14: 997 – 1013

Nathan, M. and Lee, N. 2011. Does cultural diversity help innovation in cities? Evidence from London's firms. SERC Discussion Paper 0069, Spatial Economics Research Centre, LSE.

Neffke, F., Henning, M. and Boschma, R. 2012. The impact of ageing and technological relatedness on agglomeration externalities: a survival analysis. Journal of Economic Geography 12 (2): 485 – 517.

Niebuhr, A. 2010. Migration and innovation: Does cultural diversity matter for regional R&D activity? Papers in Regional Science 89 (3): 563 – 585.

North, D. and Smallbone, D. 2000. The innovativeness and growth of rural SMEs during the 1990s. Regional Studies 34 (2): 145 – 157.

Ottaviano, G. and Peri, G. 2006. The economic value of cultural diversity: Evidence from US cities. Journal of Economic Geography 6 (1): 9 – 44.

Rammer, C., Czarnitzki, D. Spielkamp, A. 2009. Innovation success of non-R&D-performers: substituting technology by management in SMEs. Small Business Economics 33: 35 – 58.

Rodríguez-Pose, A. 1999. Innovation prone and innovation averse societies: Economic performance in Europe. Growth and Change 30 (1): 75 – 103.

Rodríguez-Pose, A. and Crescenzi, R. 2008. Research and development, spillovers, innovation systems, and the genesis of regional growth in Europe. Regional Studies 42: 51 – 67,

Roper, S., Love, J. H., Ashcroft, B. and Dunlop, S. 2000. Industry and location effects on UK plants' innovation propensity. Annals of Regional Science 34: 489 – 502.

Scott, A. J. 2006. Entrepreneurship, Innovation and Industrial Development: Geography and the Creative field revisited. Small Business Economics 26: 1 – 24.

Shefer, D. and Frenkel, A. 1998. Local Milieu and Innovations: Some Empirical Results. The Annals of Regional Science 32 (1): 185-200.

Simmie, J. 2003. Innovation and urban regions as national and international nodes for the transfer and sharing of knowledge. Regional Studies 37 (6&7): 607 – 620.

Smallbone, D. and North, D. 1999. Innovation and new technology in rural small and medium-sized enterprises: some policy issues. Environment and Planning C: Government and Policy 17: 549 – 566.

Stoneman, P. 2009. Soft innovation: Towards a more complete picture of innovative change. London: National Endowment of Science, Technology and the Arts.

Storper, M. and Venables, A. J. 2004. Buzz: face-to-face contact and the urban economy. Journal of Economic Geography 4: 351 – 370.

Wood, P. 2009. Service competitiveness and urban innovation policies in the UK: The implications of the 'London paradox'. Regional Studies 43 (8): 1047 – 1059.

Tables

Table 1. Percentage of firms innovating in urban and non-urban areas

	Firm has introduced new product innovation in past 12 months:			Firm has introduced new process innovation in past 12 months:		
	All product innovations	Entirely new product innovation	New to the firm	All product innovations	Entirely new product innovation	New to the firm
Non-urban	45.8	11. 8	34.0	33.6	7.0	26.6
Urban	52.1	14.6	37.5	43.0	7.3	35.7
Total	50.2	13.7	36.5	40.3	7.2	33.0

Total sample is 1,652 firms of which 1,167 are urban and 485 are not.

Table 2. Variables and definitions

	Variable	Description
Urban	Urban	Whether firm is located in an urban area or not
Size	Size (ln)	Size of firm (+ 1), natural log
Age	Age 1 -3 Age 4 – 10 Age 11 +	Set of three dummy variables for firm age which are one if a firm is aged between 1 and 3, 4-10 and 11 +, reference category is for firms less than a year old
Ownership	PLC	Whether the firm is a Public Limited Company (1 if so)
	Business Plan	Whether the firm has a business plan (1 if so)
	Exports	Whether the firm exports (1 if so)
	Change of owner	Whether the firm has changed owner in the previous three years (1 if so)
	Advice	Whether the firm seeks advice from external sources (1 if so)
	Multiple sites	Whether the firm has more than one location (1 if so)
	Management quality	A variable which accounts for self-reported management quality, on a scale of 1 to 5 which gives an average rating of each firm on a 1 to 5 scale for eight variables of management quality
	No growth aims	Whether firm does not aim to grow (1 if so)
	Regional Dummies	A set of regional dummies for the nine government office regions, Wales, Scotland and Northern Ireland.
	Sector Dummies	Twelve sector dummies, for the following: A - Agriculture, hunting and forestry; D - Manufacturing; F - Construction; G - Wholesale and retail trade; H - Hotels and restaurants; I - Transport, storage and communication; J - Financial intermediation; K - Real estate, renting and business activities; L - Public administration and defence; M – Education; N - Health and social work; O - Other community, social and personal services.

Source for all variables: Small Business Survey (SBS) 2010

Table 3. Product innovation and urban firms

	(1)	(2)	(3)
	Firm has introduced new product innovation in past 12 months:		
	All product innovations	Entirely new product innovation	New to the firm
Urban	0.154**	0.154	0.0762
	(0.0748)	(0.0961)	(0.0755)
Size (ln)	0.0528*	-0.0130	0.0663**
	(0.0294)	(0.0357)	(0.0292)
Age 0 -3	-0.228	-0.132	-0.130
	(0.158)	(0.184)	(0.156)
Age 4 – 10	-0.388**	-0.233	-0.240
	(0.151)	(0.174)	(0.149)
Age 11 +	0.103	0.0406	0.0747
	(0.0735)	(0.0895)	(0.0740)
PLC	0.388***	0.468***	0.0698
	(0.0835)	(0.0948)	(0.0831)
Business Plan	-0.137*	-0.0342	-0.123
	(0.0769)	(0.0966)	(0.0768)
Exports	0.0456	0.0549	0.238***
	(0.125)	(0.0835)	(0.0687)
Change of owner	0.255***	0.123	-0.0656
	(0.0679)	(0.0990)	(0.0841)
Advice	0.0198	0.165***	0.169***
	(0.0837)	(0.0588)	(0.0490)
Multiple sites	0.248***	0.278**	0.209**
	(0.0496)	(0.112)	(0.0849)
Management quality	0.311***	0.228	0.302
	(0.0827)	(0.294)	(0.252)
No growth aim	-1.565***	-2.049***	-1.596***
	(0.327)	(0.402)	(0.337)
Constant	0.154**	0.154	0.0762
	(0.0748)	(0.0961)	(0.0755)
Regional Dummies	Yes	Yes	Yes
Sector Dummies	Yes	Yes	Yes
Observations	1,652	1,652	1,652
Pseudo R2	0.0859	0.0773	0.0486

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4. Process innovation and urban firms

	(1)	(2)	(3)
	Firm has introduced new process innovation in past 12 months:		
	All innovations	Entirely new innovation	New to the firm
Urban	0.249***	0.0171	0.256***
	(0.0778)	(0.109)	(0.0797)
Size (ln)	0.123***	0.0785*	0.103***
	(0.0299)	(0.0416)	(0.0302)
Age 0 -3	0.389**	0.501*	0.256
	(0.160)	(0.282)	(0.162)
Age 4 – 10	0.156	0.337	0.0714
	(0.153)	(0.276)	(0.155)
Age 11 +	0.115	-0.126	0.169**
	(0.0739)	(0.109)	(0.0750)
PLC	0.151*	0.223*	0.0579
	(0.0842)	(0.115)	(0.0857)
Business Plan	-0.120	-0.156	-0.0724
	(0.0784)	(0.112)	(0.0793)
Exports	0.230*	0.284*	0.117
	(0.125)	(0.166)	(0.126)
Change of owner	0.437***	0.118	0.426***
	(0.0689)	(0.103)	(0.0705)
Advice	0.0555	0.0137	0.0277
	(0.0852)	(0.118)	(0.0859)
Multiple sites	0.130**	0.312***	0.0296
	(0.0504)	(0.0705)	(0.0517)
Management quality	0.326***	0.145	0.312***
	(0.0869)	(0.132)	(0.0906)
No growth aim	-2.437***	-3.874***	-2.047***
	(0.337)	(0.523)	(0.349)
Constant	0.249***	0.0171	0.256***
	(0.0778)	(0.109)	(0.0797)
Regional Dummies	Yes	Yes	Yes
Sector Dummies	Yes	Yes	Yes
Observations	1,652	1,652	1,652
Pseudo R2	0.110	0.0823	0.0914

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1