Moving People with Ideas:

Does internal mobility foster innovation?

Riccardo Crescenzi[1] and Luisa Gagliardi[12]

[1]Dep. of Geography and Environment, London School of Economics, Houghton Street, WC2A 2AE, UK;

[2]Centre for Regional Economics, Transports and Tourism (CERTeT), Bocconi University, Via Roentgen 1, Milan, Italy

Abstract

Internal movements of knowledgeable individuals represent a key mechanism of knowledge diffusion within national boundaries across regions and cities. This paper aims to explore the impact of the inflows of inventors – as proxy for the internal mobility of knowledgeable individuals otherwise impossible to capture – on the innovative performance of firms located in English local labour market areas. The analysis employs a firm knowledge production function approach, further extended in order to consider the role of mobility. Results suggest that the geographical relocation of knowledgeable individuals per se has no impact on firms' innovation. A positive impact emerges only after firm-level capabilities to exploit new sources of locally available knowledge are fully accounted for. This suggests that policies targeting the spatial mobility of skilled individuals should be complemented by measures reinforcing the "receptiveness" of local firms.

JEL Classification: O31, O15, J61.

Keywords: Innovation and Inventions, Human Resources, Geographic Mobility.

Acknowledgement: The research leading to these results has received funding from the European Union Seventh Framework Programme FP7/2007-2013 under grant agreement No SSH-CT-2010-266959; Project PICK-ME. The authors would like to thank Francesco Lissoni, Stefano Breschi and the participants to the Spatial Economic Research Centre (SERC)–LSE seminars, the Eurolio 2012 Conference at Saint Etienne (France), the OECD - Regional Development Programme Internal Seminars in Paris, the 2012 Barcelona Workshop on Regional and Urban Economics, the ONS Secure Data Service Workshop 2012 held in London and the IC10 2014 Workshop in Paris for comments and suggestions. The authors are solely responsible for any errors contained in the article.

Disclaimer

1) Introduction and background

The accumulation of human capital is fundamental to enhance regional productivity and innovative performance (e.g. *Lucas, 1988, Glaeser et al., 1992, Moretti, 2004, Duranton, 2007*). People are, in fact, the repositories of ideas and skills implying that their physical presence in certain locations is a primary conduit of knowledge accumulation (*Leamer and Storper 2001, Herrera et al, 2010*).

In this context the individually embodied nature of human capital shed light on the rationale behind the role of mobility as mechanism of knowledge diffusion. Since knowledge tends to travel along with people who master it (*Breschi and Lissoni, 2001*), the mobility of knowledgeable individuals allows for the circulation of knowledge across locations and it contributes to shape the geography of innovation. Inflows of valuable human capital enrich the local knowledge base while raising the level of productivity and creativity of local interactions (*Marè et al, 2011*). This further implies that the expected positive effect of mobility on firms located in recipient economies goes beyond the availability of new skills accessible through the learning by hiring mechanism (*Song et al, 2003, Lewis and Yao, 2006*) since it contributes to the creation of a contextually enabling environment for innovativeness (*Glaeser et al., 2010*).

However, despite the increasing attention on the topic the investigation of the impact of mobility of innovation remains a challenging task and growing consensus has been reached on the need of a closer look to the mechanisms at play. The positive effect traditionally found in previous studies (*Peri, 2005, 2007, Chellaraj et al, 2008, Faggian and McCann, 2006, 2009, Hunt and Gauthier-Loiselle, 2008, Miguelez and Moreno, 2010, Ozgen et al., 2011,*) has been challenged by recent contributions showing that the impact of skilled inflows on innovation crucially depends on firms specific characteristics and the very nature of their innovation processes (*Gagliardi, 2014, Mare' et al, 2014*). Combining firm level micro data with information on the skill structure of the local workforce these studies have, in fact, suggested

that when firm level characteristics are fully accounted for there is no evidence of an independent link between mobility and innovation. Hence, firms' heterogeneity in terms of absorptive capacities and learning behavior play a key role in the relation between these two dimensions.

This paper looks at the internal mobility of inventors as a proxy for the mobility of "innovative", individuals (otherwise impossible to capture with traditional data), aiming at assessing its impact on the innovative performance of firms located in recipient labour market areas in England. We focus in particular on the impact of mobility that passes though the creation of a contextually enabling environment for innovativeness to test for the emergence of human capital externalities associated to the spatial sorting of knowledgeable individuals in specific locations (*Moretti, 2004*). To disentangle this effect from the traditional impact mediated by the learning by hiring mechanism we matched information on mobility with firms' level data based on recipient local labour market areas (TTWAs). TTWAs as self-containing labour markets are, in fact, the geographical contexts in which formal and informal channels of knowledge exchange take place. We factor out the direct impact of mobility on firms' innovation associated to the hiring of new skilled personnel by controlling for the share of skilled employees in each firm, thus capturing the contribution of mobility that passes through the externality mechanism.

The analysis contributes to the existing literature in a number of ways. First, it focuses on internal rather than international migration. The role of internal mobility has remained fairly unexplored in the existing literature on the link between mobility and innovation due to, among other reasons, the difficulties in recovering a reliable indicator for internal flows. Looking in particular at the case of Britain few recent studies have tried to shed light on this dimension by looking on the mobility of recent graduates (*Faggian and McCann, 2006, 2009*). The focus on inventors' mobility, however, represents a relevant complement to these analyses since it makes possible to disentangle the impact of a specific typology of movers that goes beyond the simple category of skilled individuals in terms of formal educational achievement. Inventors as holders of economically exploitable tacit knowledge represent, in fact, a relevant segment of

movers explaining why patents data have been increasingly adopted to investigate mobility patterns (*Zucker, Darby and Armstrong, 1998a, Zucker, Darby and Brewer, 1998b, Almeida and Kogut, 1999, Kim et al, 2006, Zucker and Darby, 2006, 2007, Crespi et al, 2007, Breschi and Lissoni, 2009*).

Second, the paper exploits a measure of firms innovativeness provided by the UK Community Innovation Survey (UK-CIS), which allows to overcome the potential problems of mechanical correlation affecting previous studies. Related contributions, in fact, have looked at the relation between mobility and innovation by employing patent statistics to construct both the variable of interest (e.g. mobility) and the dependent variable (e.g. innovative outcome) (*Miguelez et al, 2010, Miguelez and Moreno, 2010*). However, this approach may introduce a certain degree of circularity in the identification of the impact of mobility.

Finally, the analysis relies on a sound estimation strategy. We exploit the panel structure in our data controlling for firm specific characteristics. In the light of previous studies this is a key step forward in the investigation of the link between mobility and firm's innovative performance since it allows to account for both observable (such as for example intramural R&D, skilled employees[1] and market strategies) and unobservable firm level characteristics potentially driving our results.

We also develop a novel instrumental variable approach to deal with the reverse causality bias traditionally acknowledged in the existing literature. Although weakened by the possibility to control for firms' specific characteristics, which account also for their locational attributes, it is still possible that changes in the degree of attractiveness of local labour market areas may affect our results. Our instrument exploits information on patent citations as proxy for the relevance and novelty of specific inventions. We interpret the number of citations in the twelve months after the publication as a signaling effect for inventors' quality. The immediate payoff of a highly successful (and highly cited) invention may, in fact, be associated with greater visibility and greater opportunities of mobility and job offers. In this view a highly successful invention is interpreted as an individual push factor increasing the probability of mobility

[1] The possibility to account for the number of skilled employees in each firm, in particular, is a key advantage in our data since it allows identifying the overall impact of mobility on local innovation while netting out the share of new skills that each firm can internalize by hiring new employees

independently of the degree of attractiveness and the innovative performance of specific firms in a given spatial context. This economic rationale is indirectly supported by previous related research showing that inventors characterized by more valuable patents (i.e most cited patents) are those with the highest probability of changing their job (*Trajtenberg et al., 2006*).

Our results show that the mobility of knowledgeable individuals per se does not affect firms' innovative performance in recipient areas when firms' specific characteristics are fully controlled for. The positive effect found in previous studies, in fact, emerges only when we restrict our sample to firms complementing internal with external sources of information. This evidence can be interpreted in the light of the growing literature addressing the limitations of the traditional Knowledge Production Function (KPF) approach, where innovative performance is explained by only means of internal inputs (*Loof and Heshmati, 2006, Van Leeuwen and Klomp, 2006)* as well as in relation to recent studies showing no independent link between the skill structure of the local workforce and firms' innovative performance when firms' heterogeneity is accounted for (*Mare' et al, 2014*). Differences in firms' learning behavior and degree of engagement with external sources of knowledge crucially mediate the impact of mobility on innovation.

The paper is organized as follows: the next session describes the data focusing in particular on the main challenges in tracing mobility using patents and describing in detail the main data sources and the procedure used to construct the key variables. Section 3 discusses the methodological challenges related to the estimation of the effect of mobility on innovation and at the spatial dimension of the phenomenon. Section 4 reports the main results while Section 5 concludes.

2) Data and measurement issues

2.1 Tracing inventors' mobility using patents data

Patent data have been extensively exploited within the economics literature to analyse the innovative process (*Trajtenberg et al, 2006*). In particular several studies have looked at patent records in order to shed more light on the effect associated to the mobility of star scientists (*Zucker, Darby and Armstrong, 1998a, Zucker, Darby and Brewer, 1998b, Almeida and Kogut, 1999, Stolpe, 2001, Singh, 2003, Song et al, 2003, Zucker and Darby, 2006, 2007, Hoisl, 2007, Breschi and Lissoni, 2009, Miguelez and Moreno, 2010, Miguelez et al, 2010*). In this context the potential advantages coming from patents data are primarily associated with the possibility to exploit individual based information and to track mobility at a very detailed geographical scale. This is a relevant feature since data on internal mobility and in particular on the mobility of knowledgeable individuals is often difficult to recover.

A number of additional considerations need, however, to be taken into account when employing patents records as data source for internal mobility.

Who's who problem

A key problematic aspect relates to the exact identification of inventors. Inventors' names are often misspelled or misreported in patent documents limiting the possibility to associate different patents to the same individual in the case of multi-patenting inventors (*Trajtenberg et al, 2006*). This is a relevant concern when patent data are used in order to look at mobility patterns since it is possible to observe only those inventors patenting different times in different locations.

In order to deal with this problem we refer to the KEINS database (*Lissoni et al, 2006*) containing all applications to the European Patent Office (EPO). The database represents a "cleaned version" of EPO data treated in order to solve the problems associated to the misreporting/ misspelling of inventors' names[2].

Identification of movers

Patents data reports detailed geographical information (at postcode level) on patenting inventors to identify their exact location in space. Postcode information can be re-aggregated

[2] see Lissoni et al, 2006 for further information on the cleaning procedure

at Travel to Work Area (TTWA) level, which represents local labour markets in Britain[3]. Information is also available with respect to the timing of the mobility event[4] implying the possibility to qualify local labour market areas that have been interested by inventor inflows at a specific point in time.

Since individuals are observed only when they enter the patenting process movers are identified by means of the inventors that patented different times in different locations. To construct our mobility measure we also restricted the time window associated to the mobility "event" looking only at recent movers (inventors changing their residence in the last 3 years), thus limiting the influence of alternative confounding factors that can affect the relation between mobility and innovation over a longer time interval. Despite providing information on mobility patterns across detailed geographical areas and within a specific time period, the focus on multi-patenting inventors qualified as recent movers reduces significantly the number of available observations limiting the suitability of our sample to derive a measure of actual flows.
For these reason our preferred measure of mobility has been constructed as a dummy variable taking value 1 in case of positive inflows of inventors in a certain locations and zero otherwise. Our key regressor is thus aimed at providing a representative proxy for the spatial patterns of inventors' mobility across England without claiming a specific focus on the quantitative and qualitative dimension of the actual flows.
The descriptive analysis of spatial patterns of mobility in England shows that among the total sample of movers changing TTWA of residence, the 54.2% moved in a different NUTS3 region, the 47.9% in a different NUTS2 region and the 31.3% changed NUTS1 region of residence. Figure 1 reports the map of English TTWAs based on whether they have been interested by inventors' inflows over the period 2000-2005.

[Insert Figure 1 here]

[3] TTWAs are constructed as self-containing labour markets based on commuting flows with at least 75% of people living and working in the same area.

[4] Information on the time of the invention refers to the priority data, which is considered by OECD the closest to the invention process.

Although some traditionally successful areas, such as for example London or Oxford, experienced inflows of inventors over the whole time span, some variation in the destination of movers emerge when splitting our time window in the two sub-periods 2000-2002 and 2003-2005. Internal mobility patterns have been more relevant in the first rather than the second period with some differences also in their geographical distribution. Changes in recipient areas of inventor inflows over time will be exploited to investigate the impact of mobility on local firms' innovative performance.

2.1 Additional data sources

Data on inventors' mobility are complemented by information on firms' innovative performance in recipient labour markets coming from the UK Community Innovation Survey (UK-CIS)[5].

The UK-CIS is a firm level survey providing information on firms' innovative performance with respect to different types of innovation outcomes (product, process and organizational). The survey offers detailed data also on the amount of inputs devoted to the innovative process (financial investments and employees) and a large range of firm level characteristics (such as size, sector of activity, market of reference, etc.).

It represents a particularly suitable data source for our analysis for several reasons. First, it is constructed in order to build a balanced sample among all sectors of activity reducing the traditional bias of patent data toward high-tech sectors. Second, the sample is characterised by a significant share of small and medium enterprises[6] thus capturing a typology of innovation that is substantially different from that examined by using patent records. Finally, it provides detailed information on the share of skilled employees by firm allowing to disentangle the impact of mobility into local labour markets that is not mediated by the learning by hiring mechanism (i.e. the new knowledge that firms can access by hiring new personnel).

[5] Department for Business, Innovation and Skills and Office for National Statistics, UK Innovation Survey, 2001– 2009: Secure Data Service Access [computer file]. Colchester, Essex: UK Data Archive [distributor], June 2011. SN: 6699.

[6] Almost the 70% of our total sample of firms is classified as small or medium enterprise

Two waves of UK-CIS have been merged: CIS4 and CIS2007[7]. Previous research using CIS data focused on a single wave thus limiting the possibility to fully control for firms' specific characteristics. In order to recover detailed information also on the geographical location of each firm, the final sample coming from the CIS4 – CIS2007 databases has been merged with records from the Business Structural Database (BSD 2004) database[8]. For each firm present in the former sample it has been possible to obtain the 7-digits postcode and to attribute each of them to the TTWA in which they operate. Data coming from the UK-CIS have been used to construct the dependent variable (dummy variable taking values 1 if the firm is performing any product or process innovation and 0 otherwise) and other firms' based controls.

CIS data has been matched with our measure of inventors' mobility based on both a spatial and a temporal criterion. Inventors who moved within the time span 2000-2002 have been linked to the first wave of UK-CIS (CIS4) while inventors moving between 2003 and 2005 have been associated to the second wave (CIS2007). Table 1 shows the number of firms in our sample by innovation status and whether they are located in an area experiencing investors' inflows.

[Insert Table 1 here]

Interestingly those firms located in areas experiencing inventors' inflows seem consistently to show more positive innovative performance. This preliminary evidence correlates with early studies in the field attributing a positive impact on innovation to the mobility of knowledgeable individuals. The full list of variables used in the empirical analysis and standard descriptive statistics are reported in table 2.

[Insert Table 2 here]

[7] Based on the time interval 2002-2004 and 2005- 2007 respectively.

[8] The Business Structure Database (BSD), derived from the Inter-Governmental Department Business Register (IDBR), covers the 99% of economic activity in UK and provides geo- referenced firm- based data with 7 digits postcode. Department for Business, Innovation and Skills and Office for National Statistics, Business Structure Database, 1997-2013: Secure Data Service Access [computer file]. Colchester, Essex: UK Data Archive [distributor], June 2011. SN: 6697.

3) Estimation strategy

The analysis of the effect of mobility on firms' innovation is based on the Knowledge Production Function (KPF) approach popularized by Griliches (1979, 1986) and Jaffe (1986) where firms' innovative performance can be explained by the amount of internal inputs (mainly capital and labour) devoted to the innovative process.

The standard setting is augmented by our regressor of interest to account for the role mobility as additional determinant of innovation. From the methodological point of view this implies adopting a spatial correlation approach (*Borjas, 1999*) assuming that areas characterized by relevant inflows of knowledgeable individuals tend to benefit from their relocation. By focusing on self-containing local labour market areas and factoring out the direct impact of mobility on firms' innovation by means of a control on the share of skilled employees in each firm, our specification captures the contribution of mobility on the creation of a contextually enabling environment for innovativeness. By looking at how mobility impacts on the level of creativity and productivity of local interactions, over and beyond those explicitly mediated by the labour market, the analysis provides fresh evidence on the role of human capital externalities in the emergence of innovative outcomes.

The estimation equation takes the following form:

$$P\left(Innovative\ performance_{c,t}^{i}\right) = \beta_0 + \beta_1 K_{i,t}^{i} + \beta_2 L_{i,t}^{i} + \beta_3 Inventors'Inflows_{c,t-T}^{i} + \delta_i + \delta_t + \varepsilon_{c,t}^{i} \quad (1)$$

Where:

- $P(Innovative\_performance_{c,t}^{i})$ is the probability of performing any product or process innovation for firm *i* located in TTWA *c* at time *t*;
- $K_{i,t}^{i}$ is the amount of intramural expenditures that each firm *i* located in TTWA *c* within the period *t* devoted to the innovative process;

- $L^{i}_{i,t}$ is the is the number of high skilled workers[9] that each firm *i* located in TTWA *c* within the period *t-T* performing innovation related activities
- $Inventors\_flows^{i}_{c,t-T}$, the regressor of interest, is a dummy that takes value 1 if TTWA *c* experience inventors inflows at time *t* and 0 otherwise;
- δ_i , δ_t and are firm and time fixed effect respectively;
- $\varepsilon^{i}_{c,t}$ is the error term.

The above specification allows to exploit the panel dimension of our data and to account for firm and time specific characteristics. This is an invaluable feature since the majority of previous contributions, although increasing evidences on the relevance of firms' heterogeneity in mediating the impact between mobility and innovation, do not have the possibility to fully account for such dimension.

3.1 Further considerations on the identification approach

The hypothesis tested in this paper relies to the idea that inflows of knowledgeable individuals in a specific geographical context may affect the innovative performance of local firms through their effect on the degree of creativity and productivity of local interactions (*Mare' et al, 2010*). Causality may, however, also run in the opposite way. Spatial contexts in which highly innovative firms are located may be able to attract a larger number of knowledgeable individuals due, for example, to better job opportunities.

The possibility to control for firm and time specific characteristics and the adoption of a "lagged" measure of mobility limit substantially this concern. Moreover, extreme cases apart, it is doubtful whether individual firms may operate as key pull factor for inflows in specific labour markets. Notwithstanding these reasonable considerations, it can still be argued that phenomenon of spatial clustering across highly innovative firms in specific geographical areas may shift individual incentives to move in certain locations.

[9] Personnel with a degree in science or technology

To account for this additional source of potential bias we develop a novel instrumental variables (IV) approach. Previous studies have tried to account for endogeneity exploiting a number of different instruments. Hoisl (2007) has looked at whether the invention was made in a large city or rather in a rural area assuming that inventions made in large urban areas have a greater signalling effect thus leading to a higher probability of getting an alternative job offer by a competitor. Miguelez and Moreno (2010) adopted spatial econometrics techniques using the spatial lag of the additional regressors to instrument mobility. Gagliardi (2014) employs the shift-share approach popularized by recent contributions (e.g. *Card, 2005, 2007, Ottaviano and Peri, 2006*) to attribute actual flows on the bases of patters of historical settlements.

Our IV, instead, assumes that inflows in each TTWA *i* may be instrumented by push factors operating in others TTWAs *j*. We exploit the signalling effect linked to the quality of a successful invention in terms inventor's visibility.

For each TTWA *j* we calculated the index $Cit^{j}_{t,t+1}$ as the number of citations in the 12 months after publication for those patents published the year before our mobility event[10] over the total number of patents published in the same period.

$$Cit^{j}_{t,t+1} = \frac{Number\ of\ Citations^{j}_{t,t+1}}{Number\ of\ Patents^{j}_{t,t+1}} \qquad (2)$$

The instrument is then constructed comparing for each TTWA *c* the $Cit^{c}_{t,t+1}$ index with the average number of citations per patent in the 12 months after the publication at the national level during the time span 1995-2007.

Computationally the instrument takes the following form:

$$Citations^{i}_{t} = \frac{(Cit^{j}_{t,t+1} - \frac{Number\ of\ Citations_{1995,2007}}{Number\ of\ Patents_{1995,2007}})}{\frac{Number\ of\ Citations_{1995,2007}}{Number\ of\ Patents_{1995,2007}}} * W_{ij} \qquad (3)$$

[10] 1999 and 2002 respectively

Where $W_{i,j}$ is an inverse distance matrix between each TTWA *i* and all the other TTWAs *j.*
A disproportionate increase in the number of recent citations with respect to national average trends is interpreted as a signal for the recent development of a highly successful invention. The immediate payoff of a highly successful invention may be associated with greater visibility and opportunities of mobility and job offers. In this view a highly successful invention may be interpreted as an individual push factor increasing the probability of mobility independently of the degree of attractiveness of specific spatial contexts. We thus expect our instrument to be positively correlated to the instrumented variable. This rationale is supported by previous related research showing that inventors characterized by more valuable patents (i.e most cited patents) are those with the highest probability of inter-firm mobility (*Trajtenberg et al., 2006*).

From the methodological point of view the focus on the forward citations received in the 12 months after publication is consistent with our interest in the potential signalling effect associated to the recent development of a valuable invention. The choice of the national level as comparative term, apart from being justified by its exogenous nature with respect to any local path dependent patterns, implies focusing on those inventions receiving relevant attention outside each local area. Finally the selection of a time interval spanning from 1995 to 2007 to construct the national average trend support our claim that the peak in the number of citations experienced by a certain area represents a unique phenomenon in time (reasonably connected to the development of an highly successful invention) rather than a consolidated local trend.

4) Results and robustness checks

Results for the estimation of the effect of inventors' mobility on the innovative performance of English firms are reported in Table 4. In column 1 we estimate the standard firm based KPF (adopted as baseline model) controlling for the amount on intramural investment in R&D and

the share of employment with a degree. Our baseline specification also control for firm and time specific characteristics.

Estimates confirm the relevance of financial investments in innovation related activities, which turn out to be a positive and significant determinant of innovation. The regressor for skilled employment reports the expected sign and is significant at 10%. In the interpretation of this latter result it is important to consider the specific features of the CIS sample, which is skewed towards small and medium enterprises with limited variations in their hiring capacity over time (*UK Data Archive Studies, 2008*).

Column 2 introduces our key variable of interest constructed in order to take value 1 if the firm is located in a TTWA that experienced inflows of inventors during the time span under analysis. Results confirm that inflows of inventors affect positively the innovative performance of local firms. The regressor is, however, not statistically significant. This evidence is confirmed also when we control for differences in market strategies by including a regressor for export orientation (Column 3).

[Include Table 4 here]

Our results seem to be in line with recent studies claiming for a greater caution in the analysis of the impact of mobility on firms' innovation. When firms' specific characteristics are fully accounted for there is no evidence of an independent link between mobility and innovation implying that firms' heterogeneity is the key missing link in previous studies.

This consideration is reinforced when we re-estimate our baseline specification by neglecting the panel structure of our data and employing a pooled OLS approach. The regressor of interest is in this case positive and statistically significant at 5% (Table 5, Column 1) and this result holds also when area specific characteristics are fully controlled for (Column 2).

Besides the role played in explaining heterogeneity in the degree of attractiveness across geographical areas, locational attributes do not allow to account for heterogeneity across local firms in taking advantage from new available sources of localized knowledge. This further

suggests that the effect of mobility of firms' innovation is primarily mediated by firms' specific characteristics in terms of absorptive capacity and learning behaviour.

Our baseline specification is re-run also on product and process innovation separately (Table 5, Column 3 and 4). The intrinsic nature of the knowledge flows associable to our mobility measure, focusing on people performing patentable innovations, is plausibly more directly linked with product rather than process innovation. Despite some evidence of variation in the magnitude of the coefficient along the expected direction, no evidence of systematic changes in the statistical significance is found.

[Include Table 5 here]

Results do not provide support for the existence of a positive effect of mobility on firms' innovative performance in recipient areas and this lack of impact seems to be mainly explained by firms' specific characteristics. The possibility to account for heterogeneity across firms in the capability to take advantage from inflows of knowledgeable individuals carrying with them novel information weaken substantially the expected link between mobility and innovation.

Results remain consistent also when further endogeneity concerns are accounted for by means of the instrumental variable approach presented in section 3.1. Our regressor of interest remains positively associated to innovation but not statistically significant (Table 6, Column 1). As expected our instrument is positively correlated with the instrumented variable: indeed the immediate payoff of the development of a highly successful invention is reflected in an higher probability of moving.

The first stage supports the validity of our IV approach (Column 2) showing an F statistics that is well above the value of ten based the rule of thumb proposed Staiger and Stock (1997) and the thresholds values developed by Stock and Yogo (2005).

In the IV framework the role played by firms' heterogeneity can be further analysed accounting for the emergence of heterogenous effects associated to the attitude of firms towards the exploitation of external sources of information.

Mobility is a powerful channel of knowledge diffusion potentially generating valuable positive externalities in recipient locations. Nonetheless the increasing dissatisfaction with the identification of firms as passive recipients of knowledge flows and the progressive tendency to model externality mechanisms as bidirectional exchanges has suggested the need of greater attention to differences in firms' learning behaviours (*Crescenzi et al, 2014*). Although knowledge originates elsewhere or is carried by external actors, the receiving node has to play an active role to animate and recreate that knowledge in the new context (*Barnard and Cantwell, 2006*). This implies that deliberate strategies pursued by local firms may substantially mediate the degree to which they absorb and exploit external knowledge in an effective way.

Some attempts to account for differences in firms' learning behaviours and their capability to exploit external sources of information has been carried out by exploiting patent citations (calculated looking at the industry and geography of the citing patents). However patent citations are a noisy measure of knowledge flows since many of them are often included by examiners rather than inventors themselves (*Criscuolo and Verspagen, 2008*). In the context of our investigation the UK-CIS is particularly useful for exploiting firms' heterogeneity in learning behaviours since the questionnaire dedicates an entire section to the very nature of the knowledge sources used to develop innovative outcomes. The questionnaire distinguishes between information coming from external sources covering a wide range of economic actors (suppliers, clients, customers, competitors, other businesses in the industry, consultants, commercial labs, universities and private R&D institutes) and sources that are internal to the firm itself.

We restrict the analysis to those firms declaring that they are significantly exploiting "external sources"[11] of information. The same subsample has been used in related studies addressing the role of external sources of information for firm's economic performance (*Criscuolo et al, 2005*, *Loof and Heshmati, 2006, Van Leeuwen and Klomp, 2006, Crespi et al, 2007, Agrawal et al., 2006)*.

[11] With reference to the question regarding the importance of different sources of information in the development of innovation we selected those firms rating 2 or 3 is a scale from 0 to 3 the category "market sources of information" and "institutional sources of information" that includes suppliers, clients, customers, competitors, other businesses in the industry, consultants, commercial labs, universities and public and private R&D institutes.

Interestingly when we focus on those firms that are more likely to consider external knowledge as input the effect of mobility on innovation becomes positive and significant at 5% level (Table 6, Column 3). Results suggests that firms located in areas experiencing inventors inflows are on average more likely to increase by 20% the probability of developing any process or product innovations.

It is important to highlight that our IV strategy is highly robust also on the restricted sample. First stage results reported in Column 4 (table 6) confirm that the instrument remains significantly correlated with our regressor of interest and highly significant. Also in this case the F statistics suggest that our IV approach does not suffer from weak instrument biases.

[Include Table 6 here]

These latter results provide further support for our claim on the key role played by firms' heterogeneity in explaining the relation between mobility and firms' innovation. The reasons behind the emergence of a positive and significant impact when the analysis is restricted to firms more prone to the exploitation of external sources of knowledge may refer to both the quantity and quality of information acquired. This finding, in fact, needs to be interpreted in the light of the characteristics of our sample. The benefits coming from inflows of knowledgeable individuals, such as inventors, are difficult to be fully internalized by firms (especially small and medium businesses) that may be characterized by a limited hiring capacity. For these economic actors the learning by hiring mechanism is not fully efficient to exploit novel sources of information available in the labour market. This evidence contributes to explain why firms referring mainly or exclusively to internal sources of information miss relevant opportunities. On top of that it is also important to acknowledge that the degree of novelty embedded in these external sources of information is likely to be particularly valuable and to reduce the cognitive lock in that may derive from a too strong focus on internal skills.

5) Conclusions

There has been a growing attention on the role of labour mobility as primary channel of knowledge diffusion. Policy makers have increasingly pointed out at the need of developing the capability to attract knowledgeable individuals to foster local economic and innovative performance. Recently the UK Department for Business, Innovation and Skills (BIS) affirmed that "If the UK is to compete effectively in the global economy, it has to continue attracting entrepreneurs and researchers and to enable companies to recruit skilled employees". Scholars have long debated the effectiveness of such attraction by investigating the effect of mobility on the performance of recipient economies with recent studies suggesting that no independent link between mobility and innovation is found when firms' specific characteristics are fully accounted for.

This paper examines the effect of inventors' mobility on the innovative performance of English firms. The main underlying hypothesis builds on the idea that inflows of knowledgeable individuals might favour the circulation of valuable, individual embodied, tacit knowledge operating as channel for knowledge diffusion.

The analysis does not find a significant effect of inventors' mobility on the full sample of English firms and this result seems to be driven by heterogeneity across firms in their capability to take advantage from external sources of information. In support for this claim, in fact, when the analysis is restricted to firms showing a stronger attitude towards the exploitation of external sources of knowledge the effect of mobility becomes more relevant.

This evidence points out at the limitations of previous studies investigating the link between mobility and innovation in a cross sectional setting, suggesting the need of further attention to firms' heterogeneity in terms of both learning behaviour and nature of their innovative process. We interpret our results as suggestive indication for the emergence of heterogeneous effects associated to firms' specific characteristics. The availability of novel information due to the relocation of knowledgeable individuals seems to be not relevant per se; it just becomes a significant input once we account for the effective capability of local firms to take advantage

from this new available knowledge by exploiting external sources of information to complement internal skills.

Results also provide an indirect, preliminary evidence for the mechanisms through which the mobility of knowledgeable individuals impacts firms' innovative performance. We argue that the effect on those firms exploiting more extensively external sources offers some support for the role of externalities linked to the spatial clustering of different sources of knowledge in specific spatial contexts.

Relevant policy implications are related to these findings. Policy initiatives aimed at attracting knowledgeable individuals without attempting at maximizing the linkages within the domestic economy are likely to result in a net negative sum game. Heterogeneity across local firms in terms of attitude towards the exploitation of these external resources may limit the effectiveness of the positive externalities coming from mobility. Policy initiatives aimed at attracting knowledgeable individuals in the light of the positive effect coming from an enrichment of the local knowledge base need to be complemented by capacity building strategies. Policies targeting local firms, with the aim of increasing their capability to absorb and exploit external sources of information, though effective linkages with other co-located actors, are a necessary complement to fully embrace the benefits of mobility.

Bibliography

Agrawal A., Cockburn I. and McHale J. (2006), “Gone but not forgotten: labour flows, knowledge spillovers, and enduring social capital”, *Journal of Economic Geography* 6: 571-91.

Almeida P. and Kogut B. (1999), “Localisation of knowledge and the mobility of engineers in regional networks”, *Management Science* 45: 905-17.

Barnard, H. and Cantwell, J. (2006), 'Knowledge in the Theory of the Firm and MNC: Asset or Action? A Commentary on Foss N. “Knowledge and Organisation in the Theory of the MNC”', *Journal of Management & Governance,* 10 (1), 21-27

Borjas, G.J., (1999) “The Economic Analysis of Immigration” *Handbook of Labour Economics,* Elsevier.

Breschi S. and Lissoni, F. (2001) “Knowledge Spillovers and Local Innovation Systems: A Critical Survey”, *Industrial and Corporate Change*, 10: 975-1005.

Breschi, S and Lissoni, F (2009), “Mobility of skilled workers and co-invention networks: an anatomy of localized knowledge flows”, *Journal of Economic Geography* 9: 439-468.

Card D (2005) Is the new immigration really so bad? *The Economic Journal* 115: 300–323

Card D (2007) How immigration affects US cities. In: Inman RP (ed) *Making cities work: Prospects and policies for urban America*. Princeton University Press, Princeton, NJ

Chellaraj, G., Maskus, K. and Mattoo A. (2008), "The Contribution of Skilled Immigrations and International Graduate Students to U.S. Innovation", *Review of International Economics*, 16(3):444-462.

Crescenzi, R., Gagliardi, L. and Iammarino, S. (2014) “Intra-industry effects of Foreign Multinationals in the UK: Local Innovation and Firm Heterogeneity”, CIMR Research Working Paper Series No. 17.

Criscuolo, P., & Verspagen, B. (2008). Does it matter where patent citations come from? Inventor vs. examiner citations in European patents. *Research Policy*, *37*(10), 1892-1908.

Crespi G., Geuna A. and Nesta L. (2007), “The mobility of university inventors in Europe”, *Journal of Technology Transfer* 32: 195-215.

Duranton G (2007) Human capital externalities in cities: Identification and policy issues. In: Arnett RJ, McMillen DP(eds) *A companion to urban economics*. Blackwell Publishing, Oxford.

Faggian A. and McCann, P.(2006) "Human Capital Flows and Regional Knowledge Assets: A Simultaneous Equation Approach", *Oxford Economic Papers,* 52: 475-500

Faggian, A. and McCann, P (2009), "Human Capital, Graduate Migration and Innovation in British Regions", *Cambridge Journal of Economics* 33: 317-333.

Florida, R. (2002), "The Economic Geography of Talent", *Annals of the Association of American Geographers* 92: 743–755.

Gagliardi, L. (2014), "Does skilled migration foster innovative performance? Evidence from British local areas", Papers in Regional Science (forthcoming).

Glaeser E, Kallal H, Scheinkman J, Shleifer A (1992) Growth of cities. *Journal of Political Economy* 100: 1126–1152.

Glaeser, E.L., Rosenthal, S.S. and Strange, W.C. (2010), "Urban Economics and Entrepreneurship", *Journal of Urban Economics*, 67(1): 1-14.

Griliches, Z. (1979) "The Search for R&D Spillovers", *Bell Journal of Economics* 10: 92-116.

Griliches, Z., (1986) "Productivity, R & D, and the Basic Research at the Firm Level in the 1970's", *American Economic Review*, 76: 141-54.

Jaffe, A.B. (1986), "Technological Opportunity and Spillovers of R&D: Evidence from Firms' Patents, Profits, and Market Value," *American Economic Review* 76(5): 984-1001.

Herrera, L., Muñoz-Doyague, M.F. and Nieto, M. (2010), "Mobility of public researchers, scientific knowledge transfer, and the firm's innovation process", *Journal of Business Research* 63: 510-518

Hoisl, K. (2007), "Tracing Mobile Inventors – The causality between Inventors Mobility and Inventors Productivity", Research Policy, 36(5): 619‑636.

Hunt, J. and Gauthier-Loiselle, M. (2008), "How Much Does Immigration Boost Innovation?", *NBER WP 14312.*

Kim J., Lee S. J. and Marschke G. (2006), "International Knowledge Flows: Evidence from an Inventor-Firm Matched Data Set", *NBER WP* No. 12692.

Leamer E, Storper M (2001) The economic geography of the internet age. *Journal of International Business Studies* 32: 641–665

Lewis, T. R. and Yao, D (2006), ""Innovation, Knowledge flow, and Worker Mobility," Mimeo, Wharton School, University of Pennsylvania.

Lissoni, F, Sanditov, B. and Tarasconi, G. (2006), "The Keins database on Academic Inventors: Methodology and Contents", CESPRI WP 181.

Lööf, H., & Heshmati, A. (2002). Knowledge capital and performance heterogeneity:: A firm-level innovation study. International Journal of Production Economics, 76(1), 61-85.

Lucas, R. (1988), "On the Mechanics of Economic Development", *Journal of Monetary Economics,* 22: 3-42.

Maré, D.C., Fabling, R. and Stillman, S. (2011), "Immigration and Innovation", *IZA DP* 5686.

Maré, D. C., Fabling, R., & Stillman, S. (2014). Innovation and the local workforce. *Papers in Regional Science*, *93*(1), 183-201.

Miguelez, E. and Moreno, R. (2010), "Research Networks and Inventors' Mobility as Drivers of Innovation: Evidence from Europe", *IREA WP*.

Miguélez, E., Moreno, R., & Suriñach, J. (2010). Inventors on the move: Tracing inventors' mobility and its spatial distribution. *Papers in Regional Science*, *89*(2), 251-274.

Moretti, E., (2004) "Human capital externalities in cities" in: J. V. Henderson and Thisse J.F. (ed.), *Handbook of Regional and Urban Economics*, edition 1, volume 4, chapter 51, pages 2243-2291 Elsevier.

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

Ozgen, C., Nijkamp, P. and Poot, J. (2011), "Immigration and Innovation in European regions" *IZA DP* 5676.

Peri, G. (2005), "Determinants of Knowledge Flows and Their Effect on Innovation", *Review of Economics and Statistics* 87:2, 308-322.

Peri, G. (2007), "Higher Education, Innovation and Growth", in Brunello, G., Garibaldi, P. and Etienne W. (eds.) *Education and Training in Europe*, Oxford University Press.

Singh, J. (2003) "Inventor Mobility and Social Networks as Drivers of Knowledge Diffusion" mimeo, *Harvard University WP*.

Song, J, Almeida, P. and Wu, G. (2003), "Learning by Hiring: When is mobility more likely to facilitate interfirm knowledge transfer?, *Management Science* 49: 351-365.

Staiger, D. and Stock, J.H. (1997), "Instrumental variables regression with weak instruments", *Econometrica* 65, 557-586.

Stock, J.H. and Yogo, M. (2005), "Testing for weak instruments in linear IV regression" in J.H. Stock and D.W.K. Andrews (Eds.), *Identification and inference for econometric models: a Festschrift in honour of Thomas Rothenberg*, Cambridge University Press, Cambridge.

Stolpe, M. (2001) "Mobility of Research Workers and Knowledge Diffusion as Evidence in Patent Data – The Case of Liquid Crystal Display Technology" *Kiel WP* 1038.

Trajtenberg, M. , Shiff, G. and Melamed, R. (2006), "The Names Games: Harnessing inventors' patents data for economic research", *NBER WP* 12479.

UK Data Archive Service (2008), "Persistence and Change in UK Innovation", Report 6699

Van Leeuwen, G. (2002). Linking innovation to productivity growth using two waves of the community Innovation Survey (No. 2002/8). OECD Publishing.

Zucker, L. G. and Darby M.R. (2006), "Movement of Star Scientists and Engineers and High-Tech Firm Entry", *NBER WP* 12172.

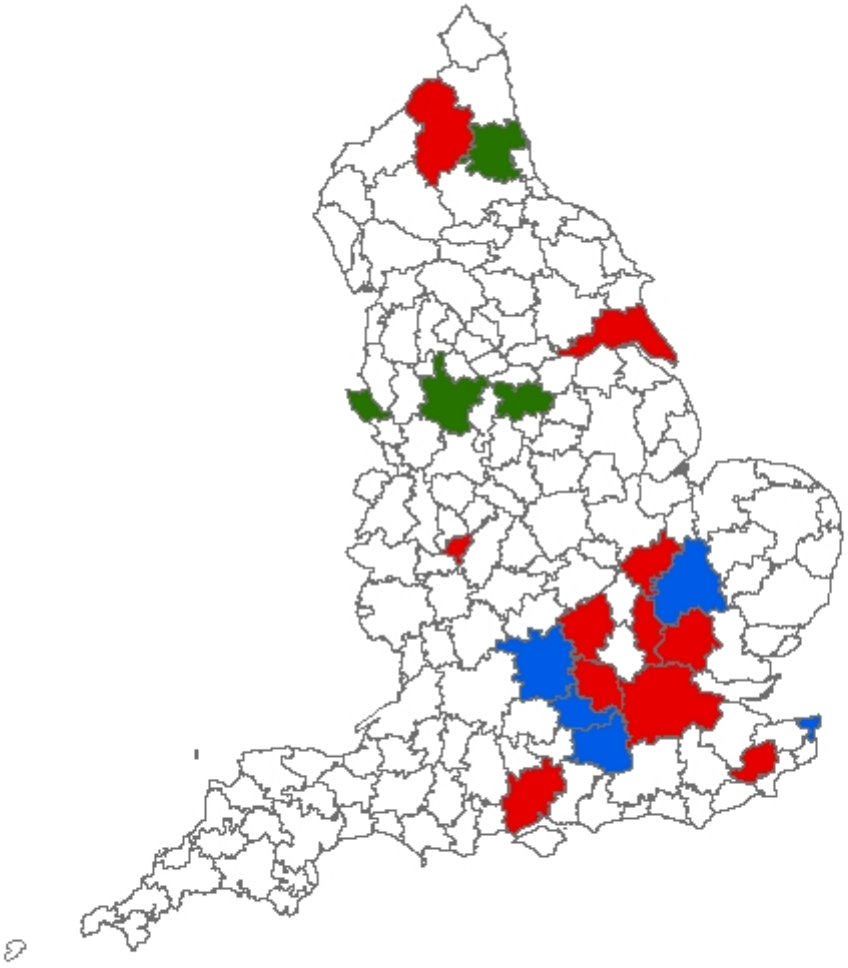
Zucker, L. G., Darby R. M. and Armstrong Jeff (1998a), "Geographically Localized Knowledge: Spillovers or Markets?", *Economic Inquiry*, 36 (1): 65-86.

Zucker, L.G. and Darby, M.R. (2007), "Star Scientists, Innovation and Regional and National Immigration", *NBER WP* 13547.

Zucker, L.G., Darby, M.R. and Brewer, M.B. (1998b). "Intellectual human capital and the birth of U.S. biotechnology enterprises", *American Economic Review* 88: 290-306.

Figures and Tables

Figure 1: English TTWAs



Areas experiencing inventors' inflows over the period 2000-2005
Areas experiencing inventors' inflows over the period 2000-2002
Areas experiencing inventors' inflows over the period 2003-2005

Table 2: Firms' Innovative performance and Inventors' Inflows

Period	Innovative Performance	Inventors Inflows			
		NO		*YES*	
		Obs.	*Share*	*Obs.*	*Share*
	Product Innovation	4868	0.29	1004	0.31
	Process Innovation	4868	0.20	1004	0.20
TOTAL	*Product or Process Innovation*	4868	0.35	1004	0.37
	Product Innovation	2284	0.30	652	0.32
	Process Innovation	2284	0.23	652	0.21
2002-2004	*Product or Process Innovation*	2284	0.37	652	0.39
	Product Innovation	2584	0.27	352	0.30
	Process Innovation	2584	0.17	352	0.18
2005-2007	*Product or Process Innovation*	2584	0.32	352	0.34

Source: UK-CIS; EPO-KITES

Note: Product Innovation refers to activities bringing to the market or into use by business, new and improved products, including both tangible goods and the provision of services. Process innovation is defined as significant changes in the way that goods or services are produced or provided. Both variables can refer to both products and processes new to the business only or also new to the industry.

Table 3: Variables List

Variable	*Description*	*Source*	*Obs.*	*TOTAL*		*2002-2004*		*2005-2007*	
				Mean	Std.	Mean	Std.	Mean	Std.
Product or Process Innovation	Dummy variable taking value 1 if the firm developed any product or process innovation	CIS	5872	0.35	0.48	0.38	0.49	0.32	0.47
Product Innovation	Dummy variable taking value 1 if the firm developed any product innovation	CIS	5872	0.29	0.45	0.31	0.46	0.28	0.45
Process Innovation	Dummy variable taking value 1 if the firm developed any process innovation	CIS	5872	0.20	0.40	0.22	0.42	0.17	0.37
R&D	Dummy variable taking value 1 if the firm is performing any intramural investment in R&D	CIS	5872	0.33	0.47	0.32	0.47	0.33	0.47
Employment with degree	Share of employees with a degree	CIS	5872	0.10	0.19	0.09	0.18	0.11	0.20
Export Orientation	Dummy variables taking value 1 if the firm has the European or international arena as main market of reference (local and national market as baseline)	CIS	5872	0.37	0.48	0.36	0.48	0.37	0.48
Inventors' inflows	Dummy variable taking value 1 if the firm is located in a TTWA that experienced inflows of inventors.	KITES-EPO	5872	0.17	0.38	0.22	0.42	0.12	0.32

Source: UK-CIS; EPO-KITES

Note: Product Innovation refers to activities bringing to the market or into use by business, new and improved products, including both tangible goods and the provision of services. Process innovation is defined as significant changes in the way that goods or services are produced or provided. Both variables can refer to both products and processes new to the business only or also new to the industry. R&D investments are defined as “Creative work undertaken within your enterprise on an occasional or regular basis to increase the stock o9f knowledge and its use to devise new and improved goods, services and processes”. Skilled employees include people with a degree in Science & Technology or other fields.

Table 4: Firms' Innovation and the Mobility of Knowledgeable Individuals

	(1)	(2)	(3)
Dep.Var. Product or Process Innovation	FE	FE	FE
R&D	0.2544***	0.2543***	0.2541***
	(0.0232)	(0.0233)	(0.0233)
Employment with degree	0.0855*	0.0866*	0.0864*
	(0.0459)	(0.0462)	(0.0462)
Inventors' Inflows		0.0228	0.0226
		(0.0190)	(0.0190)
Export Orientation			0.0075
			(0.0267)
Observations	5872	5872	5872
R2	0.0683	0.0688	0.0688

Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Firm and time fixed effects included in all specifications.

Table 5: Robustness Checks

Dep.Var.	(1) Product or Process Innovation	(2) Product or Process Innovation	(3) Product Innovation	(4) Process Innovation
	OLS	OLS	FE	FE
R&D	0.4085***	0.4006***	0.1986***	0.1714***
	(0.0136)	(0.0138)	(0.0222)	(0.0203)
Employment with degree	0.1478***	0.1430***	0.1636***	-0.0259
	(0.0299)	(0.0300)	(0.0460)	(0.0428)
Inventors' Inflows	0.0309**	0.0452**	0.0251	-0.0120
	(0.0150)	(0.0228)	(0.0174)	(0.0172)
Export Orientation	0.1234***	0.1168***	0.0158	0.0151
	(0.0128)	(0.0130)	(0.0260)	(0.0242)
TTWA Dummies	NO	YES	-	-
Observations	5872	5872	5872	5872
R2	0.2170	0.2455	0.0495	0.0449

Clustered robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Firm and time fixed effects included in the specification reported in column 3 and 4. Pooled OLS results reported in column 1 and 2.

Table 6: Instrumental Variable Estimation

	(1)	(2)	(3)	(4)
	Product or Process	Product or Process	Inventors' Inflows	Inventors' Inflows
Dep.Var.	Innovation	Innovation		
Inventors' Inflows	0.0752	0.2055**		
	(0.0605)	(0.1002)		
R&D	0.2537***	0.1609***	0.0077	0.0108
	(0.0233)	(0.0302)	-0.0173	-0.0231
Employment with degree	0.0889*	0.0836	-0.0475	-0.0627
	(0.0469)	(0.0717)	-0.0455	-0.0689
Export Orientation	0.0058	-0.0044	0.031	0.0406
	(0.0268)	(0.0382)	-0.0215	-0.0299
Citations			0.3381***	0.3457***
			-0.0585	-0.083
Observations	5872	3084	5872	3084
R2	0.0664	0.0166	0.1581	0.1518
F			33.45	17.36

Clustered robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Firm and time fixed effects included in all specifications. Column 2 and 4 refer to the subsample of firms exploiting external sources of information to develop their innovative activities. The subsample is constructed drawing from the section "Context for Innovation" restricting the analysis to firms rating 2 or 3 is a scale from 0 to 3 the category "market sources of information" and "institutional sources of information" that includes suppliers, clients, customers, competitors, other businesses in the industry, consultants, commercial labs, universities and public and private R&D institutes.