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How to cite

GAGLIARDI, Luisa. Does skilled migration foster innovative performance? Evidence from British local areas. In: Papers in regional science, 2015, vol. 94, n° 4, p. 773–794. doi: 10.1111/pirs.12095

This publication URL: https://archive-ouverte.unige.ch//unige:91800
Publication DOI: 10.1111/pirs.12095

doi:10.1111/pirs.12095

Does skilled migration foster innovative performance? Evidence from British local areas*

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Received: 12 March 2013 / Accepted: 7 November 2013

Abstract. What is the effect of an increase in the stock of human capital due to skilled immigration on the innovative performance of recipient economies? Combining firm-level micro-data with area-level labour force information, this paper investigates the impact of skilled international migration inflows on firms' product and process innovation in British local labour market areas. The paper supports the evidence in favour of a causal link between immigration and innovation. Results also show that the nature of the innovative process and the typology of innovative activities performed by local firms play a key role in the relation between immigration and innovation.

JEL classification: J61, O15, O31

Key words: Migration, innovation, geographic mobility

1 Introduction

The migration behaviour of highly skilled individuals is traditionally considered a crucial mechanism of (tacit) knowledge diffusion. Since knowledge 'travels along with people who master it' (Breschi et al. 2010, p. 367), inflows of highly skilled individuals are assumed to enrich the local knowledge base through an increase in the availability of valuable human capital and the rise in the level of creativity and productivity of local interactions (Maré et al. 2011). The coexistence of different sources of tacit, individual embodied, knowledge within the same

* Thanks to Steve Gibbons, Andres Rodriguez Pose, Riccardo Crescenzi, Ian Gordon, Olmo Silva, the personnel of the Secure Data Service (SDS), the participants to the LSE-SERC WP, LSE-Labour WP Seminars and the CESifo Conference 2012 for suggestions and comments. All errors remain my own.

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The research leading to these results has received funding from the European Union Seventh Framework Programme FP7/2007-2013 under grant agreement n° SSH-CT-2010-266959; project PICK-ME.

geographical context generates localized processes of cumulative learning (Capello 1999), fostering the innovative performance of recipient areas. In this context the concept of regional system of innovation (Asheim and Coenen 2005; Asheim and Gertler 2005; Iammarino 2005) shed some more light on the complexity of the dynamics at play. Processes of cumulative learning are shaped by systemic conditions that go beyond the pure Marshallian agglomeration economies based on firms and individuals, to account also for localized structural and institutional factors (Iammarino 2005). This further implies that the effect of skilled immigration on innovation is mediated by localized networks of private actors and institutions since their interactions may affect the likelihood of generating, importing and diffusing new technologies (Evangelista et al. 2002).

In this perspective the benefits associated to an increase in the local stock of human capital are twofold. A direct effect on the range of capabilities that firms may access through the labour market (exploiting the learning by hiring mechanisms) and an indirect effect linked to the emergence of valuable externalities due to human capital accumulation in specific spatial contexts (working through informal interactions and face to face contacts). This latter component represents the key interest of this paper and its empirical investigation requires taking into account how heterogeneity in firms' characteristics, typology of innovative activities and contextual meso level conditions in terms of system of localized interactions among different actors, affect the possibility of exploiting the benefit coming from the availability of novel sources of information.

The analysis on the relevance of these externalities associated to human capital accumulation is investigated by looking at the impact skilled immigration on the innovative performance of recipient local areas in the case of Great Britain. In the last 20 years, immigration in Britain has dramatically improved the skill composition of the population. Immigration flows have increased sharply since 1997 reaching their maximum in 2004, just after the EU enlargement. Recent immigrants in particular resulted to be extremely well educated with the 46 per cent in 2005 with full-time education at age 21 or later in comparison to the 16 per cent of natives in the same age group (Dustmann et al. 2008). Furthermore foreign-born individuals have been shown to differ from British-born individuals, as well as among each other, in education, demographic structure, culture, and skills and these differences may partly determine economic success as well as social adaptation and integration (Dustmann et al. 2005). From this perspective Britain represents an interesting case study and a relevant spatial context for the analysis of the link between immigration and innovative performance of recipient areas, in particular with respect to recent years due to the disproportionate impact of immigration flows coming from enlargement countries on the structure and characteristics of population (Dustmann et al. 2008). Nonetheless the possibility to extend the analysis in other spatial contexts remains a relevant issue. Existing studies are based mainly on the US and, with respect to this and other recent contributions, to countries such as UK and New Zealand (see Table 1 for further details). The increasing availability of detailed and comparable micro-data suggests the possibility of investigating the link between immigration and innovation also in other geographical areas.

This paper will follow the increasing attention devoted to the investigation of the impact of immigration in UK contributing to previous literature by widening the spectrum of analysis. Despite the existence of several recent contributions looking at the topic (Dustmann et al. 2005, 2008; Manacorda et al. 2006), the majority of studies relates to the labour economics literature and tend to focus on employment and wage effects. The impact of immigration on the economic performance of recipient areas has remained largely unexplored and the potential link between changes in the skills composition and characteristics of the local knowledge base due to immigration and the emergence of successful innovative outcomes generally under investigated. This is a striking feature with respect to both the large attention devoted to this issue since the earlier contributions of Zucker et al. (1998b) in other spatial contexts, such as the US, and the

Table 1. Review of existing studies on immigration and innovative performance

	Focus	Methodology	Innovation outcome measure	Immigration measure	Geography
Zucker et al. (1998b)	Link between the mobility of highly productive inventors and the birth pattern in the Biotech industry in the US	Poisson or ordinary least squares (OLS) regressions for the birth rate of active new biotech enterprises (NBEs)	– Firm birth rate from North Carolina Biotechnology Center (1991);	Star Scientist identified by means of the GenBank database reporting the total number of genetic sequence discoveries	Data aggregated to the 183 BEA-defined functional economic areas in the US
Zucker et al. (1998a)	Link between the presence of star scientists and firm innovative performance in the Biotech industry in California	Poisson regressions for products in development and on the market and Tobit estimation for change in employment.	– Products in development and on the market, employment from Bioscan database (1991);	Star Scientist identified by means of the GenBank database reporting the total number of genetic sequence discoveries.	110 California-firm observations
Zucker and Darby (2001)	Link between the presence of star scientists and firms patents and products in development in the Biotech Industry in Japan	Poisson regression for numbers of U.S. biotechnology patents granted, numbers of products in development, and numbers of products on the market.	– Patents granted, numbers of products in development, and numbers of products on the market from U.S. biotechnology patents granted to Japanese firms	– Star Scientist identified by means of the GenBank database reporting the total number of genetic sequence discoveries.	Functional economic areas within based on commuting flows
Le (2008)	Role of labour mobility as transfer mechanism for technology across borders.	Productivity estimation controlling for intermediate goods (physical production inputs, ideas, know-how, and production knowledge)	– Total Factor Productivity from Coe and Helpman (1995).	– Foreign population mainly from the OECD International Migration Database	Data aggregated at country level for 19 OECD countries
Zucker and Darby (2007b)	Link between presence of star scientist and their migration behaviour of firm entry in the US and top 25 S&T countries	Overview of descriptive statistics and estimates coming from Zucker and Darby (1999), Zucker and Darby (2007a), Zucker et al. (1998), Zucker and Darby (2001), Zucker and Darby (2006).	– Firm entry measured by means of date of their first patent application or scientific-article publication;	– Star Scientists identified through the ISI Highly Cited component of the ISI Web of Science®	Data aggregated for 179 US functional economic regions or the 25 top science and technology countries in the world
Hunt and Gauthier-Loiselle (2009)	Link between skilled migration and state level patenting activity in the US	Panel data estimation for the impact of skilled immigrants on patenting per capita by state.	– Patents per capita from US patents data	Skilled immigrant coming from the National Survey of College Graduates;	Data aggregated at state level
Chellaraj et al. (2008)	Impact of international students and skilled immigrants on the innovative activities in the US	'National ideas production function' approach estimated using time series techniques.	– Total patent applications patents granted to US-based universities and other institutions and firms from US patent data	– International graduate students, skilled immigrants and PhD engineers and scientists;	Data at US national level
Hunt(2009)	Link between immigration and the emergence of innovation and start up outcomes by typology of entry visa groups	Probit estimation of the probability of innovation (patenting activity) and start up outcomes and weighted least squares for wage level	– Probability of patenting or running a start up	– Immigrant by typology of entry visa coming from the National Survey of College Graduates	Individual level data
Ozgen et al. (2011)	Impact of the size, skills, and diversity of immigration on the innovativeness of host regions (patenting activity)	Panel estimation based on two pooled cross-sections of average patents	– Patents per capita from European Patent Office (EPO) database	– Foreign population from Eurostat's *General and Regional Database*	Data aggregated at NUTS 2 level for 170 regions in Europe
Maré et al, (2011)	Relationship between local workforce characteristics, in particular the share of immigrant population and skills, and firm innovation outcomes in New Zealand.	Maximum likelihood logit regression	– Share of firms introducing new goods or services, operational processes or any innovation outcome from business survey data	– Skilled migrants from Census Data	Data aggregated at Labour Market Areas (functional units based on commuting flows)

more systematic analysis that in the case of UK has been carried out to address the link between internal migration flows and the innovative performance of recipient areas (Faggian and McCann 2006, 2009).

The lack of comprehensive evidence is partially explained by the several data and methodological issues associated to the analysis. Data on both migration and innovative performance are in fact difficult to recover, in particular for specific segments of the skill distribution and detailed geographical scale of analysis. In order to deal with these limitations this paper exploits a novel database based on complementary micro-data sources. First, it will refer to local firms' innovative performance as measure of innovativeness. Data on firms' innovative activities, in respect to standard patents' statistics usually employed in previous studies, provide a more reliable picture of the geography of innovation at the local level overcoming the traditional biases associated with patents data at both sectoral and geographical level. Firm level data also allow controlling for the share of human capital potentially internalized by firms through the learning by hiring mechanism (i.e., the variation in the share of skilled employees in local firms). This further implies exploiting the idea that the effect of skilled migration may go beyond its direct impact into local employment. Second, the paper will focus on functional geographical unit of analysis, rather than standard broad administrative regions, allowing us to deal more efficiently with the problems associated to the so called 'ecological fallacy'[1] and the potential effect of additional confounding factors that are likely to have a greater impact at a broader geographical scale. This is a key aspect in the analysis performed because it implies a taking into account of the channels through which the impact of immigration on local firms' innovative performance – that is, learning by hiring vs pure externality based on face-to-face contacts – may pass through.

The empirical evidence based on the estimation of a place based knowledge production function approach (KFP) shows that, after controlling for its traditional endogeneity (Card 2005, 2007), the impact of skilled immigration on the innovative performance of recipient areas is not homogeneous and that the typology of innovative activities performed, and in its turn the nature of the innovative process, plays a key role.

The remainder of the paper is organized as follows: the next section introduces an overview of the existing literature. Section 3 presents a discussion on the geographical scope of the analysis and data while Section 4 describes the methodological settings and the estimation strategy adopted. Section 5 discusses the main results and robustness checks, while Section 6 concludes.

2 Literature

There is an extensive literature on the impact of immigration on the economic performance of recipient areas. Most of the existing studies however focus on the effect of overall immigration flows on wages, employment and labour force participation (Borjas 1994, 1999; Baker and Benjamin 1997; Blau et al. 2003; Dustmann et al. 2003; Meng and Gregory 2005). The literature looking specifically at the effect of immigration on innovative performance remains more limited and heterogenous in terms of definition of immigrants and geographical scope of the analysis and generally related to the US. Among the most influential papers Zucker et al.

[1] In its simplest definition the ecological fallacy may be interpreted as error of deduction that involves deriving conclusions about a certain observation solely on the basis of an analysis of broader group data. In the case of this analysis the inference on the impact of immigration on the local production system may be inaccurate if performed at a much broader geographical level of analysis for two key reasons: first, the extreme heterogeneity in terms of structure, composition and absorptive capacities of different local areas. Second, the need of accounting for the channels through which the effect is mediated (either labour market mediated interactions or face to face contacts).

(1998b) emphasized the role of star scientists as engines of innovation showing that the mobility of highly productive inventors represents a key source of knowledge externalities explaining the birth patterns of innovative industries, such as biotech, in the US. Results are robust to controls for the location of universities that are more likely to hire star scientists. Similar findings are confirmed for the Japanese biotech industry where the geographic distribution of new science-based industries appears to be systematically linked to the geographic distribution of intellectual human capital (Zucker and Darby 2001). In the same vein Zucker et al. (1998a), focusing on Californian biotech firms, showed that their innovative performance, in terms of number of products in development, number of products on the market and employment growth, benefit from the knowledge externalities coming from interactions with star scientists. More recently Zucker and Darby (2007b) argue that the presence of international star scientist in a US region or in a top-25 science and technology country significantly increases the probability of firm entry in the same field and that the impact of their migration behaviour is relevant also for developing countries. Furthermore Breschi et al. (2010), analysing the sample of US inventors patenting at the European Patent Office (EPO), suggested that the mobility of inventors is a powerful channel of knowledge diffusion, but that knowledge effectively spills when the transfer of knowledgeable individuals generate new social networks in recipient areas.

Few papers have tried to extend the definition of migrants looking at the whole sample of skilled individuals rather than just inventors or star scientists. Hunt and Gauthier-Loiselle (2009) found that skilled immigration – defined based on people with a degree of equivalent qualification – is responsible for a significant proportion of patents in the United States contributing to boosting innovation. Using a 1940–2000 state panel, they showed that skilled immigrants generate positive knowledge spillovers, resulting in an increase in patents *per capita*. Similar evidences in favour of the positive impact of immigration on state level patenting activities are provided from time series patterns (Chellaraj et al. 2008) and cross-country panel analysis (Le 2008) in the US and for NUTS 2 regions in Europe (Ozgen et al. 2011). In this latter case however authors found that the composition of immigrants from different backgrounds is a more important driving force for innovation than the sheer size of the immigrant population. More recently Hunt (2009) argues that immigrants who first entered on a student/trainee visa or a temporary work visa have a large advantage over natives in wages, patenting and publishing.

Finally and partially at odds with the positive impact found by previous studies, but most related with the structure and aim of this paper, is a recent contribution by Maré et al. (2010). Combining firm-level microdata on innovation with area-level workforce characteristics to examine the relationship between the presence of immigrants and the likelihood of innovation by firms, the authors demonstrated that the positive relationship between the two dimensions in New Zealand's labour market areas is fully accounted for by variation in firm characteristics such as size, industry, and research and development expenditure. After controlling for these factors there is no systematic evidence of an independent link between local workforce characteristics and innovation outcomes. This novel finding introduce a further element of complexity suggesting that over and beyond local characteristics, firms' heterogeneity and their attitude towards innovative activities drives their capability to take advantage from novel sources of information and benefit from local knowledge externalities (Crescenzi and Gagliardi 2013).

Despite the variety of approaches (see Table 1 for a detailed summary of recent studies) some key considerations may be drawn from the existing literature. The common rationale behind the effect of immigration builds on the evidence of human capital as individually embodied characteristic. Valuable knowledge tends to be geographically bound to the extent to which highly skilled individuals are not fully mobile in space and interactions among them remain constrained within specific spatial contexts. An increase in the stock of available

knowledge fosters collective learning dynamics that are magnified by the emergence of externalities associated to the process of human capital accumulation. Within specific geographical contexts the relational networks connecting individuals, groups, firms, and industries with different knowledge bases favour knowledge generation and transfer (Lundvall 1992; Asheim 1999; Crescenzi et al. 2013). Local capabilities involve both internal and external learning, and accumulation and integration of new knowledge on the part of the firm (Iammarino et al. 2012). They evolve through adaptive learning processes that, in their collective dimension, are highly localized and related to a specific spatial and industrial setting (Von Tunzelmann 2009). In this perspective the effect of immigration of highly skilled individuals into specific spatial contexts is twofold. In first the instance it determines an increase in the local stock of human capital enriching the knowledge base that local economic actors may directly access through the labour market. Second, it contributes to the creation of a 'contextually enabling environment for innovativeness' (Glaeser et al. 2010) based on the emergence of knowledge externalities coming from the re-combination of new and pre-existent local knowledge (Audretsch and Feldman 2004). This further implies that variations of aggregate human capital should matter in the determination of outcomes over and above individual characteristics (Duranton 2007) and that externalities coming from human capital accumulation affect local economic performance through their impact on both individual and aggregate productivity (Moretti 2004a, 2004b).

Despite this appealing rationale, this is only a part of the story. Although 'intellectual breakthroughs must cross hallways and streets more easily than oceans and continents' (Glaeser et al. 1992, p. 1126), geographical proximity is a necessary but not sufficient condition to exploit the benefit coming from an increase in the stock of human capital and to stimulate the emergence of valuable externalities. Processes of collective learning rely strongly on the level of embeddeness of the local economy, that is, enhanced by the co-presence in the same physical space of different sources of knowledge' (Leamer and Storper 2001). However the characteristics of local firms', their attitude toward co-operation and the nature of the innovative activities performed by local economic actors represent a key dimension to understand the dynamics at play (Crescenzi and Gagliardi 2013). The actual trend toward an over-reliance on external sources of knowledge as a substitute for internal inputs, as in the original article by Griliches (1979), may be misplaced (Sternberg and Arndt 2001). External factors contribute to determine a contextually enabling environment for innovativeness (Glaeser et al. 2010) generating processes of collective learning (Camagni and Capello 2000). However firms' learning behaviour and their capability to benefit from local externalities is not homogeneous and crucially dependent on the type of innovation performed (Capello 1999). Product innovation for example, relies more on internal inputs, such as financial resources and qualified scientists and engineers, in respect to process innovation for which the involvement in intensive co-operative linkages may play a more substantial role (Sternberg and Arndt 2001). This further implies that the heterogeneity of local economic actors remains a key dimension to understand how an increase in the availability of novel information due to immigrant inflows is then translated into effective innovative outcomes.

3 Data and geographical scope of the analysis

The identification of the effect of immigration on innovation is a challenging task in particular because of data availability issues and the difficulties in modelling the geographical dimension of human capital externalities arising from novel and heterogeneous sources of information. The two aspects will be extensively discussed below to shed more light on the structure on the analysis performed.

3.1 British local labour market areas

A crucial step in the investigation of the impact of immigration relies on the choice of the most appropriate geographical unit of analysis. Early contributions investigating the effect of inflows of knowledgeable individual on innovative performance are carried out at broad geographical scale (either state level or administrative regions). The general shortfall in this case relies on the difficulties in accounting for the 'ecological fallacy', meaning that a number of confounding factors that are difficult to fully control for, may play a crucial role at a greater geographical scale of analysis. Furthermore the adoption of such a unit of observation implies that the channels through which the effect of immigrant inflows is mediated cannot be explicitly taken into account. As emphasized in the previous section the rationale behind the link between immigration and innovation relies on the idea that the increase in the local stock of human capital determined by immigration benefits local firms through two dimensions. First, the possibility of taking advantage of these novel sources of information directly through the learning by hiring mechanism, that is, internalizing knowledge externalities through the labour market. Second, local firms may benefit from the creation of a contextually enabling environment for innovativeness exploiting the externalities coming from human capital accumulation through informal interactions and face-to-face contacts. This implies that the identification of the most appropriate unit of analysis to model the impact of immigration inflows should be aimed at the selection of geographical units that are large enough to proxy the dimension of the labour market, but small enough to reasonably assume that degree of geographical proximity that enhances interactions among individuals.

To provide a comprehensive investigation of the phenomenon under analysis and to deal with the above considerations, this paper adopts British travel to work areas (TTWAs) as key geographical scale to address the impact of immigration. TTWAs have the relevant advantage of including both urban and non-urban areas.[2] These functional units are constructed in order to be self-containing labour markets based on commuting patterns. This implies that statistics at TTWA level refer to people living and working in each specific area and that any potential increase in the local stock of human capital due to inflows of skilled immigrants takes into account individuals who permanently changed their residence. A similar methodological choice was adopted in other empirical analyses on the impact of immigration in Britain. In particular Nathan (2011) analysed the long-term impact of immigration on wages, unemployment and houses prices with a specific focus on cultural diversity using urban TTWAs as main geographical unit of analysis. Interestingly a similar approach has been followed by Maré et al (2010) in their investigation of the link between immigration and firms' innovative outcome in New Zealand where local labour market areas (defined as functional labour markets identified based on commuting patterns) are adopted as key geographical unit of analysis.

[2] With this respect it is relevant to emphasizes that many existing contributions investigating the impact of skilled migration concentrate on urban areas (e.g. Moretti 2004a, 2004b). Such studies are generally based on the US where cities are in terms of number, size and heterogeneity, a fairly relevant sample and where historical and cultural characteristics support the idea of a strong centripetal effect of cities within the economic landscape. It is however questionable whether the focus on cities is fully informative with respect to any European country and whether any general conclusion may be drawn from analyses looking at urban areas only. European countries are much smaller and the number of observations is generally less relevant. Moreover the sample is more likely to be strongly unbalanced with capital cities, such as London in the case of Britain, resulting as outliers in terms of size, sectoral composition, attractiveness and economic performance.

3.2 Data and descriptive statistics

The empirical investigation relies on a novel dataset constructed using as main data sources the Community Innovation Survey (CIS)[3] and the Labour Force Survey (LFS).[4]

The Community Innovation Survey (CIS) is constructed in order to build a balanced sample among all sectors of activity reducing the traditional bias of patents data toward some specific highly innovative sectors.[5]

Despite being not a relevant issue in respect to the reliability of the causal estimates of the conditional effect of immigration on innovation, the spatial stratification of the CIS data deserve deeper attention. The aggregation at a lower level of geographical detail may raise some concerns with respect to the representativeness of the sample (i.e., the definition of a noisy measure of innovation relying on a limited number of observations and a higher variance at TTWA level with respect to NUTS 1). It has however to be considered that in the investigation of the casual link between migration and innovation this critique is less relevant. While it may imply a downward bias in the estimation when the variable is adopted as key explicatory component (i.e., regressor of interest), it remains unproblematic when used as dependent variable to estimate the conditional effects of immigration on innovation (i.e., E(innovation/migration)) under the condition that the number of innovative firms per TTWA in the sample is uncorrelated with immigrant flows due to the sampling process of the two surveys (an issue that is quite common in part of the existing literature using patents data for measuring both innovation and mobility of knowledgeable individuals).[6]

Despite that and in order to exploit a larger number of observations, increasing the reliability of the measure of innovative performance adopted, two waves of CIS have been merged: CIS4 and CIS2007.[7] This procedure allows for the creation of a sample of about 22,723 firms.[8] Most of previous research using CIS data focused on a single wave. The rationale of pooling together the two waves also reflects the possibility of controlling for time invariant fixed effects at TTWA level, which are otherwise likely to affect the robustness of the results.[9]

[3] 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.

[4] Office for National Statistics. Social Survey Division and Northern Ireland Statistics and Research Agency. Central Survey Unit, Quarterly Labour Force Survey, 1992–2010: Secure Data Service Access [computer file]. 2nd Edition. Colchester, Essex: UK Data Archive [distributor], August 2011. SN: 6727.

[5] The survey provides firm level micro-data on innovation activities and related investments. It is particularly suitable within the framework of the Knowledge Production Function (KPF) because it allows the recovery of data on capital and labour devoted to the innovation process. This latter aspect is crucial in the context of the analysis because the possibility of investigating the impact of human capital externalities associated to skilled immigration relies substantially on the availability of firm level controls that are likely to net out the effect of immigration internalized by the labour market (e.g., the amount of individually embodied skills that firms can access directly through the learning by hiring mechanism).

[6] Note that in the case of this analysis this implies assuming that the CIS and LFS sampling strategy are run independently from each other and that any measurement inaccuracies in the measure of innovativeness coming from the CIS is not systematically correlated with the magnitude of the immigration variable coming from the LFS due to the sampling process of the two surveys.

[7] Covering the period 2002–2004 and 2005–2007 respectively.

[8] The CIS4–CIS5 sample contains originally 23,908 observations related to our 211 TTWA (note that the full sample of CIS also includes observations for Northern Ireland that are not included in this analysis). Some of them have been dropped due to missing information on geographical identifier and key regressor (Investments in R&D and number skilled employees)

[9] Note that the CIS allows in principle also for the exploitation of the panel dimension based on about 7,000 firms that are present in both the CIS4 and CIS5. Although implying the possibility of constructing a consistent and comparable sample across waves, the adoption of a panel drives to the exclusion of a significant number of observations exacerbating any potential concerns associated to measurement inaccuracies.

The dependent variable, constructed using CIS micro data aggregated at TTWA level,[10] is defined as the share of firms located in each TTWA performing process or product innovation. The share of firm performing only product or process innovation is also used to test for potential heterogeneity in the exploitation of external sources of information coming from the typology of innovative activities performed. Finally to provide further evidence on the fact that results are not driven by the aggregation at TTWA level the estimation is also performed at firm level adopting the standard firm based KFP approach (Griliches 1992) where immigrants inflows at TTWA level enters as key regressor of interest.

CIS data have been further used to construct some of the firm based controls exploiting the availability of information regarding intramural investments in innovation[11] and the internal availability of highly qualified personnel measured by the average number of highly skilled individuals employed in local firms as in Maré et al. (2010). This is a particularly relevant control because it allows netting out the effect of skilled immigration that is potentially internalized by hiring new personnel. Additional controls are included for the share of firms engaging in co-operative patterns with universities, government bodies and public research centres to proxy the contribution of additional relevant actors to the emergence of successful innovative performance and to account for the regional system of innovation dimension. All the above regressors are expected to be positively correlated with firms' innovative performance.

Data regarding other location specific characteristics, in particular the regressor of interest, come from the labour force survey (LFS). Skilled immigration is measured by means of the share of highly skilled migrants in each TTWA, meaning individuals with a degree or equivalent qualification (NVQ4). Given the focus on the impact that migration may have on the innovative performance of firms in recipient labour market areas and the rationale regarding the channels mediating this effect, the indicator is constructed referring to highly skilled immigrants in employment as share of the total population on interest.[12] Data show that the share of immigrant population in employment increases systematically starting from 2004 with a more pronounced positive trend with respect to the labour market participation of skilled natives (Figure 1).

The main advantage of using the LFS is the availability of a long time series and the opportunity to exploit the raw micro-data constructing the TTWAs level controls. These characteristics are particularly relevant for the aim of the analysis. Data regarding immigration and skills are often difficult to recover and the LFS allows for a focus on specific segments of the population. On the other side it has to be highlighted that the LFS is characterized by a small within year sample size that may generate more pronounced measurement errors (Dustmann et al. 2003), in particular when information is aggregated at very detailed geographical units of analysis such as TTWAs. This shortfall is likely to affect the precision of the estimates resulting in an attenuation bias of the estimated coefficients. Except for that, the suitability of the LFS as the key data source

[10] Note that in order to provide more detailed information regarding the location of each firm, the final sample of firms coming from CIS4–CIS2007 has been merged with the BSD database. For each firm present in the former sample it was possible to obtain the 7-digit postcode determining its exact location in space. This implies the possibility to locate each firm within the relevant TTWA and to construct the TTWAs based variables used in the empirical analysis.

[11] The CIS is in theory providing information on the effective amount of R&D expenditures by firm. However within the sample considered for the analysis this information is missing for about the 23 per cent of firms. This prevents us from consistently using this measure to construct TTWA averages and also explains why a proxy based on the share of firms performing intramural investment has been preferred.

[12] The measure of skilled immigrants is constructed in order to reflect the employment rate of migrants into the local economy so that its variation account for the exploitation of these novel sources of information into the local labour market. This approach is aimed at accounting explicitly for the participation of immigrants into local labour markets and the channels through which the effect of immigration on innovation is mediated. Furthermore in order to avoid any kind of potential correlation between the measure of immigration and internal movements of skilled individuals (due to either displacement or agglomeration effects) the variable has been constructed as the share of the total working age population of highly skilled immigrant resident in each TTWA rather than the total of highly skilled population (including both migrants and natives). Thanks to an anonymous referee for emphasizing the need of accounting more carefully for the potential link between internal and international migration.

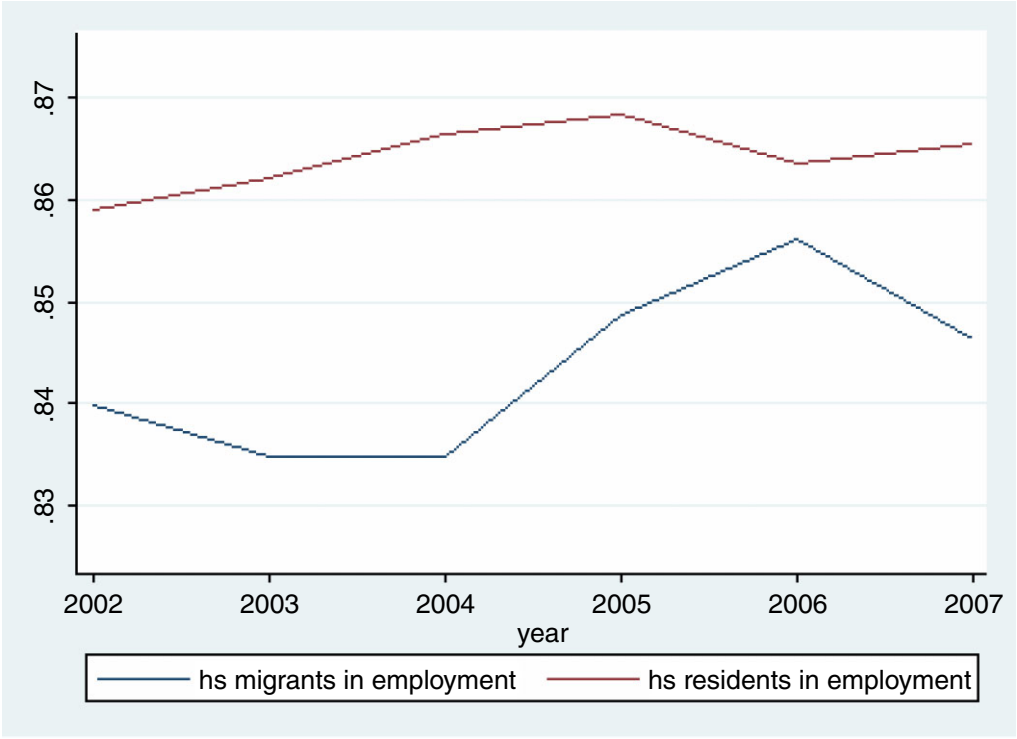

Fig. 1. Immigrants and natives in employment – UK country level
Source: ONS/ CIS-LFS.

to investigate labour market dynamics at TTWA level in Britain is confirmed by its recent adoption in a number of applied contributions (Coombes et al. 2007; Nathan 2011; Faggio and Silva 2012). The alternative source would have been characterized either by the mid estimates provided by the ONS (UK National Statistical Office) or by census data. Both provide very accurate information on immigrants at a detailed spatial level (local authorities), but the former does not allow for a specific focus on the segment of skilled migration while for the latter the frequency of data collection is low. Examining the pros and cons of different data sources, the LFS can be considered the more coherent with the aims of the paper.

The LFS is also used to construct a number of area level controls that may affect immigrant inflows increasing the attractiveness of local labour markets such as population density, long term unemployment share and wage level for skilled immigrants. Additional demographic characteristics such as share of female and young population are also accounted for.

The final TTWA based dataset includes 211 observations[13] for two periods coming from:

1. CIS data aggregated at TTWA level;
2. LFS data aggregated at TTWA level averaged[14] for the two periods taken into account.

The list of variables and sample statistics aggregated at TTWA level are reported in Table 2.

[13] Some TTWAs are missing because of unavailability of data or changes in the administrative boundaries (and subsequent non-matching postcodes) during the time period took into account.

[14] LFS data are provided quarterly. The quarterly LFS samples around 60,000 households. Each quarter consists of five overlapping 'waves', with an 80 per cent overlap within each quarter. Following ONS recommendations, to ensure a sample of unique individuals only observations from waves 1 and 5 in each quarter have been taken and then pooled to produce calendar years. Yearly data are then averaged for the period 2002–2004 and 2004–2006 to merge them with CIS data.

Table 2. Variable list and sample statistics

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
Outcomes						
Product or process innovation (share)	Share of firms performing any product of process innovation	422	0.3336	0.1430	0	1
Process innovation (share)	Share of firms performing product innovation	422	0.1821	0.1127	0	0.75
Product innovation (share)	Share of firms performing process innovation	422	0.2741	0.1311	0	0.75
Enterprise level characteristics						
R&D investments (share)	Share of firms reporting positive intramural R&D	422	0.3134	0.1443	0	0.8333
Skilled employees (with degree)	Average number of employees with a degree per firm	422	13.2906	10.56636	0	111.25
Universities and government bodies	Share of firms exploiting co-operating with universities, governments and other public bodies	422	0.0413	0.0628	0	0.5
Local workforce characteristics						
Skilled migrants	Share of high skilled migrants (with degree or equivalent – NVQ4) in employment	422	0.8453	0.1164	0.3885	1
Wage	Gross hourly wage for skilled migrants	422	13.4409	3.8146	5.2275	36.174
Manufacturing	Share of employment in manufacturing	422	0.1332	0.0444	0.0476	0.2938
Young population	Share of population with less than 29 years old	422	0.2352	0.0294	0.1458	0.3314
Female population	Share of female population	422	0.4949	0.0119	0.4514	0.5383
Long term unemployment	Long term unemployment rate	422	0.1966	0.0867	0	0.5555
Skilled residents	Share of high skilled residents(with degree or equivalent – NVQ4) in employment	422	0.8638	0.0319	0.7105	0.9430

Source: ONS/ CIS-LFS.

Notes: Variables coming from the CIS (product or process innovation, product innovation, process innovation, intramural R&D, universities and government bodies) are calculated with respect to the total number of firms. Intramural investments are defined as 'Creative work undertaken within your enterprise on an occasional or regular basis to increase the stock of knowledge and its use to devise new and improved goods, services and processes. The average skilled number of employees per firm in each TTWA is calculated with respect to employees with degrees in science and technologies or other fields. The variable 'universities and government bodies' is calculated drawing from the section 'Sources of information and co-operation for innovation' of the survey and referring to those firms co-operating with local universities or other higher education institutions (within approximately 100 miles of the enterprise) and local government or public research institutes (within approximately 100 miles of the enterprise) for the development of their innovation(as share of the total number of firms in each TTWA). Variables coming from the LFS are calculated with respect to working age high skilled migrant population for 'skilled migrants' and working age high skilled resident population for 'skilled resident', with respect to working age population for 'manufacturing' and with respect to total population for 'female' and 'youth population'.

All variables are calculated at TTWA level; variables coming from the LFS are averaged across the period 2002–2004 and 2004–2006.

4 Methodology

In the estimation of the role of skilled migration on the innovative performance of British local areas the paper takes into account the methodological indications coming from both the literature on innovation and that on migration.

The mainstream approach in the literature on innovation to model the emergence of an innovative outcome builds on the knowledge production function (KPF) approach originally defined in a firm based perspective (Griliches 1979, 1986; Jaffe 1986) and subsequently adapted to take into account the spatial dimension of innovation (Feldman 1994; Audretsch and Feldman 1996; Varga 1998; Fritsch 2002; Audretsch 2003; Crescenzi et al. 2007).

In the literature on migration the dominant methodology to model flows refers to the work of Borjas (1999) as the 'spatial correlation' approach, where the effect of migration is identified from the spatial correlation between migrants' inflows and changes in the outcome variable within each geographical unit of analysis.

Building on both strands of literature the estimation procedure adopted is constructed around a place based knowledge production function (KPF) where, in line with the conclusions arising from the traditional 'spatial correlation' approach, the measure for skilled immigrants is included as key variable of interest.

The main challenge in performing this estimation strategy is related to the endogeneity of the regressor of interest. First, migrant inflows and innovative performance may be correlated because of common fixed influences. This implies that the immigrant population may be concentrated in certain areas as a consequence of historic settlement patterns, leading to a positive or negative correlation between skilled migration and innovative performance even in absence of a genuine causality.

Second the estimation is potentially affected by a reverse causality bias. It has been argued that skilled migration inflows can be considered a fundamental determinant of innovation acting as channel of knowledge transfer. The empirical proof of the correlation is however controversial. It is in fact reasonable to assume both that migration of highly skilled individuals stimulates further innovation, augmenting and enriching the local knowledge base, and that the knowledge capabilities of a region can affect the migration behaviour of skilled individuals (Faggian and McCann 2006). Highly innovative TTWAs could be generally able to attract more skilled migrants because the return of their higher education is greater in these areas. This is likely to generate an upward bias in the estimates because any depressing impact of immigration on innovation (such as for example a displacement effect on skilled natives) could be masked by the fact that inflows of skilled immigrants occurred in areas where these potential negative effects are offset by positive economic shocks (Dustmann et al. 2003).

The statistical solution to the endogeneity problem relies on the possibility of controlling for both area fixed effect and reverse causality. The former issue is addressed including area fixed effects in the preferred specification. The latter shortfall is controlled for adopting an instrumental variable approach (2SLS).

The estimated equation will take the following form:

$$Innovation_c = K_c + L_c + Skilled\ Migrants_c + X_c + \gamma_c + \varepsilon_c, \quad (1)$$

where $Innovation_c$ is the share of firms performing any product or process innovation in TTWAc, K_c and L_c are the internal inputs of the innovation process measured respectively by the share of firms performing intramural investments and the average number of employees with a degree in firms located in TTWAc. The regressor of interest, $Skilled\ Migrants_c$, is defined as the share of employed skilled in-migrants in TTWAc. X_c is a vector of relevant TTWA controls, γ_c are area fixed effect and ε_c is a well behaving error term.

The equation above has been also run at firm level to check whether results are driven by the aggregation at TTWA level. Instead of the place based specification, the standard firm based KPF is employed where $Innovation_{i,c}$ is a dummy taking value 1 if firm i in TTWAc has performed any product or process innovation and 0 otherwise, $K_{i,c}$ and $L_{i,c}$ are dummies taking value 1 if firm i performs any intramural investments and the number of employees with a degree in firm i located in TTWAc respectively. $X_{i,c}$ and X_c are vectors of relevant firm and TTWA controls and $\varepsilon_{i,c}$ is the error term.

4.1 Instrumental variable approach

A number of different instruments were traditionally adopted in the existing literature to control for the traditional endogeneity of migration. Time lag is the simplest approach (Dustmann et al. 2005). Accessibility measures[15] were often used building on the idea that immigrants tend to cluster close to main access points (Ottaviano and Peri 2006). Both approaches are not adoptable in this case. Lagged values are likely to be weakly correlated with actual changes in the highly skilled population of migrant because during the period taken into account Britain has experienced a relevant shock due to the A8[16] accession in 2004 that has substantially contributed to change the ethnic composition of immigrant's population (Dustmann et al. 2010).

From the other side accessibility measures such as ports (Ottaviano and Peri 2006) or land borders (Bellini et al. 2013), traditionally adopted in the case of US are probably less consistent with the geography of Britain. Moreover they strongly rely on the assumption that immigrants tend to remain clustered in neighbouring areas of main access points, but this expectation is likely to be less pertinent in the case of highly skilled migrants.

The choice of the instrument has been therefore oriented to adopt the shift share instrumental variable approach popularized by Card (2005, 2007). The main intuition behind this strategy is that the initial share of immigrants by country of origin is a relevant predictor of subsequent inflows because migrants tend to be attracted by pre-existing communities.

The share of population in each TTWA by country of birth in 2001 is used to attribute to each group the growth rate in the skilled population of that group for the whole Britain between 2002 and 2006. Summing up over all groups the predicted share of immigrants in each TTWA is obtained and adopted as instrument for the actual share of skilled individuals.[17]

To construct the specific instrument the paper builds on Ottaviano and Peri (2006). Let $CoB^i_{c,2001}$ denotes the share of population born in country i, living in TTWAc in 2001 defined as base year. Assume that $g^i_{2007-2002}$ is the British national growth rate of highly skilled population by country of births i between 2002 and 2007.

The predicted population by country of birth i, in each TTWAc:

$$CoB^i_c = CoB^i_{c,2001}\left[1 + g^i_{2007-2002}\right]. \tag{2}$$

Building on the idea that the national variation of immigrants by country of birth is exogenous in respect to local characteristics and that the geographical distribution of migration inflows is systematically affected by patters of historical settlements, CoB^i_c is used as instrument for the variation in the inflows of skilled individuals in each TTWA during the period under analysis.

[15] Proxies for changes in the accessibility of different TTWAs due to major infrastructure improvements in terms of both stock or efficiency level or specific geographical characteristics (ex. proximity to coasts etc)

[16] On 1 May 2004, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Slovakia, Slovenia and Poland, became members of the European Union

[17] The instrument s constructed using LFS data for 75 countries of birth groups. Highly skilled immigrants entering Britain between 2002 and 2007 are defined as those with a degree or equivalent qualification.

5 Results

Results on the full sample of TTWAs are presented in Table 3. Column 1 reports the standard knowledge production function interpreted as baseline model where innovation outputs are related to internal inputs, share of firms with positive intramural investment and average number of skilled employees and the regressor of interest, the share of skilled immigrants is included as an additional regressor. As expected, both intramural investments and the regressor for skilled employment are positively and significantly associated to innovation activities. The key variable of interest, the share of skilled migrants, turns out to be significantly (at 5 per cent) and positively associated to innovation. As expected, areas experiencing greater inflows of skilled immigrants are those benefiting from the availability of these novel sources of individual embodied knowledge. In the following columns a number of relevant controls are also included to account local wages (column 2) sectoral specialization and co-operation with local universities and government bodies (column 3), demographical structure of the population (proxied by the share of young and female population) and long-term unemployment rate (column 4). Among these additional controls the share of firms in manufacturing, included as proxy for sectoral specialization is positive and significant at 1 per cent as well as the share of firms co-operating with local universities and government bodies that is significant at 5 per cent. This latter variable, aimed at providing a proxy for the network of relations within the regional system of innovation, shows the expected sign as well as a significant correlation confirming the complex nature of innovative processes that are often the product of fruitful interactions among different actors. The regressor of interest remains significantly and positively associated to local

Table 3. Estimation results: skilled migration and local Innovative performance

Dependant variable: product or process innovation	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) 2SLS
R&D investments	0.3082***	0.3100***	0.2917***	0.2947***	0.3082***
	(0.0621)	(0.0631)	(0.0624)	(0.0603)	(0.0578)
Employment (with degree)	0.0013*	0.0013*	0.0014*	0.0013*	0.0018**
	(0.0008)	(0.0008)	(0.0007)	(0.0008)	(0.0008)
Skilled migration	0.0151**	0.0155**	0.0146**	0.0152***	0.0643**
	(0.0062)	(0.0063)	(0.0059)	(0.0058)	(0.0277)
Wage		–0.0004	0.0006	0.0009	–0.0021
		(0.0019)	(0.0020)	(0.0019)	(0.0026)
Manufacturing			0.9460***	0.9909***	1.1046***
			(0.2589)	(0.2515)	(0.2910)
Universities and government bodies			0.2487**	0.2446**	0.1656
			(0.1014)	(0.0995)	(0.1330)
Young population				0.6423*	0.8566**
				(0.3508)	(0.4087)
Female population				0.4974	0.1476
				(0.4774)	(0.5716)
Long term unemployment				–0.0037	0.0078
				(0.0572)	(0.0622)
Constant	0.2041***	0.2117***	0.0796	–0.3415	–0.1820
	(0.0362)	(0.0501)	(0.0588)	(0.2396)	(0.2805)
TTWA fixed effects	YES	YES	YES	YES	YES
Observations	422	422	422	422	422
R2	0.7004	0.7004	0.7154	0.7191	0.6753

Source: ONS/ CIS-LFS.
Notes: Robust standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

innovative performance at 5 per cent. Results also confirm the relevance of traditional inputs such as investments in R&D and skilled employees.

The estimation performed makes it possible to control for a potential bias due to unobserved time invariant fixed effect thanks to the inclusion of TTWA dummies, but it does not control for the endogeneity coming from reverse causality between migration and innovation. This is likely to be a fairly relevant concern in our sample given the heterogeneity across TTWAs in terms of economic performance and attractiveness.

In order to rule out this additional source of bias the share of skilled immigrants in employment in each TTWA is instrumented by the shift-share instrument constructed using LFS data on country of birth (*CoB*). Results are reported in column 5. After controlling for endogeneity the regressor of interest remains significant and positively associated to local innovative performance confirming the relevance of skilled immigration as channel of knowledge transfer.

To confirm the reliability of these findings the first stage regression is reported in Table 4. As expected the instrument is significantly and positively correlated with the regressor of interest and it generally satisfies the conditions defined by the rule of thumb proposed by Staiger and Stock (1997) and the Stock and Yogo (2005) thresholds values.

Despite being not driven by weak instrument, the lack of effect for our regressor of interest may be still affected by the specification of the model. To rule out this concern the IV estimation has been replicated progressively eliminating all the additional TTWA controls. Results reported

Table 4. First stage regression

Dependant variable: skilled migration	(1) OLS
R&D investments	–0.1529
	(0.5419)
Employment (with degree)	–0.0092*
	(0.0054)
Wage	0.0745***
	(0.0170)
Manufacturing	–6.2103*
	(3.7171)
Universities and government bodies	1.5790
	(1.0958)
Young population	–2.6383
	(3.0806)
Female population	6.5301
	(5.8030)
Long term unemployment	–0.2419
	(0.9146)
Country of birth	22.8851***
	(7.9141)
Constant	–3.2996
	(3.2314)
TTWA dummies	YES
Observations	422
R2	0.5704
F Stat (1, 202)	8.36
P value	0.0043

Source: ONS/ CIS-LFS.
Note: Robust standard errors in parentheses; *** $p < 0.01$, * $p < 0.1$.

Table 5. Robustness check (1)

Dependant variable: product or process innovation	(1) 2SLS	(2) 2SLS	(3) 2SLS	(4) 2SLS
Skilled migration	0.0643**	0.0646**	0.0944**	0.1475**
	(0.0277)	(0.0274)	(0.0368)	(0.0727)
R&D investments	0.3082***	0.3080***	0.3066***	0.2921***
	(0.0578)	(0.0578)	(0.0622)	(0.0746)
Employment (with degree)	0.0018**	0.0018**	0.0017**	0.0025***
	(0.0008)	(0.0008)	(0.0008)	(0.0010)
Wage	–0.0021	–0.0021	–0.0057*	
	(0.0026)	(0.0026)	(0.0031)	
Universities and government bodies	0.1656	0.1630	0.2012	
	(0.1330)	(0.1314)	(0.1670)	
Manufacturing	1.1046***	1.1024***		
	(0.2910)	(0.2886)		
Young population	0.8566**	0.8602**		
	(0.4087)	(0.4058)		
Female population	0.1476			
	(0.5716)			
Long term unemployment	0.0078			
	(0.0622)			
Constant	–0.1820	–0.1099	0.3068***	0.2107***
	(0.2805)	(0.1024)	(0.0804)	(0.0550)
TTWA dummies	YES	YES	YES	YES
Observations	422	422	422	422
R2	0.6753	0.6747	0.5879	0.3515

Source: ONS/CIS-LFS.
Notes: Robust standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

in Table 5 confirm that the empirical evidence is not driven by model specification given that the magnitude and the statistical significance of the share of skilled migrants remain generally consistent. This test may also be interpreted as indirect supportive evidence in favour of the reliability of the exclusion restrictions.

In testing for the robustness of the results it has to be acknowledged that a relevant part of the literature on immigration discusses the emergence of a potential counter effect of native outflows correlated to an increase in the immigrant population in a given area (Friedberg and Hunt 1995; Borjas et al. 1997; Card 2005, 2007). This may be a significant concern in our case because the lack of effect may be driven by the failure to account for native outflows. In order to rule out any doubt regarding the correlation of the instrument with native outflows, it has been regressed on the share of highly skilled resident population in employment in each TTWA. Results reported in Table 6 show that, despite the negative sign, the relation remains insignificant. This evidence correlates with previous findings provided by Dustmann et al. (2008) and suggesting that in the case of Britain, in spite of some evidence of displacement effect, its magnitude is relatively small due to less intense internal migration flows.

Results show that skilled migration is a significant determinant of local innovative performance in recipient areas also once the endogeneity of the regressor of interest is accounted for. This finding is robust to weak instrument tests, model specification and additional relevant omitted variables.

This evidence is also coupled by additional relevant findings. In order to check whether the typology of innovation activities performed plays a role in mediating the impact of immigration, the main specification has been re-run on product and process innovation independently. In the

Table 6. Robustness check (2)

Dependent variable: country of birth	(1) OLS
Skilled resident	0.0229
	(0.0297)
Constant	0.6108***
	(0.0283)
Observations	422
R2	0.0015

Source: ONS/CIS-LFS.
Notes: Robust standard errors in parentheses; *** $p < 0.01$.

interpretation of these results it has to be highlighted that the existing literature has emphasized how firms' learning behaviour and their capability to benefit from local externalities is not homogeneous and crucially dependent on the type of innovation performed (Capello 1999). Based on the existing evidence it is reasonable to expect that product innovation relies more on internal inputs than process innovation for which the involvement in intensive co-operative linkages may play a more substantial role (Sternberg and Arndt 2001). Furthermore recent empirical studies such as Maré et al. (2010) has suggested that firms' heterogeneity may explain differences in the impact of immigration flows.

Results reported in Table 7 suggest that the two typologies of innovative activities are characterized by peculiar dynamics supporting the common view regarding their distinctive nature.

Looking at product innovation (Table 7, column 2) both intramural investments and the number of skilled employees confirm their relevance suggesting that internal inputs are a key component. Process innovation instead seems to be less reliant on internal resources and capabilities and to benefit substantially from an innovation-enabling environment. The regressor of interest confirms its significance at 5 per cent level, but also the demographic structure of the population seem to play a key role (Table 7, column 1). These findings correlate with the empirical evidences provided by other studies (Sternberg and Arndt 2001).

Results show that skilled migration is a relevant determinant of innovative performance in recipient areas and that the significance level of its impact, although generally positive, in higher for those firms carrying out process innovation. Despite being robust to a number of robustness checks there may be still the concern that results are driven by the geographical level of aggregation adopted. To rule out any doubts regarding the reliability of these findings, the estimation strategy adopted is replaced by a traditional firm based KFP where the investigation of the impact of immigrant inflows in each TTWA is related to the innovative performance of each firm. Results reported in Table 8 show that, also when the estimation is performed at firm level, the impact of skilled migration on the probability of performing any product or process innovation is positive and significant at 1 per cent level (column 1). Key findings are also confirmed with respect to process and product innovation. Skilled immigration is a significant determinant of process innovation in British local areas (column 2) while results for process innovation are weaker in terms of magnitude and only marginally significant at 10 per cent (column 3).[18]

The analysis shows that skilled immigrants, by enriching the local knowledge base and increasing the level of creativity and productivity of local interactions, contribute substantially

[18] Note that the first stage regression is consistent also in the case of the firm level analysis. The F statistics is well above the value of 10 and also above all thresholds identified by Stock and Yogo (2005).

Table 7. Estimation results: product and process innovation

Dependent variable	(1) Process innovation 2SLS	(2) Product innovation 2SLS
Skilled migration	0.0519**	0.0277
	(0.0239)	(0.0242)
R&D investments	0.2769***	0.2466***
	(0.0469)	(0.0490)
Employment (with degree)	0.0008	0.0013**
	(0.0006)	(0.0006)
Wage	–0.0060***	0.0009
	(0.0020)	(0.0024)
Universities and government bodies	0.0683	0.2695*
	(0.1024)	(0.1638)
Manufacturing	0.9040***	0.7892***
	(0.2313)	(0.2905)
Young population	0.7853***	0.1027
	(0.2776)	(0.3455)
Female population	–0.8123*	0.4468
	(0.4837)	(0.5365)
Long term unemployment	0.0571	–0.0440
	(0.0524)	(0.0570)
Constant	0.2957	–0.1866
	(0.2557)	(0.2624)
TTWA fixed effects	YES	YES
Observations	422	422
R2	0.6610	0.7124

Source: ONS/CIS-LFS.
Notes: Robust standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

to the innovative performance of recipient areas. Results also support the evidence in favour of a certain degree of heterogeneity across typologies of innovation activities performed emphasizing the distinctive nature of different innovative processes.

6 Conclusions

The mobility of skilled individuals has been traditionally considered a relevant determinant of the innovative performance of recipient areas. By enriching the local knowledge base and rising the level of creativity and productivity of local interactions, skilled migrants are assumed to affect local innovative performance through two different channels. First, a direct impact, coming from the availability of novel sources of valuable tacit knowledge that may be accessed by local firms through the labour market. Second an indirect effect benefiting all the local economic actors and mediated by the creating of a contextually enabling environment for innovativess, fostered by the externalities associated to the process of human capital accumulation.

Building on this theoretical rationale the paper demonstrates that after controlling for the former dimension, accounted for by the average number of skilled employees in local firms, skilled immigration is a significant determinant of local innovative performance in Britain. Results are complemented by findings on the role of local heterogeneity in terms of typology of innovation activities performed by firms. Some suggestive evidence of heterogeneous effects is

Table 8. Robustness check (3)

Dependent variable	(1) Product or process innovation 2SLS	(2) Process innovation 2SLS	(3) Product innovation 2SLS
Skilled migration	0.1931***	0.1924***	0.1259*
	(0.0702)	(0.0626)	(0.0658)
R&D investments	0.4681***	0.2846***	0.4331***
	(0.0070)	(0.0066)	(0.0070)
Employment (with degree)	0.0006***	0.0003***	0.0006***
	(0.0001)	(0.0001)	(0.0001)
Wage	–0.0116***	–0.0144***	–0.0070**
	(0.0036)	(0.0032)	(0.0034)
Universities and government bodies	0.1726***	0.1648***	0.1650***
	(0.0170)	(0.0191)	(0.0179)
Manufacturing	1.7088***	1.7375***	1.0688***
	(0.3537)	(0.3175)	(0.3249)
Young population	0.9241*	1.0209**	0.3804
	(0.4921)	(0.4302)	(0.4619)
Female population	1.4162**	0.8188	1.0259*
	(0.6104)	(0.5386)	(0.5643)
Long term unemployment	0.0683	0.1113	0.0209
	(0.0884)	(0.0788)	(0.0825)
Constant	–0.7097**	–0.4638	–0.4434
	(0.3385)	(0.2974)	(0.3133)
TTWA fixed effects	YES	YES	YES
Observations	22,723	22,723	22,723
R2	0.1879	0.0594	0.2053

Source: ONS/CIS-LFS.
Notes: Robust standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

found when the investigation is performed on product and process innovation separately. Product innovation is achieved through processes of knowledge accumulation that remain constrained by firms' boundaries. Internal factors such as investments in R&D and the number of skilled employees are key determinants. Process innovation is instead also reliant on external sources of knowledge such as skilled immigration inflows and achieved though cumulative processes within the local labour market and inter-firm linkages.

In the interpretation of these findings some limitations of the analysis need to be taken into account. First, it has to be acknowledged that the measures of innovative performance and migration are still affected by different measurement problems. The CIS has the significant advantage of providing a more comprehensive measure of innovative performance, overcoming the tradition bias of patents data towards large enterprises and hi-tech sectors, and reliable data on the internal inputs devoted to the innovative process.

Despite that, the survey is not constructed to be geographically stratified at TTWA level and this implies the need of testing carefully the reliability of results. With respect to the LFS, that in the case of Britain is still the most suitable data source in particular to address the role of immigration by different skills segments, sampling imprecision due to small sample size may be an issue. In spite of being zero on average and conceptually different from measurement errors due to misreporting and poor data definition (Dustmann et al. 2003), this characteristic of the data is likely to generate a certain degree of attenuation bias leading to the estimation of a smaller effect in respect to its real magnitude. This implies that, although being reliable, the results are likely to partially under-represent the magnitude of the real effect.

Despite the empirical challenges related to the estimation and the drawbacks concerning data issues the link between immigration and innovative performance of recipient areas remains an empirically relevant issue. The mobility of skilled individuals as channel to foster innovation is at the core of the policy agenda at different levels. The European Council in 2008 declared that cross-border mobility of researchers, as well as students, scientists, and university teaching staff is key to develop a 'truly modern and competitive economy' and that member States and the EU must remove barriers to the free movement of knowledge. More recently the Department for Business, Innovation and Skills (BIS) has highlighted that competing effectively in the global economy to attract entrepreneurs and researchers and to enable companies to recruit skilled employees is a key policy goal for the UK. In line with existing studies, results suggest that fostering skilled migration is a powerful policy option. However some caution is needed in the definition of these policy strategies given that the attraction of skilled individuals may have heterogeneous effect for local contexts depending on the nature of the innovative process performed. More research is needed to provide reliable causal predictions that can inform politicians in the identification of effective and balanced policy initiatives.

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doi:10.1111/pirs.12095

Resumen. ¿Cuál es el efecto de un aumento en la disponibilidad de capital humano debido a la inmigración cualificada en el desempeño en innovación de las economías receptoras? Este artículo investiga el impacto de los influjos de migración internacional cualificada en la innovación en los productos y los procesos de las empresas en zonas británicas del mercado de trabajo local, mediante la combinación de microdatos a nivel de empresa con la información de la fuerza laboral a nivel de zonas. El documento respalda las pruebas en favor de una relación de causalidad entre la inmigración y la innovación. Los resultados muestran también que la naturaleza del proceso innovador y la tipología de las actividades innovadoras realizadas por las empresas locales desempeñan un papel clave en la relación entre la inmigración y la innovación.

要約: 技能移民による人的資本ストックの増加は、移民受入国の経済におけるイノベーション関連の動向にどのような影響を与えるだろうか。本論文では、技能労働者の国際的な移動が、企業の製品と英国における地域の労働市場のプロセス・イノベーションに与える影響を、企業レベルのミクロ・データと地域レベルの労働力の情報を組み合わせて分析する。結果は、移民とイノベーションの因果関係を示すエビデンスを支持するものである。また、革新的なプロセスの性質と地域企業のイノベーション活動のタイプが、移民とイノベーションの関連性における重要な役割を果たしている。