REGION
The Journal of ERSA
Powered by WU

Volume 13, Number 1, 2026, 1–21
DOI: 10.18335/region.v13i1.484

journal homepage: region.ersa.org
ISSN: 2409-5370

A systematic literature review on the relations between "firm-region nexus" and firm productivity

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Received: 1 March 2023/Accepted: 29 January 2026

Abstract. An increasing number of studies focus on the impact of firm location on firm productivity. Here, *location* refers to localised resources or externalities available to firms. These studies have become possible due to advancements in firm-level data availability and productivity estimation methods. There is a growing need to better identify the effects of localised externalities – "the firm-region nexus" – on firms, which are the primary targets of many regional development policies. However, relying solely on administrative regions risks committing the ecological fallacy: attributing to all firms in a region the effects observed for a region as a whole.

This article presents the state of the art as of 2025, highlighting key issues in this area of research. A total of 165 articles were selected, mainly published in the past decade. From a methodological perspective, there is no real consensus on the models utilised, whether to estimate productivity or to investigate the relationships between the "firm-region nexus" and firm productivity. Spatial integration is still not adequately taken into account: (a) Total Factor Productivity estimations do not account for spatial dependence among methodological concerns; (b) 70% of the articles do not discuss methodological issues linked to the use of firm locations. A deeper grasp of firm location, particularly the "head office bias", emerges as critical to improving the robustness of analyses.

Quantifying the "firm-region nexus" remains heterogeneous across national and local contexts (diverging points of interest, data availability, etc.). Comparing the effects of various types of externalities across countries therefore appears ambitious. Some articles focus on the effect of one category of localised externalities, aiming not only to identify a relationship but also its type: spatial or temporal effect, linear or non-linear relationships, and threshold effects.

JEL classification: D24, O47, R58, R32, R11

Key words: firm-level, firm productivity, total factor productivity, firm location

1 Introduction

Understanding the potential contribution of the "firm-region nexus" to the productivity of existing firms is not only a common research concern in regional sciences but also a

central political issue for public authorities. The "firm-region nexus" refers to localised externalities that provide firms with a local advantage.

Firms take advantage of these localised externalities. Consequently, firms are targeted by public policies that enhance the "firm-region nexus" or localised externalities. However, most existing research about the effects of this "firm-region nexus" is carried out at the aggregate statistical unit level, such as the NUTS classification in Europe. Drawing conclusions regarding regional development strategies in these studies exposes decision-makers to the ecological fallacy (Openshaw 1984, Fotheringham, Wong 1991, Wrigley 1995). Since relationships seen at higher levels may not always mirror realities at the individual level (in this case, firm level), the ecological fallacy is a mistake that can result in misunderstandings and poor decisions. Public policies can also benefit from individual-level research (Duranton 2011). Indeed, firms are the target group of most public policies in regional development in order to boost socio-economic development of local communities as the ultimate beneficiaries.

The development of research on relationships between territorial resources and productivity measured at the firm level depends on four conditions: the availability of reliable accounting data, reliable information on the location of activities, robust indicators to quantify productivity, and quantification of the "firm-region nexus".

First, access to business databases varies from country to country. The quality of, and access to, data depends on the institutions, public and private, that collect the information, the issue of data protection, and the amount of information requested from businesses. These influence the distribution of case studies around the world.

Second, it remains difficult to link the creation of added value by a firm to a specific location: accounting data usually are available at the legal-unit level, implying that added value is located at headquarters. However, headquarters are not necessarily the main place where value is produced or where a firm benefits most from localised externalities.

Third, the productivity of a firm can be measured using various indicators. In the 1950s, the "Solow residual" was conceptualised to compare the productivity of firms regardless of differences in activities (Abramowitz 1956, Griliches 1996, 1998, Hulten 2001, Solow 1957, Van Beveren 2012, Van Ark 2014, Nadiri 1970). The operationalisation of the concept, better known as Total Factor Productivity (TFP), is now widespread. The various techniques for estimating TFP seek to deal with classical biases in econometrics, including price omission bias, simultaneity bias, endogeneity of explanatory variables (capital and labour), and selection bias linked to the use of panel data (Van Beveren 2012).

Fourth, quantifying "firm-region nexus" remains a methodological challenge due to data availability or the level of details to capture spatial variability due to, for instance, agglomeration economies. Some authors quantify agglomeration economies by proxies such as population or firm density, whereas other authors quantify agglomeration economies through sophisticated variables designed to capture different forms such as localisation, urbanisation, or competition economies.

In the 2010s, a growing number of studies sought to identify the interactions within the "firm-region nexus" and their effects on productivity measured at the firm level, seeking to integrate the aforementioned issues. This article reports on the Systematic Literature Review (SLR) implemented to identify 165 articles constituting the most exhaustive literature review possible. The SLR exploits the content of the 165 identified articles to highlight the methodological issues and to present the state of knowledge on the interactions between territorial resources and firm productivity at firm level.

The article is organised as follows. Section 2 discusses the methodology used to select and analyse the 165 articles. Section 3 analyses the metadata of 165 selected articles (date of publication, location of case study, authors...). Section 4 discusses three important factors in the methods used to analyse the 165 articles: (i) the sample or statistical population studied (size and types of firms); (ii) the methods to estimate productivity and the impact of "firm-region nexus"; and (iii) the variables quantifying this "firm-region nexus". Section 5 presents the state of knowledge on the relationship between the "firm-region nexus" and firm productivity. Finally, Section 6 concludes.

Table 1: Query formulated in Scopus for the systematic literature review

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ALL ( "plant-level" OR "firm-level" ) AND TITLE-ABS-KEY ( ( "firm" OR
"enterprise" OR "plant" ) W/5 ( "productivity" OR "TFP" OR "Total factor
productivity" ) ) AND TITLE-ABS-KEY ( "regional" OR "location" OR
"territorial" OR "localization" OR "agglomeration" OR "city" OR "spatial"
OR "place-based" OR "proximity" OR "spatial clustering" OR "local" OR
"distance" ) AND NOT ALL ( "FDI" AND "foreign direct investment" ) AND (
LIMIT-TO ( DOCTYPE , "ar" ) ) AND ( LIMIT-TO ( LANGUAGE , "English" ) )
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2 Method and Data

This section presents the method and data collected to conduct the Systematic Literature Review (SLR). The first subsection defines the SLR and details how it was applied. The second subsection details the data collected in each article considered.

2.1 SLRs: definition and application

Initially, SLRs were developed and used in the life sciences. The main advantage of SLR is that it provides a comprehensive inventory of the literature. It must meet five qualities: be reproducible, transparent, objective, unbiased, and rigorous. The selection of keywords, the chosen databases, and the interpretations are all choices that must be justified by the researchers (Boell, Cecez-Kecmanovic 2015).

The list of keywords comprises three categories that were to be represented in the selected articles (see Table 1). The first category corresponds to a clear mention (anywhere in the article) to an analysis conducted at a firm-level (and not at regional level). The second category refers to some words describing a clear mention of spatial and/or geographical dimensions. To select papers on the spatial dimension of firm productivity, these words must be in the title, abstract or keywords of each article. In the third category, an association must be made between a firm (or two main synonyms) and its productivity. This ensures that the selected articles focus on the firm-region (productivity) nexus issue. No specific period has been included in the query.

The query was conducted on December 12, 2023, using the *Scopus* search engine (see Table 1). *Scopus* is preferred over other search engines based on the two arguments made by Mongeon, Paul-Hus (2016). First, *Scopus* inventories a larger number of scientific journals, particularly in the social sciences. Second, the diversity of origins of scientific journals is broader in *Scopus* compared to other search engines like the *Web of Science*. It should be noted that *Google Scholar* was not used because it does not distinguish between peer review articles and the 'grey' literature.

The initial query identifies 920 relevant documents. We introduced two specific codes to limit the selection of articles:

- The first limits the selection to articles (to ensure the same quality standards) published in English as scientific *lingua franca*, reducing the number of documents to 839; this may impact the location of case studies.
- The second one excludes articles mentioning Foreign Direct Investment (or its acronym FDI) because it appeared that these articles do not use the spatial or geographic dimension to analyse the "firm-region nexus": either the relevant scale is national in these papers or the subnational (regional or local) scale is analysed as control variable. It reduces the number of documents to 574.

The 574 abstracts were reviewed to select relevant articles, analysing the relations between territorial resources and firm productivity. To analyse the "firm-region nexus", selected articles must fulfil the following conditions:

- Be an empirical analysis, excluding purely state-of-the-art or theoretical analysis.
- Analyse primarily the territorial resources as defined above.

- Demonstrate an analysis that includes a spatial or geographic dimension (for instance, the spatial impact of an infrastructure but not the economic impact of a national or regional infrastructure program).
- Be focused on manufacturing or service firms, excluding (thanks to Scopus research engine) articles focused on agriculture, retail or tourism firms. The location of these firms is linked to other specific location factors (high streets in city, tourist attractions, geographic conditions).
- Be focused on externalities, and not on internal characteristics of firms such as type of ownership or firm level of R&D investment.
- Not have as main subject the effect of national or regional regulations in the environmental or fiscal fields.
- Not have as main subject international trade, outsourcing, and/or export ability, because the spatial dimension refers, in these cases, to national or international scales.

The reading of each abstract resulted in a selection of 216 articles. Subsequently each article was read in its entirety: a selection of 165 articles resulted[1]. These articles contain some models explaining the firm productivity by territorial resources with or without internal characteristics. Based on the different criteria, the systematic literature review is based on these 165 articles; at https://orbi.uliege.be/bitstream/2268/340548/-2/Annex_SLR.xlsx is the complete list.

2.2 Collection of data from articles included in the SLR

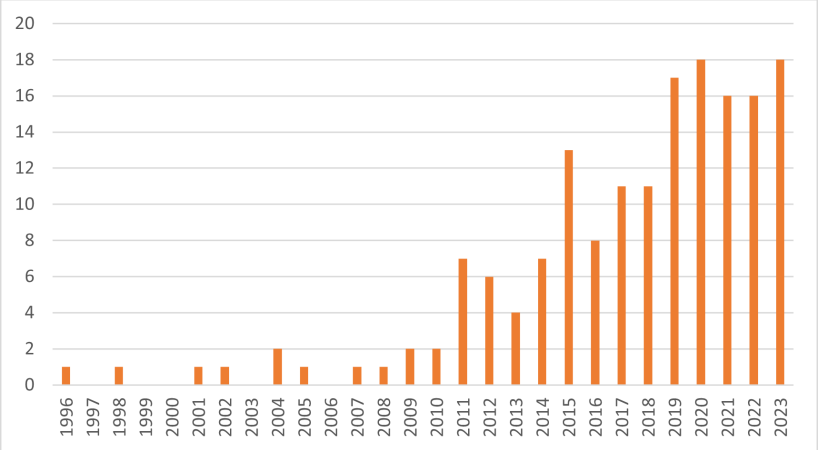
Various information was collected for each of the 165 identified articles. The metadata collected via *Scopus* include author(s), year of publication, and journal name. Data about articles was processed based on four categories.

The first category of data refers to sample details. These details include the type of firms (for instance, manufacturing or services firms), the sample size (i.e., the number of firms analysed), and the years of observation.

The second category of data refers to location information. These details include area where firms are located, the level of accuracy of firm locations, and the inclusion of information on single or multiple establishments of firms. The level of accuracy of firm location is derived from the European NUTS typology. We define seven scales. Four scales are derived from NUTS typology for regional administrative units, from NUTS 0 (country) to NUTS 3 according to the population size of study area. Eurostat, the European Office for Statistics, offers the Local Administrative Units (LAU) to analyse local level data. It corresponds to local authorities, communes, or municipalities. We add two complementary scales: local labour market, usually defined on a scientific basis, and city without any other information provided by the paper authors.

The third category refers to the analysis of relations between variables quantifying the "firm-region nexus" and firm productivity. First, indicators of firm productivity are collected (including methods to estimate productivity). Second, models quantifying the "firm-region nexus" (including the direction of the relationship with the indicators of productivity) are analysed. Most articles include several models, between one to 15 models published per article. It is important to avoid the over-representation of results published in articles testing similar models. That is why, in these cases, models considered are either the baseline model with the most variables or several models in cases where a single model did not include all the variable categories. Based on this selection, data are collected about the statistical methods, variables quantifying the relations between "firm-region nexus" and firm productivity including the basic results (positive, negative, both, or non-significant).

[1]One article was retracted on 9 Oct 2025 during the review process of this article, the retracted article was removed from the final selection.



Source: Scopus

Figure 1: Number of articles identified by SLR by year of publication

Explanatory variables are collected and then classified according to an adaptation of a typology by Tsvetkova et al. (2020). These authors have realised a large state-of-the-art of the "firm-region nexus" based on workshops and literature review within the OECD Spatial Lab. They identify twelve categories of territorial resources with a spatial dimension on firm productivity at subnational scales. These twelve categories are grouped as follows: first, agglomeration economies, including five components (localisation economies, urbanisation economies, competition economies, size and efficiency of local labour markets and global index of agglomeration economies); second, knowledge and ecosystems, including R&D, knowledge diffusion, entrepreneurship and human capital; third, finance and governance, including finance, institutions, governance and policies and regulations; fourth, infrastructure and settlement, including demography, geography and infrastructures; and fifth, local economic structure, including the effect of specific categories of firms on productivity (e.g. local share of large firms).

3 An emerging field of research in a growing number of countries

The question of the relationship between "firm-region nexus" and firm productivity is an emerging theme, as shown by the publication dates of the 165 analysed articles. Almost all the articles were published since the 2010s (see Figure 1). Since 2019, each year has seen more than 15 articles published. Two elements support the observation that this is an emerging topic. On the one hand, no single journal has established itself as a reference for publication on the research theme. No less than 91 different journals have published articles. These journals are either specialised in specific economic themes (productivity, transport geography) or specialised in regional sciences. Six journals published more than five articles in the sample: *Regional Studies*, *Annals of Regional Science*, *Regional Science and Urban Economics*, *Journal of Urban Economics* and *Sustainability*.

Among the 391 different authors of 165 articles, 9% have published more than one article included in this SLR. These authors have published about the same study case: sometimes about different samples of firms but always of the same country. Company databases comprise balance sheets of legal units. However, legal units' definition differs across national laws. Moreover, a firm is sometimes an association of several legal units, united by a distinctive organisational logic. The concept of firm is broader than legal unit: it remains ill-defined entity both in terms of its boundaries and its content (Maskell 2001), due to different viewpoints.

Moreover, there are major differences across countries about available firm data: private, semi-private, or public producers of databases alongside differences between national accounting systems and various methodological choices. The lack of harmonised data across countries means it remains difficult to carry out analyses on several countries

Table 2: Location of study cases of the 165 articles of the SLR

Continents	Countries with more than 3 articles
Europe – 82 articles	Italy – 27 articles United Kingdom – 9 articles France – 6 articles Spain – 5 articles Germany and Sweden – 4 articles Belgium, Portugal, and studies on several European countries – 3 articles
Asia – 63 articles	China – 39 articles South Korea – 4 articles India and Vietnam – 3 articles
America – 9 articles	United States of America – 5 articles
Africa – 8 articles	
Oceania – 3 articles	
Intercontinental – 1 article	

Source: Own elaboration

or for authors to publish on different countries. Researchers face specificities related to the accounting data collected and made available (see Siepel, Dejardin 2020).

The Bureau Van Dijk database, including the Europe's largest firms, or some surveys conducted among firms in several African countries, allows simultaneous analyses of several countries. These two databases are used in 7 of the 165 articles. Further, 142 articles analyse a sample or a population of firms from one country, while 15 articles focus on firms from a part of a country, typically China or Italy.

The study cases are mainly located in China (39 articles) and Italy (27 articles) (see Table 2). Apart from these two special cases, 10 countries are the case studies of more than 3 articles of this SLR (7 in Europe, 2 in Asia and 1 in America). There are several hypotheses explaining this inequal repartition of study cases across the world: first, uneven regional development is a common issue in these 12 countries; second, data availability and robustness is a crucial issue to allow research; third, the spread of English as a scientific lingua franca is not the same throughout the World. For instance, 24 articles out of 39 articles about Chinese firms are based on a firm census conducted during the 2000s.

4 How has research been conducted?

4.1 Selecting firm sample or population to quantify productivity

Most research evaluating the impact of "firm-region nexus" on firm productivity focuses on manufacturing firms (see Table 3). Most exclude some firms for several reasons: first, firm data quality remains a real issue. There are few data quality checks for firms' databases e.g., errors, omissions, omitted relations between legal units. Second, data accuracy for the smallest firms can be weaker because they do not need to report all accounting data (with variations in what must be published depending on the country). Third, some authors focus on market-oriented firms to avoid firms with specific strategies such as public owned firms. Fourth, and finally, some authors focus their research on a specific sector.

Three indicators emerge from the multitude of indicators that measure firm productivity (OECD 2020): labour productivity, wages, outputs and TFP. TFP has the advantage of allowing for comparison *all other things being equal*, but also the disadvantage of being more complex to estimate due to numerous methodological difficulties (Gal 2013, Gordon et al. 2015, OECD 2020). TFP is the most common productivity indicator among the SLR (see Table 4).

A diversity of estimation methods is observed due to the absence of a method that simultaneously deals with all methodological issues (see Van Beveren 2012). Some authors

Table 3: Firm sample or population analysed by the 165 articles of the SLR

Sectoral focus	Without exclusion	With exclusion based on accounting data (e.g., more than x full-time equivalent, amount minimum of sales...)	With exclusion based on economic sector (e.g., without financial firms with specific accounts...)	Focus on specific group(s) of firms (e.g., sector or technology level...)	Total
None (all firms)	30	21	2	12	66
Manufacturing	32	32	17	10	91
Services			1	6	7
Total	63	53	20	28	163

Source: Own elaboration
Notes: No data: 2 articles

Table 4: Frequency of use of each productivity indicator in SLR

Indicator	Number of articles in which the indicator is used
Total Factor Productivity	104
Added value	53
Outputs	13
Wages	2
No clear information	1

Source: Own elaboration

(19% of the 165 articles) favour statistical methods like ordinary least squares estimators (OLS), fixed effects, models including instruments, or generalised moment models (GMM) (see Table 4). OLS is used despite the lack of robustness because it remains easy to use and to interpret (Ehrl 2013).

Other authors (55% of the 165 articles) use *ad hoc* estimation methods discussed by Van Beveren (2012). These *ad hoc* methods are the methods of Olley, Pakes (1996), Levinsohn, Petrin (2003), Ackerberg et al. (2015), and Wooldridge (2009). These two last methods are the published version or the last version of working papers used by Van Beveren. These *ad hoc* methods account for about half of the 140 different TFP estimates identified among the 104 articles (see Table 5).

The lack of consideration in econometric research for phenomena with a spatial dimension (Anselin 2010, Tsvetkova et al. 2020) is evident in the methods used to estimate TFP. However, there is a large body of work demonstrating the existence of spatial dependence between firms. In Belgium, Dhyne, Duprez (2016) show that the probability

Table 5: TFP estimation methods across the 165 articles

TFP estimation method		Number of concerned articles
Ad hoc methods identified by Van Beveren (2012)	Olley, Pakes (1996)	23
	Levinsohn, Petrin (2003)	47
	Ackerberg et al. (2015)	14
	Wooldridge (2009)	6
Estimation of TFP by generic methods	OLS	14
	Fixed effects	6
	Use of instruments	9
	GMM	3
	Specific method (with development in article)	2
	Other	10
	No information	6

Source: Personal elaboration

of a transaction between two firms decreases as the distance between them increases. Surprisingly, the discussion of Van Beveren (2012) on the methodological issues, does not mention spatial autocorrelation as a potential bias. This element testifies to the existence of a gap between the research conducted in general econometrics and in spatial econometrics (Anselin 2010).

This gap is filled by three articles in our sample. First, Micucci, Di Giacinto (2009) have included a spatial lag of their explanatory variables. Their results are robust in terms of spatial autocorrelation. Second, Owoo (2016) identified spatial dependency between firm's TFP in African countries. Third, Harris et al. (2019) develop a model dealing with all the methodological issues, including spatial dependence.

4.2 Taking into account the spatial dimension in data and methods

Spatial dependence can be integrated into distinct parts of the statistical analysis: on the dependent variable, on the measure of the firm productivity (*spatial lag model*), on the explanatory variables, namely territorial resources (*spatial cross-regressive model*), or on the error term (*spatial error-model*). A community of researchers is interested in the Generalized Moment Method (GMM) to both estimate TFP and to integrate spatial dependence in the models. Indeed, GMM allows for dealing with endogeneity, whether spatial (Anselin, Rey 2014) or production factors-related (Wooldridge 2009). Thus, Harris et al. (2019) use an integrated methodology quantifying TFP, without spatial dependence bias. They use a GMM integrating spatial dependence to quantifying TFP in a one-step way. This model appears to fill the gap identified in the previous section.

More generally, spatial analysis methods are poorly employed among the identified articles. Out of 165 articles, 73 (44%) include at least one map and/or an application of spatial analysis tools. Maps are used more frequently than spatial analysis tools. Specifically, only 8 out of 165 articles (5%) contain both at least one map and an application of spatial analysis tools.

Firms may have several establishments. The spatial association of a firm with its headquarters is a strong simplifying hypothesis, leading to major biases (Autant-Bernard et al. 2011). These different establishments can all be places where value is produced, potentially benefiting from specific localised externalities. More generally, the observation made by Autant-Bernard et al. (2011) testifies to an insufficient consideration of the geographical complexity and sub-national variability of productivity in the scientific literature, as highlighted by, among others, Anselin (2010) and Tsvetkova et al. (2020).

The SLR confirms that the spatial association of a firm with its headquarters is generally the rule. It is striking and challenging that there is no methodological discussion about the quality of firm location data in 115 articles (70%). In these cases, it is assumed that the firm is located at its headquarters. Among the 50 remaining articles (30%), 28 articles (17%) include a methodological discussion about the data quality of firm location, assuming the limits of these data. As for the 22 other articles, 9 articles have created a dummy variable to distinguish firms with one-single location corresponding to the headquarters and firms with several establishments or plants. Harris, Moffat (2012) identify that multi-establishments firms have higher TFP than firms with one location because multi-establishments firms may have capabilities to benefit from localised externalities from several locations. Ten other articles select only single plant firms (9 cases) or multi-plants firms (1 specific case to analyse this population, see Okubo, Tomiura 2012). Finally, the 3 remaining articles assume a split of firms between different plants according to the weight of each plant (by, e.g., number of employees as weight) (Boschma et al. 2009, Gibbons et al. 2019, Mitze, Makkonen 2020).

5 What is the state of knowledge on the relationship between "firm-region nexus" and firm productivity?

In this section, the variables assessed by the different models are analysed following the methodology and the layout of Beaudry, Schiffauerova (2009). Results are also presented

by article to avoid the over-representation of results from articles including several models (see Table 4).

5.1 Between 0.4% and 11% of firm TFP depends on the firm location

Some articles identify the proportion of TFP variability resulting from firm location. The spatial variability of firm TFP does not exceed 11% and is generally lower than the sectoral variability. It depends also on the study cases, the models, and the variables. According to Campisi et al. (2022), 0.4 % of firm TFP variability is only explained by the regional location, but 44% of firm TFP variability is related to the interactions between location (at regional level) and sector among Italian knowledge intensive business services. By comparison, firm TFP variability depends also on the country: intranational variability is 3.6% in France, 9.9% in Spain, and international variability is up to 15% for firms from seven European countries according to Aiello, Ricotta (2016). Between these extreme values, the magnitude of spatial variability is around 5% for firm TFP.

5.2 Few articles focus on all categories of localised externalities

Most articles (91 out of 165) include a dummy variable identifying a region and/or a control variable of spatial variability. Indeed, authors do not necessarily try to understand all the spatial variability but the effect of one specific category of localised externalities. However, these variables, by capturing part of the spatial variability, are also "catch-all", thus preventing their interpretation. The use of fixed effect to capture spatial variability is frequent. By way of illustration, some articles use this type of variable to distinguish territories with remarkably high disparities, as in Italy (Aiello et al. 2014, 2015, Antonioli et al. 2016, Cardamone et al. 2016, Lasagni et al. 2015), but also elsewhere in the world (for instance, in Africa, see Owoo, Naudé 2017; in Great Britain, see Harris, Moffat 2015; in Canada, see Baldwin et al. 2008).

5.3 Analysis of variables quantifying the "firm-region nexus"

5.3.1 Agglomeration economies and their components

Agglomeration economies are the most studied type of localised externalities, with 49% of tested variables among the 165 articles. Variables quantifying agglomeration economies are present in 57% of articles of this SLR. Simple indicators quantifying agglomeration economies are firm or population density, or local GDP (per capita). These global indicators are used to consider the size effect of cities or urban areas on firm productivity. These indicators allow authors to focus on other types of localised externalities. Indeed, these global indicators do not aim to understand the different categories of agglomeration economies.

Relevant articles are focused on countries with cities concentrating high productivity. In dense areas of France, the productivity advantage ranges from 4.8% for the least productive firms to 13.9% for the most productive firms (Combes et al. 2012). In Belgium, a firm located in Brussels, the largest Belgian city, is 4% more productive once firm sorting and agglomeration economies integrate (Kampelmann et al. 2018). In China, doubling city size implies a productivity premium for firms between 3 and 4% (Hashiguchi, Tanaka 2015, Pan, Zhang 2002). In United Kingdom, the intranational productivity gap between the most and least productive places is broken into two roughly equal parts: on the one hand, between London, the most productive place, and the second most productive place and, on the other hand, between this second most productive place and the least productive places (Harris, Moffat 2022). This illustrates the difference between localised resources in London and in the rest of the country.

Among the four components of agglomeration economies, the competition dimension is the least tested, but the positive effect is the most unanimous among articles of SLR. The competition dimension is the most important source of agglomeration economies of manufacturing firms in Italy according to Cainelli et al. (2015), but not for the case of German firms (Brunow, Blien 2015).

The localisation and urbanisation economies are more frequently studied. The positive effect of localisation economies on firm productivity is more frequently observed than the positive effect of urbanisation economies on firm productivity. Beaudry, Schiffauerova (2009) suggest that detection of localisation and/or urbanisation economies depends on scale and sectoral aggregation. For these authors, it remains difficult to detect the right scale of aggregation and/or the right level of sectoral aggregation. Regarding the relevant scale of agglomeration economies, a threshold of 1 km has been identified for services located in cities in Spain (Coll-Martinez 2019) and in Sweden (Andersson et al. 2019): the effect of localisation economies is stronger at neighbourhood scale ($<$ 1km) and urbanisation economies have an effect at city level ($>$ 1km). Nevertheless, localisation economies have a positive effect beyond 1km as observed in Canada (Baldwin et al. 2010) or in Italy (Cainelli, Ganau 2018).

The positive effect of localisation and urbanisation economies reach consensus (see e.g. Beaudry, Schiffauerova 2009), but this is not reflected by results of SLR. Non-significant or negative effects reflect methodological designs aiming to understand the effect of agglomeration economies according to firm age, firm size, technological or knowledge intensity, or other internal characteristics of firms. Each firm has a specific equilibrium between advantages and disadvantages of agglomeration economies (Lall et al. 2004, Badr et al. 2019, Bellofatto et al. 2023, Cainelli et al. 2016, Harris et al. 2019, Martin et al. 2011) depending on the internal capabilities to capture agglomeration economies (Spanos 2019), the firm size (Knoben et al. 2016, Ramachandran et al. 2020), and the cumulative effects (with other categories of localised externalities) for some firms (Fafchamps, Hamine 2017, Di Giacinto et al. 2020). Thus, relations between agglomeration economies and firm productivity are non-linear (Carreira, Lopes 2018), including the threshold effect (Dai et al. 2017) or different temporal effects (Fazio, Maltese 2015, Martin et al. 2011); all this exerting a selection effect on firms (Hasan et al. 2018).

The quality of local labour markets is poorly addressed among the 165 articles as it remains difficult to quantify this resource. However, the local level of skilled workers (quality and quantity) is related to the firm productivity to explain difficulties of certain regions in the United Kingdom (Morris et al. 2020). The quality of local matching of these skilled workers is a component of related variety advantages as observed in Denmark by Timmermans, Boschma (2014). In China, social mobility is positively linked to firm productivity (Wang, Luo 2022).

5.3.2 Local economic structure

The local importance of certain types of firms influences nearby firm productivity. By contrast with agglomeration economies, this category refers to the effect of certain types on firms as a whole. Here, 27% of the articles include a variable related to this category into the tested models. A high local share of frontier firms influences TFP for all firms: a frontier firm leads to higher productivity for nearby firms (Serafinelli 2019, Du, Vanino 2021). A high local level of foreign direct investments influences firm productivity positively in China (Lin et al. 2011) and in Germany (Mitze, Makkonen 2020). In Italy, risk aversion of familial owned firms negatively influences their productivity and, as corollary, the productivity of neighbouring firms (Amato et al. 2022). According to the cases, the local importance of services improves productivity of manufacturing firms (Yang et al. 2018, Chen et al. 2023). The industrial specialisation also positively influences firm productivity in China (Tian et al. 2023) and in Europe (Aiello, Ricotta 2016).

5.3.3 Knowledge, innovation, human capital, and R&D

Variables in this category represent 12% of tested variables and are tested in 28% of articles. Human capital is frequently quantified by the local share of the most highly qualified (for instance, local share of university degree). This variable positively influences firm productivity according to the SLR: more than 50% positive association between human capital and firm productivity are observed among the 165 articles. In China, increasing by one year the average number of years of study of city's population increase

by 14% firm productivity (Liu 2014). Training of workers is also a way to take the most of localisation economies as observed in France by Morin, Védrine (2022).

Beside human capital, R&D is frequently tested because data are available. Also, they usually positively influence firm productivity, but there are sometimes unsignificant relations. Also, the effect of universities on neighbouring firms is not yet clear. Beneficiaries of academic activities are not well identified (Raspe, van Oort 2011).

Knowledge diffusion is poorly tested by comparison with the two previous subcategories (R&D and human capital) of "firm-region nexus". There are many ways to quantify knowledge diffusion from institutions like universities: between firms and between (certain types of) workers, among others. Knoben et al. (2016) studied the effect of face-to-face contacts in combination with internal characteristics of firms and agglomeration economies. Face-to-face contacts of a firm influence the firm capability to take benefit from agglomeration economies. Antonelli, Scellato (2013, p. 92) observed different relevant scales for contacts and benefits from proximity in terms of productivity according to sectoral proximity: "The Jacobian inter-industrial -within region- vertical knowledge interactions, the intra-industrial nationwide horizontal knowledge feedbacks, and the localised intra-industrial knowledge interactions that take place within geographical clusters".

Finally, a high local entrepreneurship dynamism, quantified by the local share of new firms, is not necessarily linked to a high firm productivity: influence of new firms is negative at the time of creation but it becomes positive several years after the initial entry (Andersson et al. 2012). However, younger firms adopt likely faster more advanced technologies than older firms, which improves their productivity (Howell 2020).

5.3.4 Quality of governance and local institutions

Our analysis shows that variables quantifying the quality of local governance and institutions positively influence firm productivity. Several international institutions have developed regional index quantifying the quality of local governance or institutions such as the European Quality of Government Index (EQI) (Charron et al. 2014, 2021). These indicators are positively associated with firm productivity even if the indicators are constructed differently in respective global regions (e.g. Manzocchi et al. 2017, Rodriguez-Pose et al. 2021, Abeberese et al. 2023, Hussen, Çokgezen 2022). Besides these indexes, low levels of corruption, rapid delivery of building permits, and low local authority debts tend to positively influence firm productivity (Agostino et al. 2020, Giordano et al. 2020, Lasagni et al. 2015, Demir et al. 2022, Qi et al. 2022).

Access to finance also positively influences firm productivity. A high local level of private fundings (by banks) or a high number of local banks positively influence firm productivity, as observed in Italy (Moretti 2014, Ganau 2016, Manzocchi et al. 2017). A high quality of local institutions moderates the negative effect of the lack of funding by financial institutions (Rodriguez-Pose et al. 2021). The results are not similar regarding public fundings (by comparison with fundings from banks), especially subsidies, leading to a sorting effect of firms (Zhu et al. 2022).

5.3.5 Infrastructure and geography

Within this category, where numerous variables have been tested (235 variables across 73 articles), most authors seek to understand the effect of geography, infrastructure, or spatio-temporal phenomena on firm productivity.

First, some authors identified the influence of human or physical geography on firm productivity: a location in less developed regions of Mexico, United Kingdom, Belgium, or Italy implies a lower firm productivity (Deichmann et al. 2004, Harris, Moffat 2012, Kampelmann et al. 2018, Di Giacinto et al. 2020). Beyond regional disparities, the effects of spatial phenomena are also studied: (a) a firm located less than 100 miles from a site hit by a terrorist attack is less productive (Mun et al. 2021); (b) the proximity to a border affects the productivity of Italian firms (Fantechi, Fratesi 2023); (c) in China, firm productivity is higher in warmer areas (Xue et al. 2021) but the projected impact of climate change, including an increasing of temperature, could negatively impact the

future firm productivity until -12% of output (without adaptation) (Zhang et al. 2018); and (d) finally, air pollution is linked to a lower firm productivity in China (Liu et al. 2023).

Second, local demography affects firm productivity in several ways. Firm productivity could be improved in places (a) where immigration increases (for firms with TFP under median in France) (Mitaritonna et al. 2017); (b) with demographic diversity (e.g. nationalities) at the regional level (but not at firm level) for German firms (Trax et al. 2015); and (c) with a younger population (Di Giacinto et al. 2020). The proximity between the firm and the entrepreneur's home influences the firm's capabilities to benefit from agglomeration economies (especially Marshall-Arrow-Romer spillovers in case of proximity between firm and residence) and the lock-in situation in Italian manufacturing firms (Stefano et al. 2023).

Third, the effects of infrastructure on firm productivity are an important point of interest. New highways are linked to an increase of manufacturing firm productivity in the United Kingdom (Gibbons et al. 2019), Spain (especially in more developed regions) (Holl 2016, Holl, Mariotti 2018), and South Korea (Lee 2021). However, the effect of new highways on firm productivity has a decreasing marginality in China (Li et al. 2017, Tian et al. 2023). Indeed, a larger number of economic agents is accessible within the same time thanks to new highways. These infrastructures improve the agglomeration economies. The accessibility benefit decreases the more the region is already connected. Moreover, a negative effect on firm productivity is identified if the better accessibility is linked to a too small city (Lin, Huang 2021). The same reasoning applies to high-speed lines for accessibility to cities: a decrease of time-distance by train of 1% is linked to an increase of 1.5% firm TFP (Yué, Nan 2019), which strengthens exchanges between cities (Zhao et al. 2021).

Fourth, IT infrastructure is crucial to ICT access and ultimately to firm productivity. This is observed by a survey in New Zealand (Grimes et al. 2012) and is linked to the quality of preexisting networks (time effect) in Italy (Cambini et al. 2023). Zhou, Wang (2023) identify a stronger positive effect of proximity to main train stations or airports for labour-intensive, non-exporting, private and small firms.

Fifth, Special Economic Zones (SEZ) have been developed in many countries to host Foreign Direct Investments or exporting firms. These zones offer facilities in terms of land, taxes, institutions, and infrastructure depending on countries. Given that the real effect depends on national or local cases, it remains difficult to generalise about SEZs. For instance, many studies identify a selection effect (Koster et al. 2019, Li et al. 2021), border effect (in or out the SEZ) (Zhou, Liu 2023), and heterogeneous effects by firm categories (Howell 2019, Hasan et al. 2020).

Sixth, regional path dependency impacts firm productivity. The quantification of regional path dependency depends on the scope of articles. The variables are sometimes used as instrumental variables. Many articles refer to phenomena many centuries ago. For instance, middle age climate is used as a variable to identify vulnerable regions that have set up institutions at an early stage. The early development of institutions explains current firm productivity of manufacturing in Europe (Rodriguez-Pose et al. 2021). The road network of Antiquity and the Middle Ages is an instrumental variable that identifies the positive effect of highways on firm productivity (Holl 2016, Lee 2021). Closer in time, local literacy levels, historical population density, and/or the existence of a cadastre at the end of the 19th century are positively linked to current firm productivity (Békés, Harasztosi 2013, Agostino et al. 2020).

6 Concluding remarks

The objective of this SLR is to identify and analyse articles that quantify the relations "firm-region nexus" and productivity at the firm level. Based on a query conducted using the *Scopus* search engine, 165 articles were analysed, revealing an emerging research field.

This literature review highlights the fact that too little research is conducted on the impact of territorial resources on productivity as measured at the firm level by comparison with the abundant research conducted at regional level. From this viewpoint,

there is a need to better identify the effect of territorial resources on firms, which are the target group for a large part of regional development policies. Staying on the level of administrative regions exposes researchers and decision makers to the ecological fallacy of attributing an observed effect for the community to everyone in that community (Openshaw 1984, Wrigley 1995). Moreover, "head office" bias could lead to overestimating the real magnitude of agglomeration economies and localised externalities linked to largest cities.

The elements discussed here not only directly impact the results of the studies about the relations between the "firm-region nexus" and firm productivity, but consequently also the conclusions regarding regional development, a major economic policy objective. That is why policymakers should pay greater attention to data and method issues. That said, new research may lead to increasingly robust insights about the impact of territorial resources on firm productivity.

The availability of reliable data on firms and the use of robust estimates of TFP as a comparable indicator of firm productivity seem to jointly condition the development of field research. The analysed articles usually focus on national contexts because data, typically produced at the national level, are not standardised across countries. This continues to make international comparisons challenging (Schuh et al. 2017). Although authors normally work within a single national context, ongoing exchanges between scientists across national boundaries are making it possible to achieve a consensus regarding appropriate statistical analysis methods and the effect of "firm-region nexus" on firm productivity. For example, some innovative variables could be assessed in multiple national contexts, notably in terms of access to financial services or the quality of supply-demand matching in local labour markets.

Few articles take seriously into account the firm location issue: only 30% of 165 articles contain a specific methodological discussion about it. Some of these articles detail the potential bias in their methodological section. Therefore, we can conclude that there is a lack of consideration for the geographical complexity and subnational variability of productivity as highlighted by Anselin (2010), Autant-Bernard et al. (2011), and Tsvetkova et al. (2020). Neglecting the "head office bias", the real advantage of agglomeration probably tends to be overestimated (Gaubert 2018, Bouba-Olga, Grossetti 2020).

Classical methods to estimate firm TFP neglect the bias induced by spatial dependence between firms. From this perspective, it is striking to observe that, for instance, Van Beveren (2012) does not include it in his list of methodological challenges. This potential bias is another methodological issue for researchers in regional science that reflects an additional lack of consideration for the spatial dimension. In the future, studies should address the remaining gap in the integration of the spatial dimension, notably by developing ad hoc methodologies and tools. First, it is observed that cartography and spatial analysis are still underused tools for describing fundamentally spatial phenomena. In parallel, the development of tools in spatial data analysis, such as *Geoda Space* (Anselin, Rey 2014), is likely to facilitate wide usage of these techniques. We should also mention Harris et al. (2019), which develops an innovative methodology combining, within the same model, a robust estimation of the TFP, spatial dependence, and an explanatory model of territorial resources using GMM.

The quantification of "firm-region nexus" remains very varied, depending on national or local cases (diverging points of interest, data availability, different ways to quantify "firm-region nexus" ...). A critical perspective is more developed in articles focusing on one category of externalities. Thus, a "general" effect (identified by a classical regression) could hide specific effects or relations (threshold effect, decreasing marginality...).

These more detailed analyses explain a part of the non-significant, heterogeneous, or negative effects on firm productivity among the 165 articles. There are some tests of specific relations between firm productivity and variables. Many articles challenge the real effect of agglomeration economies on firm productivity: spatial and/or temporal effect, linear or non-linear relations, and the threshold effect. Regarding entrepreneurial dynamics, some articles identify the key importance of firm age on TFP of nearby firms with, from a temporal perspective, a negative and then a positive effect.

Among the 165 articles, it appears that the "firm-region nexus" influences firm TFP. Regarding articles including the variety of variables quantifying this "firm-region nexus", firm location potentially influences TFP within a range of 0.4% to 11%. Therefore, location does influence firm productivity, but it is a minor factor compared to internal company organisation.

Among the different categories of localised externalities, scopes diverge. Agglomeration economies increase firm productivity. Beyond this stylised fact, the scientific debate focuses on the spatial and/or temporal effect, the magnitude of each type of agglomeration economies, the cumulative advantage, the selection effect on firms with varying degrees of interest for agglomeration economies, and the local magnitude of diseconomies of agglomeration. The quality of matching on the local labour market is another aspect of agglomeration economies. A better understanding of the "head office bias" could improve analysis robustness. In addition to agglomeration economies, some firms have a specific effect on firm productivity nearby due to their nature (e.g., size, frontier firms, financial services...).

The local quality of governance, institutions and human capital are less frequently tested but are more frequently positively linked to firm productivity. This is clearer than knowledge diffusion or local level of innovation due to difficulties in quantifying these categories.

Finally, geography, demography, history, and infrastructure could influence firm productivity, but these variables are strongly related to agglomeration economies, institutions, or human capital. For instance, infrastructure improves accessibility to economic agents and therefore to agglomeration economies. SEZ are developed to improve agglomeration economies in locations open to the world. Historical variables, quantifying past levels of development (sometimes even from the Roman era for European countries, see Holl 2016), seem to explain the variability across space of firm TFP in the modern era.

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